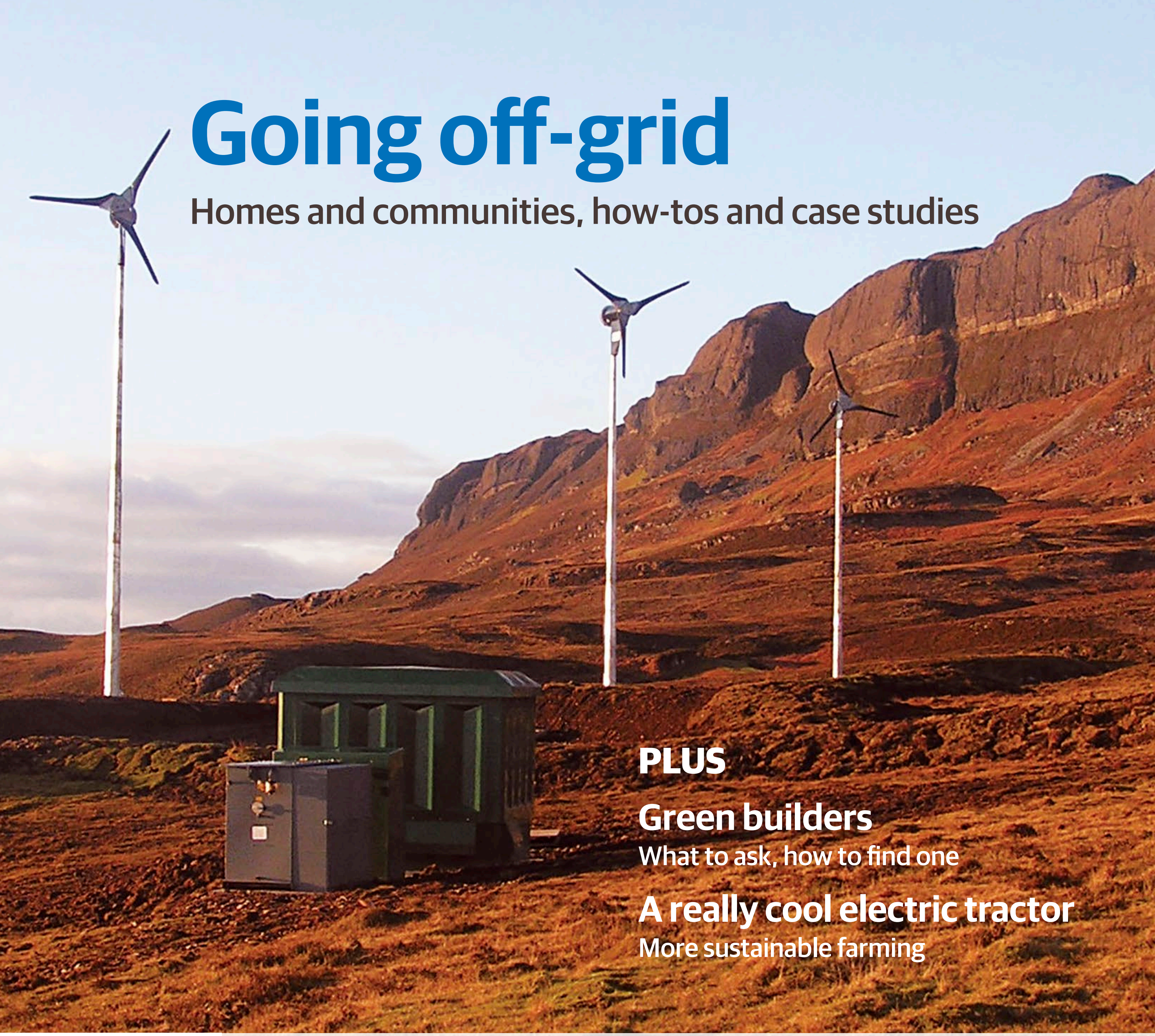
ReNew

Technology for a sustainable future

Issue 128

THE OFF-GRID ISSUE

Energy storage
buyers guide inside



Going off-grid
Homes and communities, how-tos and case studies

PLUS

Green builders
What to ask, how to find one

A really cool electric tractor
More sustainable farming

Issue 128 July–September 2014
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Low PV prices: a winning formula
Oversizing PV: how much is enough?
DIY: integrated hot water and hydronics

WIN
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How feasible is it?

↑ The conversion of an Allis Chalmers 'G' tractor to electric. Page 24.

↑ Chickens are champion composters and one of the more sustainable pets. Page 26.

↑ Our off-grid special covers everything from an independent household water supply, page 54, through to battery systems in our off-grid basics article on page 45.

Cover image courtesy Wind & Sun Ltd (www.windandsun.co.uk). These wind turbines are part of the Scottish Isle of Eigg's microgrid, pictured on page 38. The island had been heavily reliant on diesel generators until Eigg residents came up with an ambitious plan to establish their own renewable energy company, called Eigg Electric. Eigg Electric runs three hydroelectric generators, four small wind turbines, pictured, and photovoltaic cells at various locations to supply the island with clean green energy. The output of all the renewable energy generators is brought together and distributed to homes and businesses via an 11km island-wide high-voltage grid.

A composting loo in an urban area. Page 56.

Regulars

About
ReNew and the Alternative Technology Association

ReNew magazine
ReNew has been published by the Alternative Technology Association (ATA) since 1980. Each issue features renewable technologies such as wind and solar power, along with ways to make our homes more energy efficient. *ReNew* also includes practical examples of water conservation and reuse, recycling of materials and alternative modes of transport such as electric vehicles. It provides practical information for people who already use sustainable technologies and practices, and demonstrates real-life applications for those who would like to.

ReNew is available from newsagents, by subscription and as part of ATA membership. *ReNew* subscriptions start at just $30.
www.renew.org.au

Sanctuary magazine
The ATA also publishes *Sanctuary: modern green homes*, providing inspiration and practical solutions for a sustainable home. The current issue looks at home, kitchen and bathroom renovations, sustainable heating options for winter and edible shade gardens.
www.sanctuarymagazine.org.au

ATA branches
ATA branches are involved in activities such as running monthly seminars, visits to sustainable homes and projects, and attending community events.
www.ata.org.au/branches

Webinars
With the support of bankmecu, the ATA has produced a series of online webinars with experts sharing practical knowledge about sustainable living. Webinars include what to look for when choosing a solar PV system, building a sustainable house to suit your site, hydronic heating, retrofitting for energy efficiency, lighting, insulation and more. View the webinars at the ATA YouTube channel:
www.youtube.com/user/alternativetechassoc

Alternative Technology Association
The Alternative Technology Association (ATA) is Australia's leading not-for-profit organisation promoting sustainable technology and practice. The ATA provides services to members who are actively walking the talk in their own homes by using good building design, conserving water and using renewable energy.

The ATA advocates in government and industry arenas for easy access to these technologies as well as continual improvement of the technology, information and products needed to change the way we live.

With branches and members around Australia and New Zealand, the ATA provides practical information and expertise based on our members' hands-on experience. The ATA also offers advice on conserving energy, building with natural materials, and reusing, recycling and reducing the use of natural resources.
www.ata.org.au

Advocacy and projects
The ATA conducts research projects with partners from the government, industry and community sectors, as well advocacy on issues important to sustainable households. The ATA has recently campaigned to defend the Renewable Energy Target, and is producing ground-breaking research on off-grid living and the economics of gas and electricity for Australian homes. The ATA has also been a proud partner in Australia's first Community Energy Congress this June.
www.ata.org.au/projects-and-advocacy

International projects
Travel to East Timor with the ATA international projects group and help install solar power in villages. The ATA is teaming up with Timor Adventures for two nine-day tours in July and August 2014. For more information, go to www.timoradventures.com.au/tours/light-up-timor-leste.

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The construction articles presented in this magazine may require the handling of potentially dangerous AC or DC electricity. All wiring involving these voltages should be carried out according to the instructions given. Extreme care must be taken to ensure that no contact is made with these voltages. Never work on a circuit when it is connected to the power supply. The publishers of *ReNew* take no responsibility for any damage, injury or death resulting from someone working on a project presented in any issue of this magazine.

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Editorial

Going off-grid: How feasible is it?

IT MAY not be popular with Joe Hockey, but we hope you like this issue's cover!

Depicted are wind turbines on the Isle of Eigg in Scotland, part of a microgrid providing around 85% of the island's electricity needs from renewables. The diesel generators have been largely silenced and the community has come together behind a project that's providing more reliable, cleaner and cheaper energy.

Amidst the devastating winding back of renewable energy programs in Australia, such community-led microgrid initiatives are emerging as one ray of light.

Before starting work on this issue, I wasn't that familiar with the term 'microgrid'. I imagined it applied to remote regions without access to mains power, such as the Isle of Eigg, or, here in Australia, places such as King Island or outback communities.

It turns out there's also a lot of research going into 'urban islanded microgrids'—separated from the main grid (thus, 'islanded'), these are independent energy systems for urban areas, powered mainly by renewables. Showing where such microgrids might be heading, Mitchell Lennard describes his research analysing optimal design, and Kristian Handberg describes how they're being used in the USA to improve energy resilience.

The ATA's recent study into the economics of going off-grid (p. 34) shows that such microgrids are the most economically viable way to 'unplug', given the economies of scale. The research shows that in several scenarios this sort of microgrid 'unplugging' means the householders would be financially better off in the long-term compared to staying connected to the main grid.

Also in that report, you'll find analysis of the economics of individual homes going off-grid in a variety of scenarios in Victoria. There's been a lot of interest in this topic recently, given reduced feed-in tariffs and hefty rises in electricity prices. For those in urban areas, it seems the economics are not quite there yet, given current battery prices. However, the research indicates it's not far off, particularly for energy-efficient households. And, as Lance Turner writes in our 'how-to' on going off-grid, economics may not be the only motivation.

We've also tracked down case studies of households living off-grid around Australia. Most are in areas where the economics made sense, with grid-connection costs equal to or exceeding off-grid system costs. But we also include a case study of an 'almost off-grid' urban system, where the grid connection acts purely as a backup 'generator'.

There's much more besides: a great article on what to ask your builder, our energy storage buyers guide, a really cool electric tractor, PV array oversizing and more. Enjoy!

A quick note: we have a price increase to AU$8.95 this issue, after six years at $7.95. But we haven't changed the subscription price, making it even better value to subscribe!

Robyn Deed
ReNew Editor

In *ReNew 129*, out mid-September
Community energy, energy-efficient appliances, courses guide + more.

THOUGH they may not have come as a surprise, the recent massive cuts to renewable energy and environmental programs in the Federal Budget are another big blow to action on climate change.

The government has cut $1.3 billion from the Australian Renewable Energy Agency (ARENA) and broken an election promise by scrapping the Million Solar Roofs program, a program designed to assist low-income households access solar and save on energy bills.

What does come as a surprise is the extent of the cuts across portfolios including CSIRO and the Bureau of Meteorology, both of which play such an important role in researching and communicating the impacts of climate change.

These cuts have not just been at the federal level. At the same time, the WA Government has abolished the body responsible for a variety of energy efficiency initiatives and the Victorian Government has axed the Victorian Energy Efficiency Target.

Now, more than ever, it is vital for the Alternative Technology Association to be an independent voice for sustainable solutions.

The ATA is proudly taking part in organising Australia's first Community Energy Congress in Canberra, happening around the time you're reading this issue of *ReNew*. We have been campaigning to defend the Renewable Energy Target. We are producing groundbreaking research on off-grid living and the economics of gas and electricity for Australian homes. And our magazines *ReNew* and *Sanctuary* continue to explore new horizons in practical sustainable living.

To help support ATA's work, you can make a tax-deductible donation: go to shop.ata.org.au or call 03 9639 1500.

Donna Luckman
CEO, ATA

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Up front

Buses charging along

The Volvo Group in Sweden is studying the potential for electric roads to charge battery-powered buses as they travel.

The bus's batteries would be charged continuously using inductive charging, with energy transferred wirelessly to the underside of the vehicle via equipment built into the road. As part of the study, the group plans to build a 300 to 500 metre electric road test section along a bus line in central Gothenburg (Volvo's home town) and develop vehicles that will be automatically charged from the road.

Volvo currently runs three plug-in diesel-electric hybrid buses in Gothenburg which charge their batteries at stations at the end of the line. A fully electric bus dubbed ElectriCity will start running in Gothenburg in 2015 as part of the study.
www.bit.ly/volvoebus

An abnormal autumn

While some of us enjoyed a much warmer than usual autumn, the Climate Council has confirmed that it was indeed unusually warm and a sign of increasing climate change.

Daytime temperatures were 4 to 6 °C above normal over south-central Australia during a "remarkable, prolonged warm spell" from May 8 to 26, according to the Climate Council's latest seasonal update, *An Abnormal Autumn 2014*, released in June. This, combined with above average temperatures in April "has delayed the onset of winter conditions across Southern Australia," according to the report.

The report also states the last 24 months are shaping up to be the hottest in Australia's recorded history, further evidence that climate change is already influencing our weather. Last year was Australia's hottest year on record, which started with the record-breaking summer of 2012/13. Temperatures last September and October were above average, creating conditions for an early bushfire season in New South Wales, while the summer that just passed broke 156 extreme weather records.

The warm conditions are likely to continue throughout winter and the odds of an El Niño weather event in the second half of the year are increasing, too, which would drive temperatures even higher and trigger drier conditions in the east and south of Australia. The warm, drier conditions could lengthen the bushfire season and worsen drought conditions.

"El Niño events usually make life tougher in rural Australia, often triggering drought, water restrictions, extreme heat and increased bushfire risk. When it comes on top of two years of climate change-related record warmth, you have to be concerned," says Climate Council's Professor Will Steffen.

The report states that these record-breaking trends can be turned around through a rapid and significant reduction in CO_2 emissions to help stabilise the climate.
www.climatecouncil.org.au/abnormalautumn

Testing the battery-grid

A growing commuter town north of London is the site for a new smart grid project that, if successful, could be replicated around the world. UK Power Networks is installing a giant battery farm at Leighton Buzzard that will supply electricity to households at peak times, while testing the feasibility of using storage to reinforce the power grid and help meet peak loads.

The battery farm demonstration project will use around 240 tonnes of lithium-ion batteries, installed in a specially designed building raised two metres above the ground to protect it from flooding by the nearby river. Leighton Buzzard will have a 10 MWh energy storage capacity and a power output of up to 6 MW, enough for 6000 homes.

The project will have many keen observers, with interest in energy storage growing rapidly. California has plans to procure 1300 MW of storage generation capacity by 2020 to increase renewable generation and reduce emissions. Germany, Italy and China all have ambitious electricity storage plans. Energy storage is also ideal in places with an unreliable electricity supply such as remote island communities.

The battery farm is expected to be operating by September.
www.bit.ly/1nJbre8

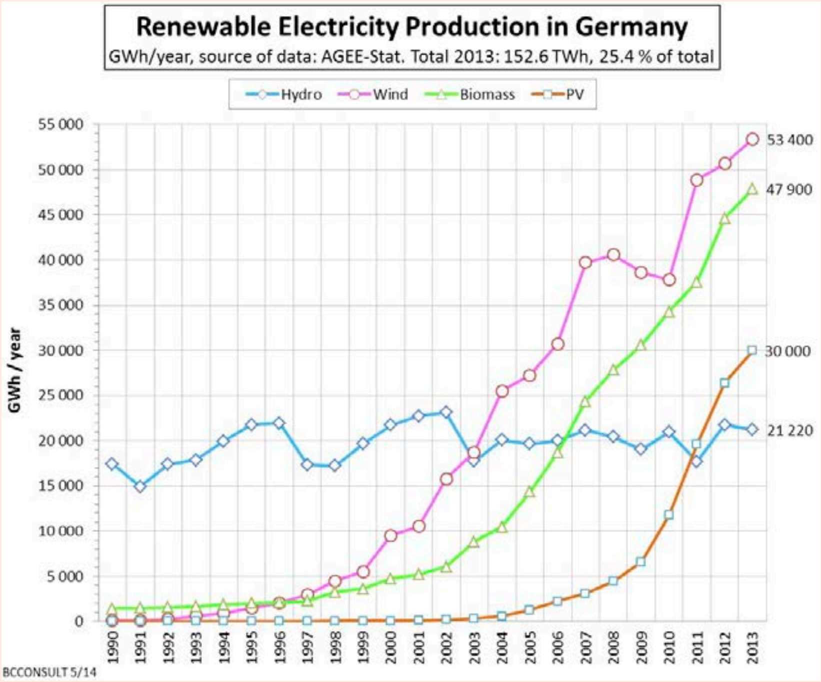
Germany sets new renewables record

In Germany, the records keep tumbling as the country pursues Energiewende, or energy transformation. *Climate Progress* reports that, on Sunday 11 May, renewable energy generation surged to a record 74% of the country's overall electricity demand by midday.

With Germany aiming for 80% renewables by 2050, and nuclear being phased out, the graph (right) shows the extraordinary growth in renewable generation over the last 10 years.

Renewables provided a record 27% of supply in the first quarter of 2014. Interestingly, despite not being known for its sunshine, Germany had much more solar power capacity per capita than any other country at the end of 2012. Wind power also reached record output levels in 2013—25.2 GW—and accounted for 39% of supply on one day in December.

It's not all roses. *Climate Progress* notes that the feed-in tariff (FiT) for renewable generation is funded by a surcharge on energy supply, with industry exemptions meaning the burden mainly falls on householders. However, one observer says that wholesale prices have dropped 18% due to lower operating costs for renewables and this should feed back into lower retail prices. It's interesting to also see community energy at work. The article quotes Amory Lovins of the Rocky Mountain Institute: "Citizens, cooperatives, and communities own more than half of German renewable capacity." Source: http://thkpr.gs/1oMlaN2



Graph: Bernard Chabot

ARENA supporting CST pilot system

A first-of-a-kind concentrating solar thermal (CST) plant is on its way to commercialisation in Australia with support from the renewable energy funding agency ARENA and private funding. The next stage of Vast Solar's project is a grid-connected pilot-scale plant in Jemalong, NSW. Construction of the plant has already begun with completion due by the end of this year.

The pilot plant will be capable of generating 6 MW of thermal energy—which generates 1.1 MW of electrical output, enough to power 400 homes. The plant will also include three hours of thermal energy storage.

The plant follows earlier work by Vast Solar, also supported by ARENA, which developed a single CST 'module': a solar field of 700 mirrors focused on a tower with a thermal energy receiver. Vast Solar's design aims to reduce the cost of CST power to levels comparable with wind-generated energy, via the added value that thermal storage's reliable dispatch of power provides.

ARENA CEO Ivor Frischknecht said the project was a demonstration of how ARENA "invests along the innovation chain—from early lab research to pre-commercial deployment—to advance renewable energy technologies."

The new pilot-scale plant will include five CST modules (3500 mirrors and five receiver towers), a thermal storage system comprising a hot tank (over 500 °C) and 'cold' tank (over 200 °C), and a steam turbine based electrical generation system.

Data will be collected to demonstrate the technical performance, cost and long-term safety and durability of the technology used in readiness for commercial deployment. www.bit.ly/ARENACST

↑ The CST pilot plant under construction in Jemalong, NSW.

Image: ARENA

Up front

Big 10 food companies must do more to tackle climate change

A recent report by Oxfam shows that the top ten food and beverage companies together emitted more greenhouse gases than Finland, Sweden, Denmark and Norway combined. Oxfam Australia singled out Kelloggs and General Mills (Old El Paso, Latina pasta) as two of the worst on climate change and is calling on them to put in place more responsible policies and practices.

"If the top ten were a single country, they would be the 25th most polluting country in the world," Oxfam's food policy specialist Kelly Dent said.

The global food system accounts for about 25% to 27% of global emissions, including sources from production of agricultural inputs like fertiliser and emissions from agricultural production, refrigeration and transport.

The top ten companies are Associated British Foods, Coca-Cola, Danone, General Mills, Kellogg's, Mars, Mondelez International, Nestle, PepsiCo and Unilever. Of their total emissions, about half come from the production of agricultural materials from their supply chains, yet these emissions are not covered by the reduction targets the companies have set.

Dent said some of the companies had admitted that climate change is already hurting them financially. Unilever says it now loses $444 million a year, while General Mills reported losing 62 days of production in the first fiscal quarter of 2014 alone because of extreme weather conditions that are growing worse because of climate change.

"As companies that are deeply exposed to climate impacts, it's in the interest of food and beverage companies to seek a more ambitious national and global response. We are therefore urging them to also speak up for stronger government policies and programs to tackle climate change," Dent said.
www.bit.ly/Oxfamtop10

Solar for strata

Is it possible to get solar on an apartment block? You betcha! Check out the ATA's contribution to Smart Blocks, a national program helping apartment owners and managers improve the sustainability of apartment buildings. The ATA has contributed advice on what you need to think about when planning a solar installation in an apartment block, whether you're powering common areas or individual apartments. It's a great resource!
www.bit.ly/Smartblocks

6 Star UQ building first

University of Queensland's new Global Change Institute represents the first use of structural Geopolymer concrete in Australia, a product with significantly lower greenhouse gas emissions than conventional concrete.

Designed to help researchers understand sustainable design in the sub-tropics, the 6 Star (world leadership rated) building features a shading system that tracks the sun and protects the glass louvres, which create natural ventilation. The central atrium acts as the building's lungs, discharging warm air through its thermal chimney. The translucent ETFE (ethylene tetrafluoroethylene) atrium roof optimises natural light to the interior and is also heat-resistant. The building is cooled with chilled rainwater flushed through exposed sculptural precast floor panels.
www.bit.ly/UNIQLDGCI

← Solar Tower 2 in operation at the CSIRO Energy Centre in Newcastle. CSIRO has used solar energy to generate hot and pressurised 'supercritical' steam at the highest temperatures ever achieved outside of using fossil fuels.
www.bit.ly/1kw4A49

Clarification of safety issues with a DIY fire-fighting unit

Energy Safe Victoria recently contacted ReNew *about potential safety issues with the DIY fire-fighting unit mentioned in John Hermans's article in* ReNew 126. *Here, John Hermans recaps important safety information.*

In 'Wildfire Safety in a Bushland Setting' in *Renew 126*, I briefly described my portable fire-fighting unit that consists of a re-purposed gas cylinder and hot water tank. This referred readers to an earlier article in *ReNew 108* for details, in which I highlighted the need to make sure all gas was completely emptied from the cylinder.

In the case of such fire-fighting systems, it must also be noted that all the following information would need to be adhered to in order for a system to be compliant with relevant codes and regulations.

1) A system needs to be tested to relevant Australian standards or checked for compliance with the Building Code of Australia and should not be installed unless that has occurred.

2) Some of the safety factors to consider are the potential for exposure to excessive pressures for both the LPG cylinder and hot water service tank. Although gas cylinders are tested to a pressure of 3.3 MPa, the condition of the tank needs to be checked—anything more than surface rust and the tank should not be used. If in doubt, have it pressure tested. Mains pressure tanks are designed for a maximum working pressure of 1 MPa but make sure the test pressure of the hot water service is above this value.

3) If the LPG cylinder is owned by a gas company (e.g. Kleenheat, Elgas or Origin), using the cylinder for this purpose must be okayed by the company as there may be legal ramifications.

The other issue of concern is a potential for an explosive mixture of air and gas in the LPG cylinder if there is any residual gas in the cylinder before adding the air. Gas cylinders can be evacuated by filling them with water and then thoroughly draining them. This is common safety practice before working on gas or liquid fuel tanks, where heat or sparks may occur.

Letters

A burning issue

ReNew 127 contained several good articles on the subject of home heating and insulation options, but there was one article that failed to meet what I would have considered a *ReNew* prerequisite: ethics and sustainability. I have no doubt that when Lance Turner found a solid fuel heater with an efficiency return of 92%, he thought he had a product that we all needed to know about, and I accept that. However, reading on I found that he was burning one and a half tonnes of wheat grain annually, which immediately started alarm bells ringing.

There are several levels of concern here. The first is that I believe that we in the developed world should not be burning cultivated food grain to keep ourselves warm.

Lance made it clear that the grain was feed-grade and that it was bought from just up the road, but consider what is being promoted here. Once our native forests are cleared for food cultivation, then the energy inputs into growing and processing the grain primarily needs to go to feed people.

I think the East Timorese people who so gladly receive solar lighting assistance from the ATA would be outraged to learn that the very same organisation is promoting the burning of stock-feed grain (which is clearly linked to human food production) back home in Australia.

I have spent time there and know they would happily eat our feed grain. For them, food is an essential and lighting is a luxury.

In Australia, over half of our cultivated, grain-growing farmland is dedicated to feed-stock grains. Nearly all is destined for penned feedlot animals, including space-restrictive pig and poultry feedlots. Is burning this grain a better option? No, preferentially it needs to be grown to feed people, with a much smaller quantity grown for some stock. Burning it will only drive up the stock-feed market.

If the wheat that Lance was purchasing was so degraded that it was not even suitable for stock, then what about the repercussions of many less morally assertive people installing this type of solid fuel heater. What certainty is there on what fuel they will burn? The stoves might well be used to burn wood chips from old-growth native forests, which is the very product which drives the environmentally destructive logging industry. And with such a falling price on this product, it is foreseeable that the forest industry would be gleeful of their new found outlet.

In addition, does a near smoke-free, high-efficiency wood and grain heater mean that we will see them being installed in urban areas, thus driving up demand for the fuel, be it wood or grain?

However, if this stove was to be used to burn truly waste wood products, in rural areas where no grid connection exists, then I can see the value in it.

I would prefer to promote high-efficiency heat pumps such as the new Daikin Ururu Sarara with a COP of 5.9 (one unit of electrical energy in, with 5.9 units going to heat the space). The cost with the additional PV roof panels to drive it would be little more than the cost of the stove, and a whole lot more ethical and sustainable. The few times that the grid goes down could be dealt with by an inexpensive generator. It appears the stove needs power to run it in any case!

There is a good reason why heating stoves attract people to stand close to them; it is because on the other side of the room it is cold. An appropriately sized reverse-cycle air conditioner such as the Daikin gently pushes their heat or coolth to the whole space.

And of course my favourite home heating option is nuclear fusion, through my windows, from our sun.

John Hermans

Thanks for your concerns, John; I will try to explain my reasoning for the choice of this heater.

Overall, I think that our heater fuel has a low carbon cost compared to feeding that grain to livestock, and compared to other fuel options such as firewood, which is often forest harvested.

Growing grain and feeding it to animals has a poor environmental outcome as it turns a good proportion of the CO_2 absorbed when the wheat is growing into methane, a much stronger greenhouse gas.

While it may be true that the East Timorese would happily eat the stock-grade grain, I doubt this is a practical option as there may be legal issues with exporting stock-grade wheat to other countries for human consumption.

With regards to using wood in pellet heaters: pellet heaters cannot burn woodchips as the wood must be turned into pellets of a specific size and density. The lack of large-scale mills will prevent the forestry industry taking advantage of these heaters as a possible market—pellet heaters have been available for decades yet the availability of hardwood pellets is very low and the price very high.

As noted in the article, my partner and I had found the rate of air movement from a reverse-cycle unit to have a cooling effect, requiring a higher thermostat temperature than we'd otherwise need. The pellet heater produces a low flow of quite hot air, heating the space like a reverse-cycle unit, but without the high flow air movement.

Our pellet heater does require electricity to run, but our small off-grid PV system is enough to run it for around two days. It would run the Daikin unit for only about two hours and the cost of upgrading our PV system would be more than the cost of the pellet heater, and more than we could afford at the time

Although I understand your concerns, I feel that the pellet heater was a good solution for us personally, and environmentally.

Lance Turner

It's a complex issue and we are planning an article on the ethics and sustainability of using food for fuel in an upcoming *ReNew*—*Ed*.

Caravan fridges

With interest I read Alan Pears's report in *ReNew 126* and the letter from Rodney Champness in *ReNew 127* on caravan fridges.

I am not an engineer but an ordinary caravan user and have found the three-way fridges—12 volt, 240 volt and gas—to be quite inefficient and not very practical.

Three-way fridges are quite expensive (over $1000) and mostly produced in cool Sweden. Used on 12 volts they flatten batteries in hours (with 20 amp draw continuously) and will only keep a fridge at the starting temperature whilst travelling.

The 240 volt element is very small, the size of a thumb, and left on for two weeks it literally doubled our power bill. On gas they can be very efficient as long as the outside temperature stays below 33 °C—anything over 35 °C it goes into meltdown and at 40–45 °C butter melts, milk goes off and you get hot beer. Overnight these fridges will pick up somewhat.

Our alternative is a 12 volt/240 volt Engel compressor bar fridge which neatly fits into the three-way fridge hole. The main problem is that the 12 volt wiring should be 6 mm² or more and as most caravans are not that heavily wired, wiring should be replaced, which is difficult. I ran cables through conduits under the van, the shortest route to the battery.

I found that by removing the drip tray in the fridge the temperature inside the fridge is much colder although at the expense of the freezer which then is not as efficient (no icecream).

If the temperature inside the Engel bar fridge goes above 10 °C (e.g. after leaving the door open), it may sometimes take hours for the temperature to reach the normal 2 to 4 °C.

Our caravan has three 80 watt solar panels feeding into two 100 Ah AGM batteries to run our Engel bar fridge continuously for up to three or four months on long trips. Our next batteries are going to be lithium for more endurance.

We never use 240 volts except for the air conditioner. We would like a larger fridge but there is no room!

I will be looking forward to the article on caravan fridges in *ReNew 128*. (The article on caravan fridges has been deferred; apologies, Rick, but it will come eventually!—*Ed.*)

Rick Honschooten

Cargo bikes

The article on cargo bikes in *ReNew 126* was a useful guide on how to replace a second car, or a 'shopping trolley car' as second cars often are, with a practical and versatile cargo bike. Unfortunately there was no reference to the culture and economics of transport in Asia where cycles, including electric-assist cycles of all shapes and sizes, have been built and used for years by many millions of people. In most of Asia cycles are and have been the preferred choice of transport for both goods and people.

Australia has a proud history of inventiveness but thanks to the 'consumption for the sake of the economy' madness, we have also made, but mostly bought in huge quantities, some of the laziest and wasteful technological contraptions known to man (patio heaters sit on top of my long list). Being inventive is an important and worthy skill for any society but technology will always be abused by opportunists who want to make a quick buck.

And cycles are by no means immune from such abuse. Just visit your local refuse centre and look at the piles of broken cheap cycles. We certainly can offer the world some terrific applications of technology, but, in general, non 'first world countries' like most in Asia have a far better record of adopting practical, simple and proven technology. We would be wise to utilise their experience before reinventing the wheel.

Michael Harries

Use SHW correctly

I have recently been re-reading some old *Soft Technology/ReNew* and similar magazines and have noticed some questions about solar hot water efficiency and the need for boosting.

To gain the most benefit from solar and limit boosting requires a bit of a lifestyle change.

Do the laundry, dishwashing and big showers in the morning so the solar is working on cooler water all day and little or no boosting is required. Using big quantities of hot water in the evening causes the booster to fill the storage overnight so that the solar is only a top up.

When my late parents had a Solarhart two-panel and tank system installed at Merbein in the 1970s they were told of this and found that from November to March they could switch the off-peak booster completely off.

This system faced northwest and copped full afternoon sun. I drove past the house last week and the system was still up on the roof!

Bill Burns

Solar powered biking

My wife and I have recently bought electric-powered bicycles. Age takes its toll! I was looking through your magazine to see if there was a seller of solar panel chargers for the batteries they use, without success.

Most of the e-bicycles I have seen and tried use a 36 V Li-Ion battery pack, with the supplied charger rated at around 42 V at 2 A.

I spoke to the people at Excelsior Power, but they have nothing directly suitable, although they suggested three 12 V panels plus regulator, for about $1000.

Given the increasing popularity of e-bikes it surely should be possible to produce or design something for much less than $1000. The power needed would only need to be around 80–100 watts.

I would be interested to know if any of your readers has encountered or solved this problem.

John Webster

Thanks!

I want to thank *ReNew* magazine for picking me to spend two days at Halcyon Hideaway near Strathbogie. It was a perfect opportunity to see the scenery, visit local wineries, dine at cafes and restaurants in the area and visit the Benalla Art Gallery.

The off-grid accommodation provided a restful break following days of enjoyable adventures as well as ideas for things to try at my home. The website, halcyonhideaway.com.au provides all the information you need to investigate further.

Tim Rowley

Write to us

We welcome letters on any subject, whether it be something you have read in *ReNew*, a problem you have experienced or a great idea you have had.

Please limit letters to 350 words. Due to space restrictions we can't guarantee to publish all letters received, and letters published may be edited for clarity and length.

Email letters to renew@ata.org.au or post to ReNew, Level 1, 39 Little Collins St, Melbourne VIC 3000, Australia.

Products

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

DIY double glazing

DIY double glazing can be a cost-effective way for anyone with budgetary constraints to reduce their energy bills. There are a number of kits on the market, including the Duck 5 and Duck 10 window insulation kits from the Enviroshop.

The Duck 5 kit includes a 1.5m x 5.3m sheet of clear shrink film and 25m of double-sided tape. The Duck 10 kit contains twice the amount of film and tape, for larger projects.

To fit the film you apply the tape to the window frame, cut the film to the approximate size and stick to the tape. Excess film is then trimmed off and the film shrunk tight using a hair dryer.

The film is said to be non-splitting and the tape removes cleanly and easily with no residue.

The kits are for indoor use only, and are suitable for most window frame types, including painted or varnished wood, aluminium and PVC.

RRP: 39.95 for the Duck 5 kit, $69.95 for the Duck 10 kit and extra rolls of tape are available for $9.95. For more information and to buy contact Enviroshop, 253 High Street, Northcote VIC 3070, ph: 1300 430 430, info@enviroshop.com.au, www.enviroshop.com.au

02

Semi-flexible solar panels

Most solar panels are rigid and have aluminium frames, but if you need to mount a panel on a slightly curved surface, such as a boat deck or even a vehicle roof, a framed panel isn't really suitable.

Jaycar Electronics have semi-flexible solar panels consisting of crystalline cells bonded to an aluminium substrate. Because they have no rigid frame they can be curved to a reasonable degree without damage.

The panels are available in 20W and 100W versions which measure 730 x 330 x 2.5mm and 1260 x 570 x 2.5mm and weigh 780g and 2.8kg respectively. Both are nominal 12 volt panels, with maximum power currents of 1.12A and 5.26A.

The panels have a fully sealed terminal box with 1.2m of power cable with PVC outer sheath.

RRP: $99.95 and $399. For more information and to buy, contact Jaycar Electronics, ph: 1800 022 888, techstore@jaycar.com.au, www.jaycar.com.au

03

Hybird500 electric bike

The Hybird500 electric commuter bike from Erider features a 250 watt hub motor and is configured to the Australian pedelec standard. It is powered by a 36 volt, 10 amp-hour lithium-ion battery with a rated life cycle of greater than 800 recharge cycles. Charge time is around three to four hours, so you don't need to wait all day.

The bike has a maximum speed of 25km/h and a range of up to 40km. Maximum load is 120kg while the bike itself only weighs 31kg.

The Hybird features a 6061 aluminium alloy frame made in Taiwan, 20 x 2.5" Kenda tyres, and front and rear Tektro disk brakes for reliable stopping.

Other features include seven-speed Shimano gears, Zoom aluminium alloy handlebars, KMC stainless rust-resistant chain, Zoom suspension seat post, adjustable suspension front forks and a programmable digital speedometer.

The assembled bike measures 1750 x 620 x 1050mm. It is available in black, blue, red and silver.

RRP: $1999. Shipping can be arranged for extra cost. For more information and to purchase, contact Erider All Electric Transportation, ph: 0419 409 110, sales@erider.com.au, www.erider.com.au

04
A new NUC

There are many mini PCs around nowadays, but most lack processing power if you need them to be a fully capable desktop machine. The NUC (next unit of computing) from Intel has been around for some years, but has previously been a bit hobbled by its lack of decent capabilities. However, it seems Intel finally got the message and the latest 4th generation versions (skus D54250WYK and D54250WYKH) are much more powerful.

For a start, the new NUC comes with an i5-4250U dual-core processor with HD 5000 graphics, can be loaded with up to 16 GB of DDR3L (1.35 V) RAM, has dual PCIe mini card connectors for expansion, a 6 Gb/s SATA port (the H version), four USB 3 ports, both mini HDMI and Display Port, the latter supporting 4k screens, gigabit ethernet, infrared sensor (for remote control), 7.1 channel audio, fast boot capability and a three-year warranty.

Power is via a DC power socket on the rear and the NUC can run from any DC voltage between 12 and 19 volts, making it ideal for running directly from solar power. It comes with a 65 W mains power supply.

The NUC is tiny, at just 116.6 x 112 x 34.5 mm. It is sold as a bare-bones unit—you add your chosen RAM and storage—or many retailers will configure it for you. The NUC is also available as a bare board for embedded applications.

RRP: varies depending on chosen components. Available from many larger computer suppliers.

05
Fancy LED replacements

Brightgreen has released a string of interesting and high quality LED light bulbs and fittings over the years, and their latest offerings run true to form.

The BR220 candle bulb combines the form and appearance of a traditional 15 W incandescent candle bulb with LED technology, producing a 220 lumen, warm-white candle bulb that draws just 3.5 W.

The BR250 fancy round bulb produces 250 lumens of warm-white light through a transparent globe, just like a traditional fancy round bulb, while also using just 3.5 W.

Both bulbs produce light in a very warm 2700 K colour temperature. They also feature E14 screw bases, the most common base in these sorts of globes, 25,000-hour rated lifetimes, and both come with a three-year warranty. They are ideal for lamps, pendants, chandeliers and decorative fittings, or even as low-level always-on safety lighting in stairwells and the like.

RRP: both bulbs are priced at $15. For more information and to find a local stockist, go to www.brightgreen.com.

06
Portable solar generators

When most people think of portable power supplies, they think of a genset. But gensets require maintenance and fuel, and are quite polluting, especially when run at low loads, as most are for a large percentage of their runtime.

Ecoboxx provide a great alternative with their portable solar power systems. Just set up the panel, connect it to the main Ecoboxx unit and you are done.

There are three models—the 160, 600 (to be released in August) and the 1500. They feature 100, 600 and 1500 watt inverters respectively, with the two larger models having sinewave outputs. Storage capacities are 13 Ah and 45 Ah at 12 V for the 160 and 600 respectively using sealed AGM batteries. The Ecoboxx 1500 can use batteries from 100 Ah to 300 Ah, but it is supplied without a battery as standard. To make the most of the solar panels, the Ecoboxx 1500 also features a MPPT solar charge controller.

The solar panels for each unit are rated at 20, 80 and 130 watts respectively (the 1500 can handle up to 300 watts in total) and each Ecoboxx comes with a 3 W LED bulb and lead set, and an AC charger, for when you need to charge the unit from mains power.

RRP: $299 for the Ecoboxx 160 and $1299 for the Ecoboxx 1500. The 600 will be priced around $800 when released. For more information and to find your closest dealer, contact Ecoboxx, ph: (02) 9724 3344, info@ecoboxx.com.au, www.ecoboxx.com.au

Products

07

Invisible electric bike kit

Electric bikes make it possible to use bikes for longer rides and in hillier areas than the average rider could cope with without electrical assistance. However, most electric bike kits either look less than ideal, add a lot of weight to the bike, or both.

The Vivax Assist kit has been designed to eliminate these problems by fitting the drive unit and electronic controller into the seat tube. The special design of the drive unit allows it to be built into any bicycle frame with a seat tube internal diameter of 31.6 mm or 30.9 mm.

A simple on/off button is mounted to the handlebars and the 30 volt lithium-ion battery pack (available in 5.5 Ah or 8.25 Ah versions) is mounted in the most suitable location.

The drive motor transfers power to the bottom bracket (pedal crankshaft) via a bevel gear that fits to the bottom bracket. The whole drive freewheels when no power is applied. The controller operates in a pedal assist (pedelec) mode, and the units are legal here in Australia as they have a maximum power of 200 watts.

Possibly the most impressive thing about the Vivax Assist is that the total weight is just 1.8 kg including the (smaller) battery. However, there is one big drawback to this system, and that's the price—a massive €2550!

For more information, contact Firma Gruber Antrieb GmbH & Co KG (Austria), ph: +43 5332 70317, www.vivax-assist.com

08

Excellent Excelet

There are a few composting toilets on the market, but they often require clearance under the bathroom floor for installation. This adds to the cost and complexity of installation, limits the positions they can be placed in the room and can make accessing them for maintenance difficult.

The Excelet from Nature Loo is a batch composting toilet sized for up to three people full time or six people part time (depending on the option chosen) and is designed to mount entirely above floor level, making installation and maintenance easier.

Other features of the Excelet are a power consumption for the fan of just 2 watts, urine separation and a barrier to block any view of the contents of the chamber. It is available with different numbers of 55 litre composting chambers depending on requirements (four chambers are required for council approval) and comes complete with everything except for the external vent pipe and absorption materials.

The Excelet is made in Australia and has ANZ1546.2:2008 certification and is approved by the QLD, NSW and WA state authorities for installation in homes. A modified version is planned for VIC, SA and Tasmania that will suit four to six people full time.

RRP: $2100 inc GST for the four-chamber model. For more information contact Nature Loo, ph: 1300 768 013, info@ecoflo.net.au, www.nature-loo.com.au

09

Long-life sealed batteries

One often-heard complaint about sealed lead-acid batteries is that they can have a short lifespan. The Solazone silicate batteries are designed for an increased lifespan and higher charging and discharging rates, making them suitable for demanding applications.

Available in sizes from 12 V, 7 Ah through to 2 V 2000 Ah, they feature high energy density of around 45 Wh/kg (compared to 30 Wh/kg for typical lead-acids), fully sealed construction and a typical recharge time of two to four hours. They can also be rapid charged in just half an hour—a rate that would damage many other lead-based batteries.

Unlike most lead batteries, they also have a very low self-discharge rate of less than 10% every two years, so they can be stored for long periods without needing a recharge. Discharge capabilities are also excellent, with 10C to 19C discharge rates possible, depending on model.

According to Solazone, another area where they perform better than other lead batteries is in cold weather—they have a rated operating range of -40 °C to 70 °C—temperature extremes which would severely hamper or damage most lead-based units.

RRP: range from $28 for the 12 V, 7 Ah unit to $760 for the 2 V, 1100 Ah model. For more information contact Solazone, ph: (03) 9808 7337 (VIC) or (07) 5448 8304 (QLD), vic@solazone.com.au, qld@solazone.com.au, www.solazone.com.au

10

Low wattage kettles

We have been asked many times for low wattage kettle options for use on smaller SAPS systems, but most models either disappear soon after their release or are not available in Australia.

If you can live with the slightly utilitarian look, Birko has a versatile option that may suit many people looking for a good quality, low wattage appliance.

Available in 800 mL and 1300 mL sizes, the excitingly named Birko Food & Drink Heater has a rated power consumption of just 750 W, meaning it will work on all but the smallest of inverters.

The units feature a removable cord, sealed element, stainless steel body, and have an all-round pouring lip so you can pour from any angle. Of course, they also feature a thermostat and boil-dry protection and you also get an egg-poaching attachment that sits on the top for quick, fat-free eggs.

Both units measure just 130 mm in diameter and are 160 and 200 mm high respectively, making them quite compact.

RRP ranges between $90 and $100. Available from catering and some department stores. For more information contact Birko Australia, ph: 1300 724 955, sales@birkoheaters.com, www.birko.com.au/catering/drink-heater

11

A nicer Nokero

We have looked at the base model rechargeable Nokero solar lights previously and testing had mixed success; however, the latest model, the N222, has addressed the issues and added a heap of features that makes it a much more usable device.

As well as a more powerful LED that produces 50 lumens on high and flash modes, and 25 lumens on low, the N222 comes with a 1400 mAh $LiFePO_4$ battery and a high-grade solar panel made by SunPower Corp in the US. This gives the light up to six hours runtime on high and 15 hours on low, depending on the amount of sunlight the unit receives during the day, of course. Battery life (to 75% remaining capacity) is rated at five years if used daily.

Other features include a 5 V, 300 mA USB output which is sealed under the removable dome during charging. This allows the charging of phones and similar devices, so the lamp acts as a solar-powered spare battery for your devices. It can also be charged from a mains charger (not included) and will accept standard USB and Nokia-style chargers.

The N222 is much more solidly built than the cheaper Nokero lamps too, with an ABS housing and polycarbonate clear dome, with a large O-ring seal to keep out the weather. It comes complete with green and red colour lenses, table stand and stainless steel hanger.

RRP: $60. For more information and to buy, contact Solar Gods, ph: 0407 776 907, spencer@solargods.com.au, www.solargods.com.au

12

High efficiency wood heating

Wood heating is a popular method of staying warm during winter, especially for those in rural areas with access to low cost or even free sources of firewood. However, not all wood heaters are created equal, and many are run in a very inefficient manner, producing high levels of pollutants such as particulates and methane.

The Pyroclassic IV Freestanding by Pyroclassic is rated to heat 160 m^2 and has an emissions rating of just 0.3 g/kg of fuel burned, with efficiency up to 74% for heating only and up to 65.3% when using the optional 3.7 kW wetback to produce hot water.

Useful heat output is rated at 2 to 8 kW, with a maximum output of 15 kW including the flue. Rated fuel consumption in the 21 litre fire chamber is 1.1 kg/hour, although this will obviously vary depending on fuel and burn rate.

Other features include a 10 mm thick steel cooktop, so the heater can double as a cooker, an optional oven lid and an optional log rack.

The Pyroclassic IV is available in a range of optional colours. It measures 650 mm deep x 450 mm wide x 625 mm high and weighs around 140 kg.

RRP: $3690 before colour and other options. A $300 trade-in discount is available for your old wood heater. For more information or to buy, contact Pivot Stove & Heating, ph: 1300 474 868, sales@pivotstove.com.au, www.pivotstove.com.au

Shades of green
Sourcing a green builder

By Elizabeth Wheeler.

"While it might feel daunting (or even rude) to ask challenging questions of a prospective contractor, remember that a lot is at stake. What's more, if it doesn't feel right asking questions of a builder in the contracting process, how will you ever raise thorny issues when they inevitably arise?"

↑ The plasterers were already at work on site when this photo was taken. Insulation as installed here would have been a complete waste of money; luckily, it was detected and the plasterers were called off until the insulation could be rectified. The problem is, who checked to see if the job was done any better the second time around?

ONE of the things I hear most when I speak with people about their builder is, "He said he was open to incorporating our ideas about green building." Sadly, the context for our conversations is almost always their disappointment, frustration and even anger at how their home was ultimately constructed. And quite frequently these people say that, upon reflection, they didn't enquire deeply enough about the builder's knowledge, values and experience.

I suspect that fear is often what stops people asking 'too many' questions of prospective builders. It is common for people to worry that the builder won't want to quote on their job and/or that the builder will apply a premium to the contract for a client they perceive to be pushy or 'hard work'. Sometimes time pressures are also in play—for example, wanting to be in by Christmas or before the baby comes. Almost always, clients seem to feel that it is the builder, not them, who is in a position of power.

Yet for most people the cost of a house or major renovation is the most significant one-off bill they will ever pay. And in ecological terms, what happens in construction is critical—a well-designed house will still perform badly if the builder hasn't done their job properly. What's more, given that working drawings rarely specify products and brands for the building fabric, issues such as VOCs, embodied energy and ethically sourced timber are usually the domain of the builder.

From both a personal and environmental perspective, it's critical for people to work through their fears and expectations and contract a builder who can deliver a quality, environmentally sensitive home.

"If I were to build another environmentally sensitive home tomorrow, I'd choose a deep green builder any day, regardless of how much more that might cost. If I needed to, I would sacrifice space, put off solar panels and economise on fit-out."

← Poorly installed (left) and well-installed insulation (right). It's important that insulation batts are installed without gaps and aren't compressed. When it comes to reflective foil, there are other things to consider including ensuring there is the appropriate gap between the foil and batts and that any joins are properly taped.

What shade of green?

In environmental terms, I put builders in three categories: conventional, green and deep green.

Conventional builders might or might not have any idea about environmentally sensitive construction.

Green builders have some sort of training in environmentally sensitive construction (for example, certification by the Master Builders Association as a Green Living Builder), but (for most) it is not their core business.

Deep green builders might or might not have Green Living Builder certification, but environmental thinking is at the core of their business and they can demonstrate that it's part of their lives.

When we commissioned a company to construct our house, we were looking for people who could build us a house that minimised our environmental impact and reflected our social justice values. We were delighted to find a company whose partners totally 'got' our project. They had a deep understanding of our value statement, and even had a matching one of their own. The working relationship that we forged during the design and construction of our house was first-rate and I'm sure that our shared approach was an important factor.

Our builders typified a deep green approach. Their principled environmental stance meant they:

- were personally and professionally committed to bringing our environmentally sensitive design to fruition
- were well informed about current product options, especially when it came to the building fabric
- had a network of tradespeople who either worked within the same building paradigm, or at least were willing to fit in with it on jobs where it matters to the client
- were willing to work with our environmental expectations, but also knowledgeable enough to challenge them.

As a consequence, our house has—for a new dwelling—significantly less environmental impact than most other houses being built in suburban Australia today. And this was achieved without me having to argue, harangue, pester, complain or take on the management of the entire project myself.

If I were to build another environmentally sensitive home tomorrow, I'd choose a deep green builder any day, regardless of how much more that might cost. If I needed to, I would sacrifice space, put off solar panels and economise on fit-out. Because the everyday choices the builder makes are absolutely fundamental to a house's immediate and long-term impact on our environment.

Choosing a deep green builder

Regardless of whether your renovation or new build has been designed with the environment in mind, choosing a deep green builder will help you to minimise the impact of its construction, increase the lifespan of the actual building, and improve the health of its inhabitants.

If you google 'how to choose a builder', you will find any number of tip sheets. There are also tips out there on finding a green builder. All of that information will be helpful, but to find a deep green builder, I suggest looking at the following in addition to your basic quality and probity checks.

While it might feel daunting (or even rude) to ask challenging questions of a prospective contractor, remember that a lot is at stake. What's more, if it doesn't feel right asking questions of a builder in the contracting process, how will you ever raise thorny issues when they inevitably arise? A deep green builder should understand why a client might ask a lot of questions—and be able to answer them in a respectful and constructive way.

VALUES

What evidence is there that the builder really cares about environmental matters? For example, how has green building influenced how they live their own life? How sustainable is their own house?

KNOWLEDGE

Can the builder talk knowledgeably about the range of products out there? For example, can they tell you what building materials are preferable in terms of embodied energy? What is their response to the term 'greenwash'? How do they spot it?

What accreditation systems are they aware of? Do they know what a WERS rating is? Can they name timber certification schemes? Do they know what VOCs are?

Do they seem to have a really strong attachment to one style of building or one product? (If it coincides with your interest, that might be a good thing, but if they feel they've found the best, they might have stopped looking at alternatives.)

Is the builder familiar with the features and products specified in your design?

"Houses are mandated to be designed to a six Star energy rating, but there is no process to check whether they have been constructed to perform at six Stars."

UNDERSTANDING
What evidence is there that the builder has thought about the complexity of issues that need to be considered in environmentally sensitive building. For example, what do they think of plantation versus logging native forests? Where do they sit on issues that are close to your heart?

NETWORKS
Does the builder have a network of similarly minded and skilled tradespeople? How do they ensure that subcontractors work within their environmental charter? How do they check the work of subcontractors? What guarantees are there that subcontractors will use low VOC products?

How does the builder stay up to date with new information and practices in the construction industry? What was the last seminar they attended? What have they been reading or researching recently?

PROCESSES
How would shared environmental expectations be documented in the contract?

How would you and the builder communicate?

What if you wanted the builder to use a product they didn't know much about?

What if the builder wanted to use a product you didn't feel comfortable using?

How would the builder go about getting information about new products or building techniques?

Why it matters

If builders were mandated to use environmentally sensitive materials and if there were an adequate process for checking building quality and performance, then there wouldn't be so much at stake in trying to find a green-ish builder.

Did you know that in your standard new construction or renovation, nobody checks that insulation has been installed correctly? I recently intervened in two residential construction projects in which the insulation had been so poorly installed as to be entirely useless. I've also had the joy of watching a house being wrapped up so tightly by the insulation team that I wanted to put them on a retainer for gift-wrapping services. The difference between the first two houses and the third is that the latter is being built by a company that is deep green.

I find it very disturbing that houses are mandated to be designed to a six Star energy rating, but that there is no process to check whether they have been constructed to perform at six Stars. This points to a systems failure, one of many in the construction industry.

Regardless of the builder you choose, please consider sharing your building experiences with politicians, policy makers and professional associations. We desperately need these people to understand how and why environmentally sensitive construction matters, and to act accordingly. It's critically important that mainstream builders start to move towards even a very light shade of green if today's children are going to have the chance of a decent life on this planet. ✱

Elizabeth Wheeler is a second-year building design student with a keen interest in product specifying. Her home featured in *Sanctuary 18*.

In *ReNew 127*, Elizabeth wrote about ways to minimise the stress of choosing materials when building a green home. You can also read her blog about her building experiences at buildingour9starhome.blogspot.com.au

If your builder is not deep green (or even if they are)

Think carefully about how to pitch your requests, including what might affect the builder's willingness to work in a more environmentally sensitive way. Common challenges for builders include limits on what their supplier usually stocks and concerns about blowing out timeframes. Many builders lack knowledge of the issues in environmentally sensitive construction and/or alternative products; they often believe that alternative products inevitably cost more. The mentality "I've always done it this way" can also be a barrier to doing things differently.

Work out what you want in terms of environmentally sensitive construction, then discuss with the builder what is possible. Confirm all agreements in writing.

Identify what, if any, research you might do yourself. Negotiate roles, responsibilities and timeline with the builder.

Make sure the builder has the information they need. If you can't provide it, agree on a way for them to obtain it elsewhere.

Arrange extra checks along the way. Most critical of these is to check reflective insulation before exterior cladding and batts before plastering. If you don't know what to look for, consider paying an independent third party (such as a building surveyor) to come and check for you. This could save you thousands of dollars in energy bills.

If your contract is already underway and the construction is seemingly not as environmentally sensitive as you expected, call a meeting. Make sure you have prepared beforehand and be very specific about your concerns. For example, "I'm not happy with using Merbau decking. I said that I wanted to make sure we didn't harm the environment with this building and harvesting Merbau for decking is reducing habitat for orangutans." It helps to have constructive suggestions. For example, "I would prefer to use radial sawn timber decking boards. They are available from ..."

Decide on how much you want to enter into debate with your builder. They don't have to agree with your reasons for environmentally sensitive construction, but you are the client and if you made clear at the outset that this was important to you, then they have an ethical obligation to deliver the goods.

There will be compromises! Make sure the builder knows that you accept this, but also ensure that they know when you are compromising. This can make it easier to hold your ground on things that really matter to you.

From chug to whir
Farming, renewably, without diesel

On a recent trip to Tasmania, ATA's branch manager Doug Rolfe found something even more rewarding than the 'EV grin'.

I'VE been lucky enough to be involved in an ATA branch in Geelong working on converting petrol cars to electric drive. This has been very educational and exciting, but being exposed to electric transport forms something of an addiction—you start to look for possibilities for electric transport everywhere. Living on a small farm, the potential for electrification of farm machinery is an obvious candidate.

So, when I visited Ronald Winckel's organic farm in Barrington, Tasmania, I found something even more rewarding than the 'EV grin'—my first drive of an electric tractor.

As I'm used to larger 50-60 hp diesel tractors, the diminutive Allis Chalmers 'G' looked cute, but not particularly capable. However, its application to Ronald's need for an organic method of weed control was perfect. It quietly moved along the rows of healthy herbs with only a few squeaks and a gentle whir. Quite a contrast to my tractor which requires wearing hearing protection and chug-chugs along like any diesel motor of its age. Ronald's tractor accelerates quickly, but smoothly, and without any suggestion of being underpowered. Okay—I'm convinced!

Ronald's EV tractor forms a part of a broader holistic plan for his farm. From solar thermal herb drying to solar water pumping and the large PV array supplying the property's electricity needs (including the tractor's), Ronald is working towards a form of agriculture that finally brings the industrial revolution onto a sensible and sustainable path.

It struck me that the use of renewable energy technology in farming is the perfect extension to primary production itself. All farm production is based on the biological capture of solar energy!

Conventional farming practices in Australia have strayed far from a fundamental appreciation of that fact, relying instead on huge inputs of fossil-fuel derived pesticides, herbicides and fertilisers. The production of GMO 'terminator' seed technology is perhaps the final indication that we are losing the desire to farm based on solar-driven self-renewing cycles.

Ronald's conversion

A few years ago while researching community supported agriculture, I came across an amusing YouTube video from the folks at the Flying Beet Farm which featured an electric Allis Chalmers 'G' tractor (www.youtube.com/watch?v=vJUtTvZQGpM).

Ronald had also seen this video and purchased a kit from the Electric Vehicle Association of America to enable him to convert his beloved 'G', which he'd brought with him to Australia.

↑ The electric tractor—a conversion of an Allis Chalmers 'G'—is used for seeding and cultivating.

"Ronald is working towards a form of agriculture that finally brings the industrial revolution onto a sensible and sustainable path."

↑ The farm's large solar array (5kW) provides the electricity needs of the farm and tractor.

The 'G' is a lightweight tractor for seeding and cultivating with mid-mount and rear-mount implements. The simplicity of this machine makes conversion to electric very easy (no three-point linkage, rear PTO drive or front-end loader). The conversion involves unbolting the rear-mounted internal-combustion engine and then bolting on the electric motor with the supplied adaptor plate. Then you attach a frame to install the batteries, controller and other circuitry. Finally you put in the forward instrumentation and throttle sensor.

Coming from an electric car background, this is a very simple conversion!

When operating, the tractor draws around 50 amps (2.5kW), peaking at 150 amps (7.5kW). Ronald finds that he often gets around four hours of normal use per charge.

What does it mean for farming?

Some of the biggest costs for farmers are fuel and maintenance of equipment. Renewable electricity and electric-powered vehicles (with their low maintenance costs) provide a way to reduce monetary and environmental costs. While Ronald would agree that he has a long way to go to make his farm truly independent of fossil fuels, he's on the right path for sure!

If you're thinking of something bigger, then it's worth looking into Steve Heckaroth's EV tractors on the internet. It's completely feasible to have an electric tractor in the 60–70hp range (or larger) with all the 'normal' tools and implements that a general farm would require. As with electric vehicles generally, the initial outlay is high, but the system starts paying itself off immediately. ✱

Doug Rolfe is the ATA' s branch manager and a member of the ATA Geelong EV branch.

Resources

Ronald's Farm: www.marleenherbs.com
Huguenot Farm: huguenotfarm.com, www.flyingbeet.com/electricg
ATA Tassie North branch: community.ata.org.au/branches/tas-north-branch
ATA Forums: community.ata.org.au/forums
Electric Vehicle Association of America: www.evamerica.com/farm.html
Steve Heckaroth: www.renewables.com/Permaculture/ElectricTractor.htm, www.evalbum.com/216.html
EV parts suppliers: evworks.com.au, www.evpower.com.au

We've set up a webpage off the ATA Tassie North branch page with more photos and details on Ronald's tractor. There will be ongoing ATA discussion on the topic aimed at encouraging more interest and capability in exploring electrification of agriculture. If you have an electric tractor in Australia then we'd love to hear from you.

↓ The tractor's battery pack.

Conversion components

- Motor: Advanced DC Motor (6hp)
- Controller: Altrax AXE-4834 48V, 300A
- Instrumentation: ElCon fuel gauge, 200A ammeter and 50mV/200A shunt
- Fusing: 250A DC-rated fuse
- Potentiometer (throttle): PB-6 Curtis Potbox
- Contactor: Albright (12V coil)
- Charger: 48V, 15A
- Batteries: 105Ah (C5) Nor-Co wet lead acid and 12V auxiliary battery.

The underrated pet
Backyard chickens

Keeping chickens in your backyard can have many advantages, and not just for you, as Justin Brasier explains.

I ONCE heard about a man who recovered from serious depression after acquiring a small backyard flock of chooks. Observing the complex, often hilarious social hierarchy of his chooks as they foraged and explored his backyard gave the man a focus, helped him wrestle with his own inner demons and reminded him of the simple pleasures of life. His story is proof that eggs aren't the only benefit of backyard chook-keeping.

Chickens are indeed beautiful, giving creatures and while they may not have the same apparent therapeutic impact on you as they did the above-mentioned man, I promise they will change your life for the good and, in the process, transform your backyard in a productive and positive way!

As most backyard chook-keepers already know, chooks really do have their own personalities. We grow to appreciate this in our daily routine of feeding and egg collecting, or when we take a moment to observe them as they entertain us with their antics. One of the greatest motivations to start up your own flock of chooks is that they encourage you to actually venture into your backyard and experience your immediate outdoor environment.

Chickens are the ideal backyard companions and are truly giving pets. For a start they feed you—one to three hens will usually provide the average family with more than enough eggs. They are relatively easy to keep, although some thought and preparation is required for their overnight housing (more on that later). And chooks are not particularly needy. Unlike dogs, they don't have to be exercised daily nor like cats do they need to be constantly stroked and fussed over.

↑ Rosie and Daisy were both ex-battery chooks and made fantastic pets.

Sustainable 'pets'

Many of you who are reading *ReNew* are already trying to make a difference at home with your environmental footprint. Some will have water tanks, others solar panels; worm farms and compost heaps are also popular. Well, chooks can help complete the picture. In fact, chooks are also champion composters. Since I got chooks I have had next to no food rubbish. With the exception of citrus and potato and some vegetable peel and coffee grounds, all kitchen scraps are decimated.

Chook-keeping is becoming trendy. Normally, I'm not interested in the latest fads but I don't mind being on board this bandwagon. Maybe you've had a similar epiphany—well, you're not alone. There's a groundswell rejecting the multinationals who are dictating our food choices, and much of this movement is occurring in the suburbs. We seem to be returning to the ways of previous generations when keeping chooks was commonplace.

Keeping chickens in your backyard is more than a hobby; it's a more sustainable way of life! I would also like to believe there is a repulsion towards the way we 'manufacture' chicken meat for profit, and that people are reacting to the cruelty of the poultry industry. I was horrified when I learnt that the average hormone-boosted table chook lived only 8–10 weeks in a small cage, not once feeling the rays of the sun on their feathers. And in the egg industry, 'spent' hens and male chicks are routinely killed. How did we get to the stage where we devalue other animal life so much?

→ Miniature breeds like these Pekins are not much good for eggs (they are only 30 to 40 grams per egg), but they make excellent pets and they do far less damage to your garden than larger breeds. Many chook owners will include a rooster, like "Romeo", aka "Mister Roo" (back).

Getting started

Setting up a chook house need not involve big bucks. Okay, you can purchase a custom-built wooden chicken hut with run for up to $500. But you can recycle plenty of materials to build your own. I'm pretty useless with the hammer but even I managed to build a sturdy elevated chook house and separate run for less than $80.

I recycled wood from a mate's home renovation, bought new and secondhand chicken wire and found a discarded dog house with tin roof in good condition in which my chooks now lay their eggs and sleep safely at night. I cut out an area in the floor of the dog house for the chooks' 'drop zone'—they poo through the wire floor as they roost at night.

Chicken manure is another of the great benefits of backyard chook-keeping. After your birds have hoovered your kitchen scraps they then produce amazingly rich poo that is about 20 times more intense than cow manure. It can be made into compost over months or used as a liquid fertiliser (with a ratio of 1:4 manure to water). A warning—fresh chook poo is too strong in ammonia to apply straight away to your garden. Work the manure into a pile of dirt with leaves and grass clippings and let it dry for four to five months to produce fertilised soil.

Once you've decided to take the plunge into starting your own backyard flock, the next thing is to buy and source your chooks. Poultry is sold at markets, but how can you be sure you're buying a healthy chicken from a reputable supplier, and are you actually getting a hen and not a cockerel (young male)?

You shouldn't just rush into this purchase and buy the first available chook. When it comes to any pet you normally do some research, so why should it be any different for chooks, which can live for as long as a dog or cat. A great place to start your search is to spend some time tracking down a local poultry breeder, or a club or society devoted to specific breeds. A list for the latter can be found in the specialist poultry magazine Australasian Poultry. The Weekly Times newspaper also has chickens for sale in the classifieds section. Most poultry clubs have websites where you can find out more, while there are other poultry-oriented websites that offer chickens for sale.

Hybrids versus pure breeds

If you are primarily interested in backyard chooks for egg laying and are not fussed about pure-bred chickens, the best way to start is to buy a small flock of two or three hybrids. But if you want to show your bird off, and prefer impressive colours and shape, maybe hoping to be a competitor breeder at poultry shows, then pure or heritage breeds would be a good fit.

Pure breeds dominate domestic poultry keeping and show exhibitions, but if you want to guarantee high egg production, hybrids are the answer. Hybrids are commercial cross-bred chickens that have been produced specifically for eggs. I recommend them for the beginner because they can be easily tamed, are docile and family-friendly, and are inexpensive (about $15 for a point-of-lay 20-week-old pullet). Okay, they might be 'ugly ducklings' compared to the pretty pure breeds, but the humble hybrid delivers in spades when it comes to eggs—usually more

Save an abused chook

Buying ex-battery hens is not for the faint-hearted, but the rewards can be fantastic—just ask Melbourne's Jeff Hollis.

He bought six battery hens from a chicken meat processing factory one year ago for the grand total of just $18 and has had a steady supply of eggs since. "When one laid an egg in the car on the way home I knew I'd done the right thing," says Jeff.

While it may not be to everyone's taste, buying ex-battery hens makes you feel good and saves the life of a chook too. However, things can go wrong and sometimes birds will die suddenly. It may be a shock when you first see them too. Most of the hens look like porcupines without their feathers. However, with a little nurturing, sunshine and a diet of backyard vegetation and kitchen scraps, these chooks will regrow their feathers and develop muscles and coordination for life outside the space of an A4-sized cage.

Jeff's birds had about 50% of their feathers when he bought them. "There was just bare skin—I was worried about them getting sunburnt, but I wasn't going to put

sunscreen on them," he says.

Jeff is honest when he said his intentions weren't just to liberate the factory chooks—he was also motivated by the low cost of the hens. Jeff says, "I paid $18 for the lot. It usually costs that much just to buy one from a hatchery." But liberation is part of it. He adds, "I gave them lots of TLC, and now they're doing just fine."

Battery hens are usually 'turned over' after 180 days of egg production. If a chook cannot lay about one egg per day it is considered a commercial liability and is usually killed for food products including chicken stock.

than 300 a year in its first year of egg-laying.

Pure breeds just can't compete on numbers when it comes to eggs, but there is a twist in the tale. While popular pure breeds like Sussex, Rhode Island Reds and Leghorns may not reach such heights in egg numbers (they normally lay below 300 in the first year), they are more enduring. Indeed, hybrids like Isa browns are great egg layers over two to three years, but several pure breeds are known to keep producing beyond five years, albeit at a reduced rate.

You will probably need to venture out of the city to find breeders or poultry club members who can sell you a chook. Most of these people are reputable and are absolute chook lovers, so they will provide you with a great starting flock and won't sell you a dud. However, it pays to be buyer beware. Ensure that the chickens you are buying, whether chicks or pullets (females less than 12 months), are vaccinated. A healthy chicken will have bright eyes, glossy feathers and be active. A pullet won't have a big red comb and this will develop as she begins to lay. Check the chook's beak and avoid any that have a discharge. Watery eyes, droopy feathers and a dirty vent are all signs that the bird is not 100% healthy.

Beware the fox

Winter and spring are seasons when foxes are active; and unfortunately, chickens are fair game, especially if they are not securely housed at night. Foxes are very cunning and can squeeze through the tightest of gaps—under all that fur they are actually a lot smaller than you think. Foxes like to hunt under a full moon, and also like it when it is windy and wet—they are hard to hear when it's raining on your roof and blowing a gale. How do you combat them? First, closely inspect your chook coop for holes. Also, foxes can dig underground so it is a good idea to reinforce the enclosure with wire under the ground.

Chickens and gardens

If you think your perfectly manicured lawns and tidy flowerbeds can remain untouched with chooks around, you might be in for a shock. Chooks do not scratch gently and will see your vegie patch as the ideal place for a dustbath and to nibble at new shoots. If left unchecked even a small flock can turn a green garden into a brown moonscape within days.

Don't despair! Gardens and chooks can co-exist; they just have to be managed properly. If you want your chooks to free-range in the backyard, you need to protect your valuable plants and keep the chooks away from new plantings and the vegies. Wire mesh in the ground around plants and flexible fencing around the vegie patch are some of the best ways to do this. Encourage the chickens to make a mess where you want them to by giving them an area of rough ground with bare earth to forage in. A 2m high fence will keep them in nicely.

Chickens will change your life for the better, but remember they are totally reliant on you: you'll need to feed and water them, allow them room to exercise and protect them from predators (including dogs). But they are not an onerous pet: just a little attention and TLC and they will reward you handsomely. And if it means saving one more chook from a life in an A4-sized cage, that's got to be a good thing! ✷

For more information on backyard chook-keeping, check out Justin's blog: www.chookchat.com.au
Justin will also conduct beginner's workshops on backyard chook-keeping in Melbourne in September. For details, refer to his blog.

↑ Harry the hooter (right) and Millie are Plymouth Rocks, one of the less common breeds. They are hardy, smart, medium-to-large birds (Harry is around 6 or 7 kg). Millie lays eggs over 80 g regularly in the warmer months.

Suggested breeds

ISA BROWN

Most chooks you see in a neighbour's backyard or on a community farm are likely to be hybrids, which are the result of cross breeding, generally derived from Rhode Island Reds. The most common of these hybrids are Isa Browns. For most people these fit the bill—they are more vigorous and productive than pure breeds. They lay more than 300 eggs in their first year of production, and 150–200 in their second year, but their production noticeably drops off after that. They are used to humans and can be easily tamed.

There are ethical issues with choosing Isa Browns directly from a hatchery—as they have been bred for increased egg production, they have a good chance of suffering reproductive tumours and other diseases after a year or two. If you want Isa Browns, get rescued chooks!

RHODE ISLAND RED

A great beginner's backyard chook. Originating from the USA from crossing Asiatic fowls such as the Malay and Java, the Rhode Island Red is a hardy breed for prolific egg-laying. This soft feather breed is usually placid and friendly and loves the freedom of the backyard.

AUSTRALORP

You just wouldn't be patriotic if you didn't decide on adding a few of Australia's best-known pure breed to your flock. The Australorp is one of the best egg layers among pure breeds—one reputedly holds the record for producing 364 eggs in 365 days back in the 1920s—and they make good mothers and friendly pets. They are derived from black Orpington stock imported from England but this large bird has become an Aussie poultry icon.

BARNEVELDER

The Barnevelder is a medium heavy breed of chicken named after the Dutch town of Barneveld. It is a cross of 19th century Dutch landrace chickens with Asian breeds imported to Europe in the mid to late 19th century such as the Brahma, Cochin, Croad Langshan and Malay. They are hardy birds and good foragers and lay a good number of eggs.

Note: There can be a lot of variability within a breed, as some strains are selected for show rather than practical traits.
en.wikipedia.org/wiki/Chicken
www.backyardchickens.com

Oversizing PV arrays
How far should you go?

Oversizing your PV array compared to your inverter size can increase system output, but how much PV is too much? What can go wrong? Global Sustainable Energy Solutions looks at the issue and explains the ins and outs.

THE price of solar modules has dropped to the level where consumers are now looking for ways to increase their system yield without outlaying the costs necessary to build large systems.

Array oversizing refers to solar photovoltaic (PV) systems designed so that the solar array has a higher peak capacity than the inverter. Due to intrinsic losses (such as from the solar panels' thermal coefficient), a solar system of a given installed capacity may deliver up to 20% less than the nameplate rating of the array. If the number of installed modules is increased, the inverter's yield in relation to the PV array power output during times of low irradiance (e.g. early or late in the day or during cloudy periods) will increase.

Oversizing can be a cost-effective way to improve the system yield for a given inverter size. However, several questions need to be considered: is the existing inverter suitable for use on an oversized array? What impact will oversizing have on the inverter? What impact will oversizing have on system yield? And what impact will oversizing have on the hip pocket? To answer those questions, this article looks at the 'how' and 'why' of array oversizing.

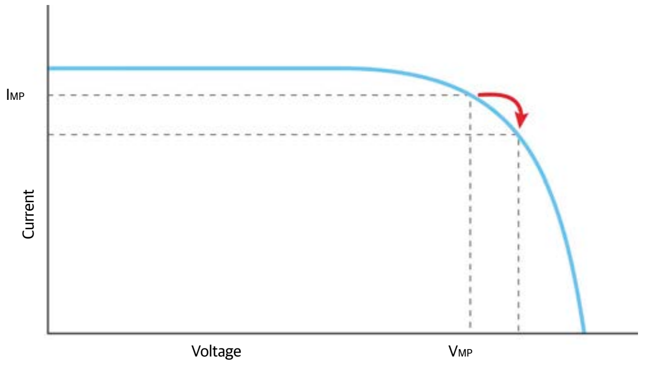
How the inverter does it

To connect to an oversized array, an inverter must be capable of limiting current flowing from the array. It does this in the following way.

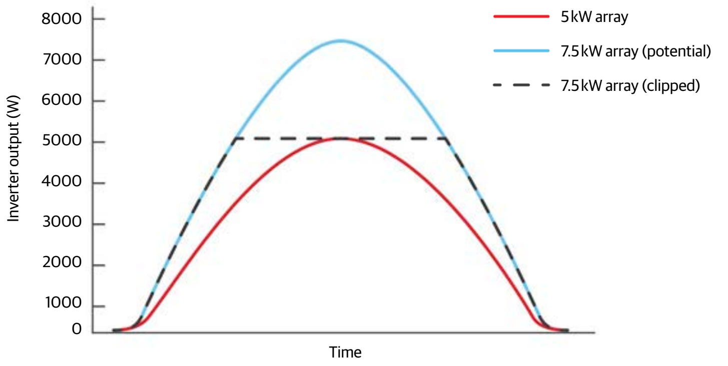
When the array current (I_{MP}) increases to greater than the inverter's maximum current rating, the inverter will increase the operating voltage of the array, thus reducing the current (to a value below I_{MP}). In effect, the array will be operating at a decreased efficiency and a sub-optimal voltage (above V_{MP}); this is shown in Figure 1. The inverter does not dissipate additional heat; the array is simply operated at a lower efficiency. However, it is important to ensure that the array's open circuit voltage does not exceed the inverter's input voltage rating; the inverter will be damaged if this occurs. Some inverters can protect themselves from currents greater than their specified range, but all inverters will be damaged from open circuit voltages above their specified range.

Impact of oversizing on the inverter

Oversizing is not a common practice, and not all inverters are capable of voltage shifting. As such, manufacturers may not honour the

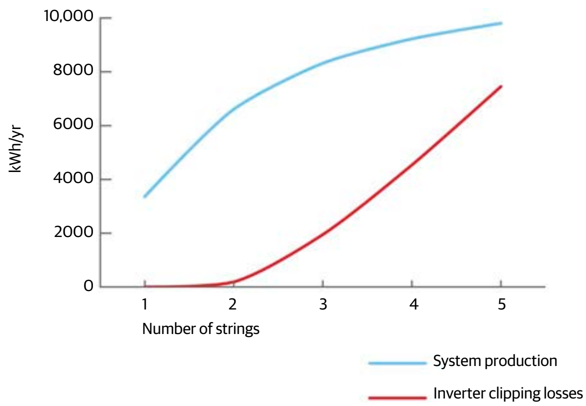


↑ Figure 1: IV curve showing different operating voltages for the array. If the inverter is suitable for oversizing, it will increase the operating voltage of the array, thus reducing the current. This will cause a net decrease in array power.

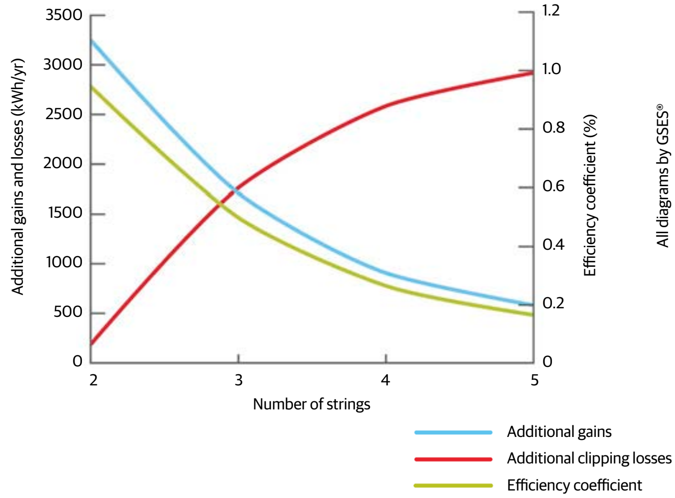


↑ Figure 2: Clipping effect when a 5 kW inverter is connected to an oversized array (7.5 kW, i.e. a 150% oversizing ratio). The area above the 5 kW line represents energy that is wasted.

↓ Figure 3: Sample production and losses of a system with 5 kW inverter and 2.4 kW strings. In this model, two strings represents an array that is closely matched to the inverter (4.8 kW).



↓ Figure 4: Additional gains and losses of a system with a 5 kW inverter once array size exceeds inverter size.



All diagrams by GSES®

warranty for a failed inverter that has been installed in an oversized system. Therefore, assurance (preferably in writing) should be sought from the inverter manufacturer stating their equipment is suitable for this application and that using the inverter in this way will not void the warranty. Many inverter data sheets list a maximum DC power. Clarification is required from the manufacturer as to whether this figure is a safety restriction on the inverter or the maximum amount of DC power that can be converted to AC.

Each inverter type may be affected differently when connected to an oversized array. In such applications (and assuming the inverter is capable of restricting its input current), the inverter will be operating at its maximum power capacity for a larger proportion of the time. This means that components within the inverter will also be operating at their maximum capacity for longer. There is a risk that individual components will age at a faster rate than anticipated, owing to higher component operating temperatures, and this may cause the inverter to fail earlier than expected.

To minimise potential adverse effects, it is especially important to install the inverter in a suitably cool and ventilated environment. Some inverters may be equipped with temperature sensors that can shut down the equipment in the event of overheating or regulate the operation of internal cooling in response to temperature variations. These are important aspects to consider when selecting an inverter for an oversized array. It is also important to note that the current CEC design guidelines do not allow the inverter to be undersized by more than 75% in relation to the array. Expressed in another way, under these CEC guidelines, the array cannot be oversized by more than 133% of the inverter AC capacity.

Impact of oversizing on system yield

By oversizing the array, the inverter will be operated at its maximum capacity for a larger percentage of time and the solar system will produce more energy during times of low solar irradiation. In effect, this will increase the amount of time the inverter is operating at nameplate capacity. The downside of oversizing is that, when solar conditions are favourable, the output of the array is 'clipped' and potential energy from the system is lost (see Figure 2).

Using a 5 kW inverter fed with strings of 2.4 kW (an array power of 4.8 kW: 96% of the inverter power), the maximum benefit of oversizing is realised with an array to inverter size ratio of 150% (i.e. 3 strings). Figure 3 indicates the increase in system yield losses as a result of the inverter clipping production.

When applying a sizing coefficient of greater than 150%, the losses from any additional strings will be greater than the incremental gain in production (see Figure 4), as for most of the day the array is potentially producing more current than the inverter can handle. The inverter's specifications should state what the maximum DC power input rating is for the inverter; if stated, this figure should not be exceeded. It is only during overcast and low-light conditions that the additional current is useful.

In effect, oversizing the array lowers the efficiency of each additional string, as the inverter will increase the operating voltage of the array above V_{MP} in an effort to reduce the array current.

Oversizing: a cost–benefit analysis

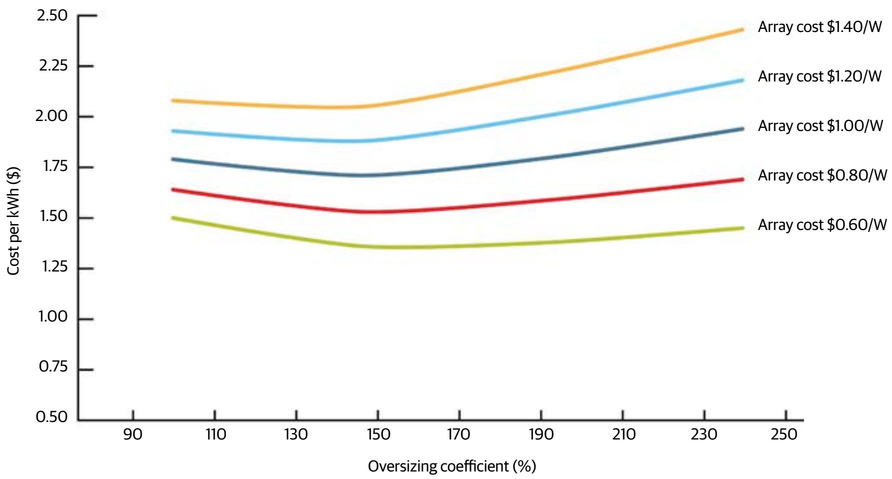
The cost-benefit analysis of oversizing is a function of array costs (in both materials and labour), inverter costs and other balance-of-system costs. Figure 5 shows the results of modelling various costs of the above system, assuming a static cost of $1.60/W for the inverter and balance-of-system costs, and array costs varying between $1.40 and $0.60/W. As can be seen for all costs within this range, the optimal cost-benefit point is around an array sizing of 150% of inverter rating.

"The cost-benefit analysis of oversizing is a function of array costs (in both materials and labour), inverter costs and other balance-of-system costs."

These assumptions are optimistic, as the inverter and balance-of-system costs will potentially decrease as the industry matures. Installation labour costs of the system will also increase with the scale of oversizing. The financial benefit achieved by oversizing relies on the solar array being much cheaper than other components of the system.

It is important to remember that the benefits of oversizing an array should be weighed against safety requirements and warranty restrictions and most importantly what the customer wants. ✱

For more technical papers and information on solar energy systems go to www.gses.com.au



↑ Figure 5: Cost of generation over a single year assuming various array costs. Inverter and balance-of-system costs are assumed constant at $1.60/W installation costs.

What happens when we unplug?
The economics of going off-grid

Recent ATA research explores Australia's 'unplugged' potential. Just how financially viable is it to go off-grid? And if it's not financially viable now, when will it be? Mischa Vickas explains the study's modelling and results.

Image: Off-Grid Energy Australia

← The research found that going off-grid is likely to be economically viable by 2020 for individual homes in regional areas (in certain cases)—and can be viable now for 500-home community projects.

WHILE rising energy prices are leading some to unplug their appliances, others are considering unplugging their homes and entire communities. In a new report, *What Happens When We Unplug?*, researchers at Energy For The People and the Alternative Technology Association have examined when it will become economically viable for households and communities to free themselves from electricity and gas networks using off-grid solar photovoltaic (PV) and battery storage systems—often called stand-alone power systems (SAPS).

Their report highlights the strong economic case for some regional and outer-suburban communities to unplug today, while noting that unplugging could be cost-effective for others by the end of this decade.

The story of solar PV should be all too familiar to readers of *ReNew*: prices have fallen by around 90% since 2009, and there is now over 3.2 GW of installed capacity across Australia[1] (equivalent to nearly 6% of total electricity generation capacity[2]), including solar panels on the roofs of 1 in 8 Australian homes[3]. Combine this with lithium-ion battery storage—the price of which is expected to fall 40% by 2020[4]—and you have the ideal ingredients to develop SAPS for single households or entire communities.

Why go off-grid? A key motivation is the increasing risk of the 'utility death spiral': as demand for electricity continues to fall, for reasons including behaviour change, energy efficiency and solar PV, distributors may be forced to increase prices in order to remain viable. The flow-on in higher retail energy prices drives consumers to use even less electricity. The end result is that centralised electricity generators (power plants) and distribution infrastructure (poles and wires) are increasingly becoming stranded assets, with the costs of keeping them alive passed on to consumers. And so the death spiral continues.

Modelling an energy transformation

In modelling Australia's unplugged potential (see box), the researchers used scenarios of typical Victorian housing types found in the inner-Melbourne suburb of Preston, the outer-Melbourne greenfield suburb of Werribee and the regional town of Bendigo. Victoria was chosen as a 'worst-case scenario' region—in most of the remainder of the country, due to better solar insolation and often higher grid prices for energy, the value proposition for SAPS would be more attractive.

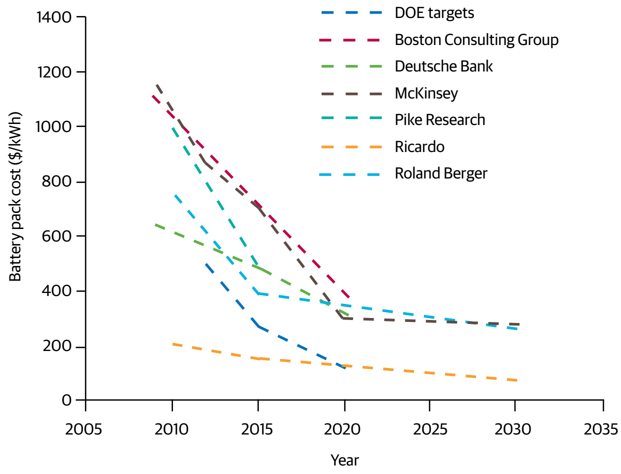
SAPS were modelled for both single houses and 500-home community projects in scenarios with and without access to mains natural gas. The cost of these scenarios was then compared with the 'business as usual' cost of sticking with centralised electricity and gas networks, including the expected energy price rises and potential upgrades that go with them. Scenarios considered economically viable were those where homeowners break even or make a profit within the 10 or 25 year periods modelled.

Economically viable today

There is good news for those in regional and outer-suburban areas of Victoria: going off-grid today via a 500-home community project can be cost-effective in the long-term. This applies for the regional scenarios with and without mains gas as well as outer-suburban scenarios with mains gas. Such projects could involve communities collectively purchasing local electricity network infrastructure and re-purposing it for a solar microgrid with the help of an energy services company.

In developing projects outside the metropolitan area, for example, each household could be over $9000 better off (in net present terms) after 25 years being off-grid

"Combine the fall in solar PV prices with lithium-ion battery storage—the price of which is expected to fall 40% by 2020—and you have the ideal ingredients to develop SAPS for single households or entire communities."



← Predicted fall in lithium-ion battery prices per kWh from a range of sources. All are predicting a steep decline by 2020!

than they would be if they remained with centralised networks[5].

The viability of such community-scale projects for both regional and outer-suburban areas is found in the economies of scale that community investment provides in relation to infrastructure, operation and maintenance costs. Although the majority of homes would require solar PV, only one in five to seven homes would require battery banks, with the ability to centralise any backup generation.

For a regional town such as Bendigo, the upfront capital costs for a home in a community project could be up to 50% less, and the operating costs up to 34% less, than installing SAPS for a single dwelling without mains gas[6].

Economically viable by 2020

While it's technically viable for many other Australians to go off-grid already, the research also shows that it will be only a few years before it is financially viable.

For those in outer-suburban areas (such as Werribee), 500-home off-grid projects in communities without access to mains gas can easily be viable by 2020, particularly where the cost of upgrading a deficient local electricity network is in the order of $8000 per household. In this scenario, wood could be used instead of natural gas or electricity for winter space heating.

Single homes in regional areas could also go off-grid from 2020 and be in a positive cash position after around 10 years, especially if electricity networks are already in need of augmentation to improve reliabilty. This scenario assumes that communities self-organise to bulk-buy SAPS infrastructure at wholesale costs, potentially financed through home loans.

Although it is more viable for entire communities to unplug than single homes, it was found that taking individual, newly built homes in outer-suburban areas (such as Werribee) off-grid from 2020 would be economically viable, if construction cost savings were achieved by reducing the average home size by 3% (about 9 m²) and occupants made behavioural adjustments (such as limiting energy use during the peak of winter)[7].

Unplugging in the city

The situation is less economically attractive for those in inner-suburban areas. Modelling of the Preston scenarios showed that unplugging single homes or entire communities is unlikely to be viable by 2020 for typical (i.e. average) energy consumption households.

Many houses in these areas do not have sufficient space to install SAPS infrastructure, and issues with particulate emissions in built-up areas limit the use of wood heating as an alternative to natural gas.

On top of this, the economic motivation for unplugging is limited by the lower cost of delivering gas and electricity to inner-suburban areas compared with greenfield and regional areas.

The situation is different, however, for very low-consumption households—for example, households that use in the order of 5 kWh per day and less (good news for efficient ATA members!). For these households, SAPS viability is likely to occur by (and potentially before) 2020, and would be further enhanced by more significant price reductions or innovations in SAPS technology than is currently forecast.

What did the model consider?

- typical size and energy efficiency of homes in Bendigo (regional), Werribee (outer-suburban) and Preston (inner-suburban)
- typical solar resource available at the locations
- energy efficiency measures (such as insulation and appliance upgrades) implemented to reduce energy demand before SAPS installed (e.g. in new builds, upgrade from 6 Star to 7 Star rating)
- where practical, wood heaters, electric heat pumps and electric induction cooktops installed for new homes or retrofitted for existing homes
- SAPS delivered by a professional energy services company (i.e. profit margins, labour and service overheads included).

SAPS design:

- photovoltaic (PV) array (combination of 3–8 kW for single homes and up to 456 kW for centralised array)
- lithium iron phosphate batteries and battery management system
- balance of plant, including inverter-charger/s and regulator/s
- backup from small petrol generator for single home scenarios
- backup from centralised diesel generators (possibly using biodiesel) for community scenarios
- electricity price rise of 3% p.a.
- gas price rise of 5% p.a.
- current PV retail price of $0.94/W
- current lithium-ion retail price of $350/kWh; $200/kWh by 2020 (7.5% p.a. price drop).

"For very low-consumption households—households that use 5 kWh per day or less, SAPs viability in urban areas is likely to occur by (and potentially before) 2020—good news for efficient ATA members!"

Bright present, promising future

Unplugging homes and communities would to some extent transform the current energy system from a centrally planned and controlled market to a model where generation, storage and control of energy occurs at least partially on a local scale. The installation of SAPS across communities, especially in regional and outer-suburban areas, could provide greater energy price certainty for those consumers. Community projects could also be designed such that customers pay for a combination of energy services (such as space heating, hot water and electricity) and not just energy volume. This means that improving energy efficiency would not necessarily undermine the business model of the energy services company—as it currently does for utilities—so long as the services are required.

The research also highlights a number of barriers to going off-grid. For example, the management of a community project by a single company could remove competition and limit choice, potentially compromising consumer protections and creating difficulties if customers fall behind on their payments, become dissatisfied, or the company becomes insolvent. As well as this, consumers may be comfortable being part of a centralised network, and may not necessarily make the decision to unplug, even if the financial incentive is there.

The future of unplugged homes and communities, however, could be even more promising than predicted from this research. Though only a Victorian case study was used, the state's cool climate, relatively low solar resource and relatively low energy prices mean that going off-grid in other states is likely to be even more viable. Further, while the report assumes conservative decline in battery storage costs, prices may be more likely to replicate the more dramatic experience of PV over the past decade. This could be driven by policy developments, such as the battery storage subsidies and targets in Germany, Japan and California, as well as technological innovations such as the Tesla Gigafactory, a planned $5 billion lithium-ion battery factory set to be the largest of its type in the world.

In asking 'What happens when we unplug?', researchers at EFTP and the ATA have highlighted one path to cheaper sustainable energy using SAPS. The technology exists, as do the economic incentives, for many Australians to unplug. A key factor currently emerging is the community drive to transform Australia's energy sector, whether it be by unplugging from the grid individually or via community-based microgrids, or via community energy projects. ✱

Mischa Vickas is a recent graduate in chemistry and geography, currently volunteering for Beyond Zero Emissions (BZE) and undertaking an internship at Bush Heritage Australia.

Read the full report at www.ata.org.au/ata-research/towns-and-estates-could-unplug-from-the-grid-report

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Top tips for wood heating

Heating off-grid homes is often done with wood, as in some scenarios in this report. There are pros and cons to using wood for heating, but if you are going to use wood, here are some tips to make it more sustainable and efficient, and minimise pollution.

1. Source your wood as sustainably as possible, such as fallen timber from your own property, recycled timber (untreated), sugar gum (preferred over red gum), or eco logs made from recycled content such as paper or sawmill waste. See www.foe.org.au/firewood for more information.
2. Wood should be dried for as long as possible—at least six months including summer is a good drying period to aim for. Never burn 'green' wood that has been recently cut from a living tree.
3. Never burn treated timber as it produces toxic fumes and ash.
4. To keep smoke (particulates) to a minimum, do not overload a wood heater and keep the air damper open to enable the wood to burn cleanly. If it burns too fiercely then use smaller pieces of wood more regularly. Loading up the firebox and turning the air damper down overnight is a common practice, but very polluting!
5. Buy the most efficient heater you can afford. Multi-stage slow-combustion heaters make the best use of the energy in wood.
6. Never burn in an open fireplace—over 90% of the fuel's energy is lost up the chimney.
7. Maintain your wood heater by regular cleaning and have the flue cleaned every year or two.
8. You might want to invest in a wood-fired boiler such as the Pivot Gasogen wood boiler. A boiler gives you hot water as well as hydronic heating, and advanced units do most of the work for you while making the most of the wood.
9. Wood heaters can be fitted with a cool-air intake to improve efficiency. An example of such a retrofit appeared in *ReNew 123*.

Energy independence
The power of microgrids

Why is there a lot of research and commercial interest in microgrids right now? Mitchell Lennard explains.

Image: Wind & Sun Ltd, UK (www.windandsun.co.uk)

↑ These wind turbines are part of the Scottish Isle of Eigg's microgrid, which provides around 85% of the island's electricity needs from renewable energy, including wind, PV and hydro.

THE term 'microgrid' covers a large range of energy system architectures. Researchers with a background in utility-scale electrical engineering tend to refer to any system smaller than, for example, the Victorian state grid, as a microgrid. At the other end of the scale, many designers see remote area power systems (RAPS) as the best representation.

The Microgrids at Berkeley project, one of the centres of excellence in this area of research (building-microgrid.lbl.gov), uses the following definition.

"Microgrids are electricity distribution systems containing loads and distributed energy resources (such as distributed generators, storage devices or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded (disconnected from the grid)."

This definition covers a wide range of system capacities and technologies. It certainly covers the sorts of systems that ATA members have been perfecting over several decades. It could even cover power systems in ships and aircraft.

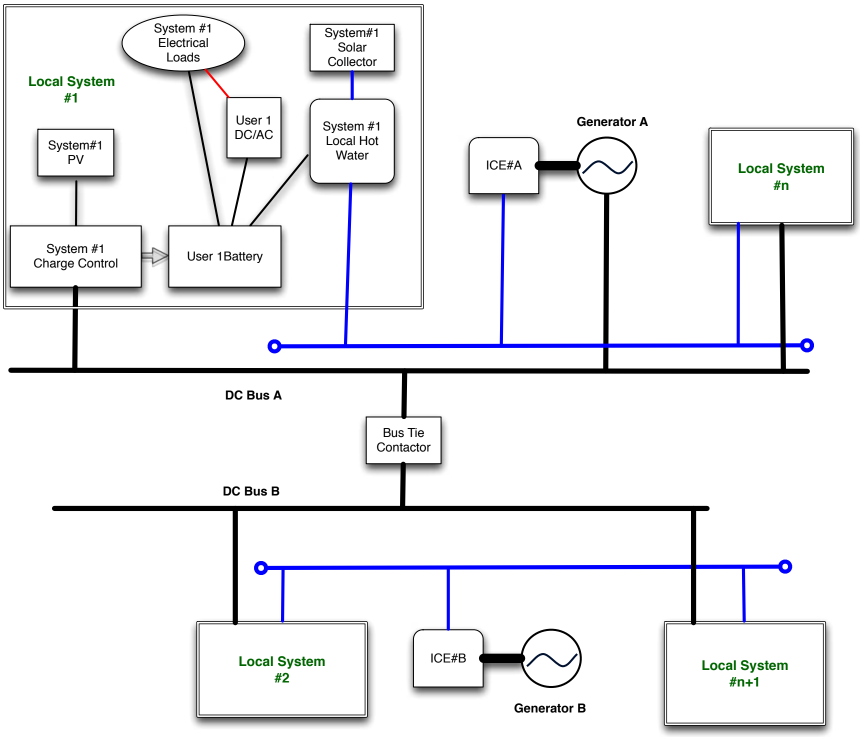
The main reason there is growing interest in microgrids is that many of the generating technologies referred to as renewable (think PV, small wind, small hydro, solar thermal, wave) are all suited to and in some cases best used in microgrid or distributed energy system configurations.

The 2009 CSIRO report *A Value Proposition for Distributed Energy in Australia* concluded that: "In general, distributed generation appears to be an effective early action greenhouse gas mitigation option for Australia when it is considered within a portfolio of other mitigation options...but before distributed energy achieves wide-scale uptake, technology and market development needs to be focused on reducing costs and improving reliability."

This notion that distributed energy systems and microgrids are a quick way to get greenhouse advantageous renewable generation into the energy mix is the main driver for most microgrid development work presently underway.

While it is possible to categorise microgrids in a range of different ways (have a look at the Berkeley site for one such set of definitions) the main projects running around the world can be seen as falling into two broad categories: campus-scale and remote-area microgrids.

Campus-scale optional grid-connected microgrids—I have called these 'campus-scale' because in many places around the world researchers are transforming their university campuses into living, real-world laboratories. These systems tend to use a lot of PV, combined heat and power (CHP) systems (usually gas-powered), some battery storage and perhaps wind (or wave) generation. All these generation sources are coordinated by an intelligent control system that decides when the microgrid should import power from the grid, export power or disconnect and operate in 'islanded' mode. Large commercial facilities such as hospitals and prisons that have a large hot water requirement are adopting such architectures in the hope of not only reducing energy costs but, if possible, making money by exporting energy at peak times.



↑ A typical schematic for an Urban Islanded Microgrid (UIM) system. The system manages total energy supply and storage (electricity and hot water) to a small cluster of houses, operating as a stand-alone system.

Another early and enthusiastic adopter of these microgrid architectures is the US Department of Defence. The US DoD is interested both in cost reduction (their significant base infrastructure is one of the largest energy users in the USA) and security; they want to be able to keep operating if the main grid goes down during natural events or in times of conflict. There is a great deal of innovation being funded by the DoD that will make its way into the commercial microgrid energy market over the next decade.

Remote-area (diesel-replacement) village-scale microgrids—Unsurprisingly microgrids are being extensively investigated and deployed in remote areas, beyond the grid. Most of these microgrid projects start out as diesel generator replacement, but that's about the only thing they have in common. This sector has a remarkably diverse and interesting range of technologies being trialled. Usually they include PV and battery storage combined with the existing diesel gen-sets, but that's just the beginning. From wind and wave generation in remote Scottish islands (for example, the wind/PV/hydro microgrid pictured in the Isle of Eigg), to village-scale pumped hydro storage in Chile, these projects are investigating all manner of existing and new technologies to meet a diverse range of community energy needs.

Indicative of this style of microgrid is the King Island Renewable Energy Integration Project (KIREIP) (www.kingislandrenewableenergy.com.au). Over 10 years the project has trialled technologies building on a traditional AC distribution backbone. The present configuration incorporates wind turbines, a utility-scale UltraBattery storage system, bio-diesel generation, tracking solar PV and an innovative flywheel-based UPS-diesel set, all tied together by a control and monitoring system (confusingly referred to as a smart grid). Recently this system supplied all of King Island's needs for 125 hours (five days) without the gen-sets being needed.

Systems like KIREIP are building a significant body of real-world experience that will soon start flowing to communities. As the cost of maintaining the existing rural distribution system increases, cross-subsidisation to edge-of-grid communities is rolled back and the price of technologies keeps falling, it is likely that many more remote and not so remote Australian rural communities will look to microgrids, like the KIREIP, as viable energy alternatives.

Cost competitive

What both of these categories of microgrid projects are demonstrating is that it is possible to design and operate microgrids that can supply energy at similar prices to the existing 'monolithic grid'. The days of microgrids being high-cost alternatives used only where the grid can't reach are over. Many systems are already cost competitive and this situation improves year on year.

My research

Working in microgrid research, I am constantly amazed and encouraged by the diverse range of technologies, the new architectural concepts and innovative commercial arrangements that are being explored by the microgrid community. My project, while nothing out of the ordinary, illustrates the sort of research underway and the questions being explored.

My project, hosted at RMIT University in Melbourne, is investigating design optimisation of urban islanded microgrids. I have chosen urban islanded grids since they raise a number of issues not readily apparent in RAPS style grids. Most importantly, they drive me to come up with solutions that can provide cheaper energy than the existing grid (or the grid in five years time!).

Design optimisation is a mathematical approach to establish the best configuration of a system (size of batteries, size of PV array etc) and the operating rules. Where most RAPS designers might use rules of thumb to establish a battery size, based on system load, depth of discharge and cycles per annum, design optimisation techniques use more complex mathematical approaches. The optimisation aspect involves finding the best possible design to ensure the minimum cost of energy over 25 years or the least CO_2 emissions or perhaps the best possible combination of both.

My research uses a reference system based on PV, solar hot water collectors, hot water storage and battery storage at each household, with every four to eight households sharing two DC generators powered by diesel engines and connected by a dual-DC bus system

Images: Wind & Sun Ltd, UK

↑ The microgrid on the Isle of Eigg uses a bank of 12 SMA Sunny Island 5048 off-grid inverters and a Rolls 212 kWh, 48 V battery bank for storage.

and a hot water reticulation system. Several houses share one diesel generator and the hot water generated from the diesel. The whole microgrid would have a common control and monitoring system. In common with many microgrid projects, my reference system does not introduce any new technologies. The high-efficiency diesel engine and CHP technologies are new to Australia but are in use in Germany; the lithium-ion battery is new but not a developmental item and the DC bus architecture, while unusual in the utility sector in Australia, would be very familiar to anyone who has worked on a twin-engine aeroplane.

A new aspect to my project is the detailed integration design and the operating rules. Traditionally in many RAPS systems, batteries charge and discharge within fixed limits and diesel generators are load-following or they start based on battery state of charge (SOC) limits. In the Urban Islanded Microgrid (UIM) designs, generator run times and battery discharging are based on analysis of the weather and its impact on the energy requirements. This system may choose to discharge the battery very deeply during a predicted weather event, such as three or four consecutive cloudy days, taking into account the impact this will have on cost over the 25-year lifecycle.

The initial results show that often the system elects to start the diesel to make hot water, with electricity a secondary consideration. The analysis shows that over the 25-year design lifecycle it is possible to get the cost of energy below 30 cents/kWh and we are confident of coming close to our 20 cents/kWh target over the next few years. We will have a single house prototype running toward the end of the year. In Victoria there is a potential 80% reduction in CO_2 impact per household available from the UIM system.

Adding new technologies

Like many existing microgrid projects we have a long-term plan to slowly incorporate new technologies as they mature. The UIM reference architecture uses a bio-diesel engine but this will migrate to new technologies (bio-gas, hydrogen?) when those technologies can meet the economic criteria. We will investigate compressed-air storage or steam storage. New developments in PV technologies will be assessed. This is another exciting advantage that opens up with microgrid architectures; we are not committing to a single technology solution, but can constantly evolve designs. The systems we deploy in 10 years time will incorporate different technologies than today's systems. The batteries in today's systems are predicted to last about eight years and, if an economically superior option becomes available by the end of that eight years, the design can be changed during the required mid-life maintenance.

One of the reasons we chose the 'urban' constraint is that it forces the project to confront some of the social, commercial and economic issues that come with the move to microgrid architectures. The UIM is at its most efficient for 8 to 12 domestic households, but those houses need to all be physically adjacent. This means the UIM microgrid needs eight neighbours to agree and cooperate! Such issues mean our project is looking at more than just the technical issues. For example, we plan to study how to address these social issues and how this will flow into the commercial structures that could be used to support the microgrid deployment. Around the world microgrid research is about a great deal more than the technology, which in many ways is the easy part!

Finally, our microgrid work is about more than just shutting down brown-coal-fired power stations (though that would be very satisfying). Around the world it is estimated that two billion people have no access to electricity and perhaps another billion have unreliable energy for only a small percentage of the day. If you don't already have a monolithic grid then a microgrid is the quickest, most cost-effective and sustainable way to provide electricity along with the significant increase in quality of life that comes with access to reliable cheap energy.

It will come as no surprise to many ATA members that the technologies that they have championed for many years are now proving to be a significant part of our future energy solutions. Microgrids are making technologies that were once seen as alternative, mainstream. Perhaps in time the Alternative Technology Association will need to think about a name change. *

Mitchell has 30 years design experience in aerospace engineering and is now investigating how to bring aerospace design analysis to small power system design.

Local energy is reliable energy
The resilience of microgrids

The need for reliable energy is driving microgrid development in the USA, and paving the way for smarter, cleaner, community-based energy here in Australia. Kristian Handberg shares his latest microgrids research.

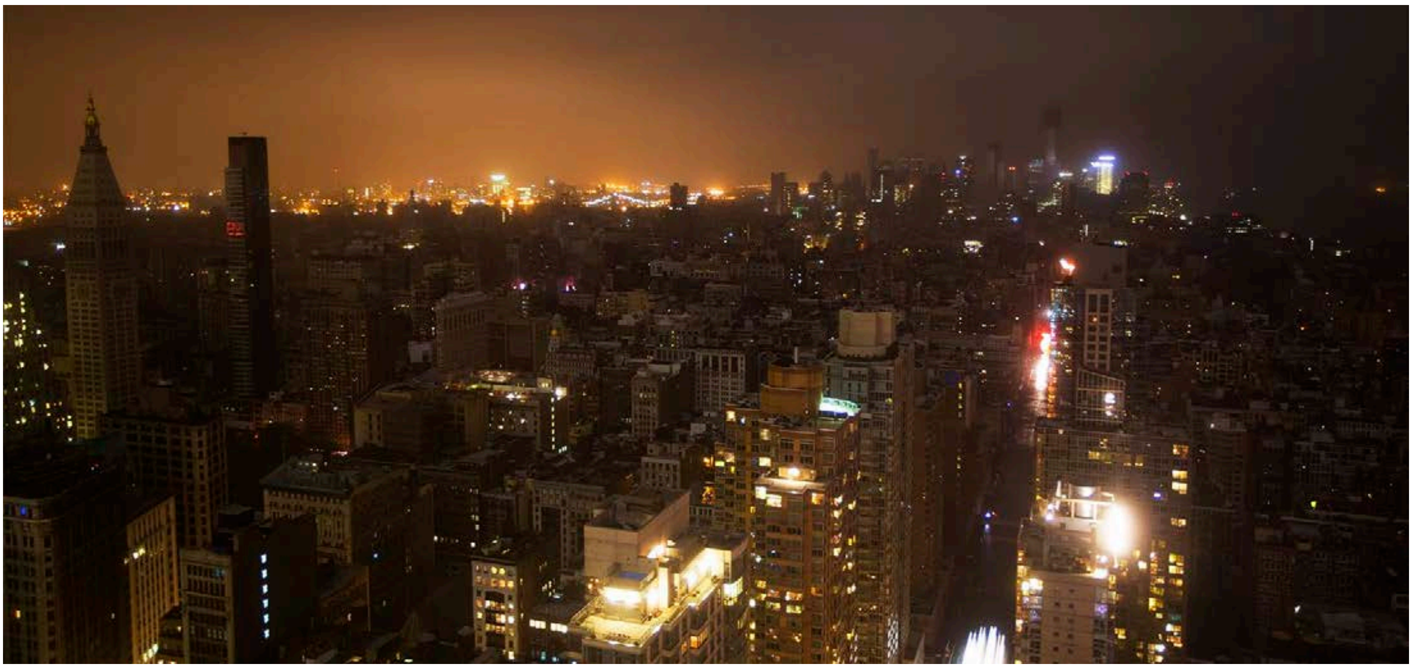


Photo: Kevin Deamandel

↑ A power outage in Lower Manhattan, New York, following Hurricane Sandy in 2012.

HOW would you feel if you lost power for days or even weeks, when your electricity provider knew it was likely to happen but did very little to avoid it?

For many in the USA, this is exactly what happened in 2012 after Hurricane Sandy. In response to this and other natural disasters, many communities and businesses in the USA are pursuing local energy solutions. Microgrids—as described elsewhere in this edition of *ReNew*—are being promoted by US policymakers and adopted by end-users as a means of improving energy system resilience.

These efforts are focused on hardening the grid and reducing the impacts of events such as extreme weather[1]. By way of an example, power outages caused by Hurricane Sandy in October 2012 cost an estimated US$14–26 billion and resulted in 50 deaths[2].

Microgrids can be used to strategically fortify critical infrastructure such as hospitals, police stations, public shelters and emergency response facilities, giving them the ability to disconnect from the main grid in times of widespread outages.

Investments to promote system resilience are also aligning with cleaner, smarter energy objectives. Projects are increasingly incorporating renewable energy, as a result of both sustainability concerns and reductions in technology costs. Such decisions reflect the ability to tailor microgrid design and operation to specific customer needs, in contrast to the 'one size fits all' approach in the traditional grid.

For corporations, resiliency translates to business continuity. With the cost of unplanned outages necessitating uninterruptable or backup power sources, the wider benefits and decreasing costs of microgrids are increasing their appeal[3].

In addition, the peak demand charges that apply to large electricity users provide an incentive for increasing levels of self-sufficiency, boosting the financial argument for commercial microgrids. Data centres—large energy users that may access cost savings by switching to direct current (DC) power systems—have been identified as an early market application for microgrids.

"Microgrids can be used to strategically fortify critical infrastructure such as hospitals, police stations, public shelters and emergency response facilities, giving them the ability to disconnect from the main grid in times of widespread outages."

The situation in Australia

So what of Australia: is our electricity system resilient?

Our system vulnerabilities have already been exposed. On 16 January 2007, around 690,000 Victorian electricity customers (including 70,000 businesses and public infrastructure services such as transport, telecommunications and health care) experienced electricity supply outages caused by a fire near transmission lines[4] in the northeast of the state. Despite there being no direct loss of life and just seven homes lost to the bushfires themselves, the economic impact on the state from the supply outages alone was estimated at $500 million.

And it doesn't end there. The community ability to respond during the 2009 Black Saturday bushfires was severely hampered by loss of power[5]. In Queensland around 200,000 people lost power after Cyclone Yasi in 2011, while some residents lost power for up to four weeks after Cyclone Larry in 2006.

Actions to address these vulnerabilities have been slow and largely superficial. In 2010 the Australian Government released a national Critical Infrastructure Resilience Strategy that is based mainly on information sharing. A request by distribution network operators in Victoria to address climate risk by upgrading components of the network was declined by the Australian Energy Regulator, who were unpersuaded by the companies' submission[6].

With the long lead times in electricity network price determination and infrastructure investment, it seems we are some way off from increased resilience being provided by the system operators.

Instead, responsibility has largely been passed on to electricity users themselves. As the leader of the energy sector group for the Critical Infrastructure Resilience Strategy, the Australian Energy Market Operator advice on preparing for power interruptions[8] is to create a business continuity plan and install backup power supplies where appropriate.

Guidelines currently prevent network operators from providing services such as microgrids; the review of these guidelines has been deferred despite the Australian Energy Market Commission recommending their revision[9].

As in the USA, the path forward therefore seems to be one of customer action.

Australia has many examples of microgrids in isolated or island communities with power systems described as off-grid, stand-alone or remote. Resilience may serve as the bridge for this experience to be applied to existing grid-connected renewable energy investments, and in doing so hasten the move towards smarter, cleaner, locally produced energy. ✱

Kristian Handberg is a principal consultant with Melbourne-based cleantech start-up Percepscion. He is currently completing a research project on the topic of microgrids courtesy of a George Alexander Fellowship, with the report to be released in mid-2014.

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↓ Alan Rubacha from Wesleyan University inspecting part of the infrastructure used in the first project to be finished under Connecticut's microgrid program.

Photo: Patrick Raycraft

Wesleyan university microgrid

In March 2014, Wesleyan University in Middletown, Connecticut, commissioned their microgrid into service. The first site to be launched under the state's microgrid program, Wesleyan is also a designated emergency shelter and distribution facility.

The microgrid project added a 676 kW gas-fired combined heat and power (CHP) plant and interconnection to the university's existing infrastructure, including a 2.4 MW CHP plant, three solar PV systems totalling 250 kW, and two geothermally heated student residences.

It has provided Wesleyan with one of the most environmentally friendly college campuses in New England, a region that includes Harvard, MIT and Yale.

Alan Rubacha, Wesleyan's director of physical plant, says that, although the microgrid was the culmination of a long journey in distributed energy, energy efficiency and demand management, resiliency became a priority as a result of their loss of power during a huge snow storm in 2011. "We lost power and it was a big deal. We had 4000 students in residence with nothing to do, in the dark for three days. We're responsible for those students. So resiliency suddenly rose to the top of our list."


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Know your renewables
Off-grid basics

With reducing grid reliability and steadily increasing electricity prices there's been renewed interest in giving energy companies the flick. Lance Turner takes a look at the how and why of going off-grid.

MOST people never think about their electricity supply until it isn't there. Most blackouts are short-lived events caused by car crashes or fallen tree limbs and are, at most, an annoyance. But what if your electrical supply disappeared for days, even weeks?

Anyone who has experienced a natural disaster knows that an extended power outage can have serious consequences. For instance, you might be dependent on a bore pump for your water supply or for pumps in a bushfire, or you might be in the depths of a cold winter and find yourself without heat.

Even if you are an optimist and believe that such an event won't happen to you, there are still other reasons to get off the grid.

↑ A typical AC coupled off-grid system. The battery bank is on the left, the yellow box is the inverter/charger and the red box is the grid-interactive inverter.

Energy independence

It's not just the thought of days without electricity that makes people think about becoming their own energy generators. Another incentive is the variability of energy prices and the steady transfer of costs towards the fixed component of energy bills—so even energy-conscious people are receiving high bills.

Being responsible for your own energy also means that you are more aware of your energy use. Additionally, the sense of being independent for your energy needs and generating energy from renewable sources such as solar panels instead of using grid power from dirty generation sources can be enormously satisfying. One comment I have heard repeatedly over the years is just how good it feels to be independent of the big generators and retailers.

And, of course, for many remote properties the cost of connecting to the grid may be higher than installing even a large independent energy system. In those cases, there's simply no reason to connect to the grid.

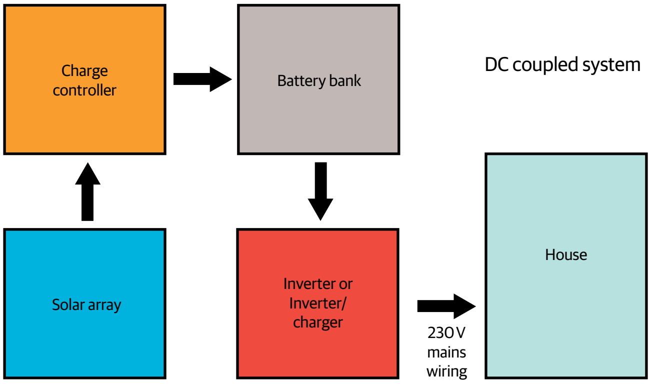
There are some disadvantages to being off-grid. The most obvious is that you can only use the energy available from your generation system. Use too much and your system will run down and simply shut down from low battery voltage. If you have a backup source of energy such as a petrol, diesel or even steam-powered generator (yes, they do exist, such as those from Strath Steam, www.strathsteam.com/page6.html), then you are truly independent.

There is also the system maintenance required, such as battery electrolyte level checking, although with sealed batteries this chore has disappeared. Modern systems can have very low maintenance requirements until the components reach end of life.

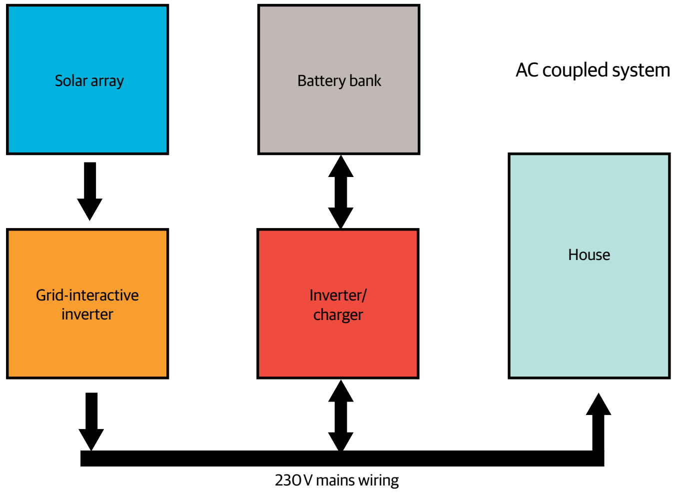
One point to note is that you can legally disconnect your mains-connected house from the grid without having to pay any further service fees. You just call your electrical retailer and ask for a disconnection, although you may need to give a reason, such as renovating or moving out, to avoid them arguing the point.

Economics

While we should also look at the economics of going off-grid compared to staying grid-connected, comparisons are difficult as the cost of renewable energy equipment is steadily decreasing, while grid power prices



With a DC coupled system, the solar array charges the battery directly via the charge controller. The inverter creates 230VAC for the house, but all of the charging side is DC. If a genset is used it is either a DC output unit, or an AC output unit that charges the batteries via a battery charger. In this case, the inverter is often replaced with an inverter/charger to simplify the system and allow the house to run directly from the genset when it is running.



In AC coupled systems, all energy inputs and outputs are done on the 230VAC bus. Energy from the solar array is immediately converted to AC and fed into the bus. The inverter/charger controls all flows of energy into and out of the battery and into the home for use in appliances. Extra charging sources are simply coupled onto the AC bus. AC coupled systems can reduce cabling costs as no heavy DC cables are required. However, should the inverter/charger fail, the whole system ceases to function.

are increasing for many people.

However, a typical example might be an energy-efficient house that uses 5kWh per day on average. The energy cost at a fixed price per kWh of 28 cents is $1.40 a day or $511 a year. Add to that the fixed supply charges (we pay $1 per day here in Tasmania) and you could be looking at close to twice that.

A quick look around shows that an independent energy system that can supply 5kWh per day will cost around $20,000 to $30,000 dollars, depending on equipment used. At first glance, taking a grid-connected house off the grid is not an economic proposition—especially as the batteries need to be replaced every 10 years or so.

But there's more to this equation, including the aforementioned advantages of independence from large energy companies, potentially greater supply reliability and the fact that mains electricity is likely to steadily increase in price, while the cost of renewable energy equipment has steadily decreased (although less so for batteries). See 'The Economics of Going Off-grid' on p. 34.

The three parts: generation, storage and conversion

Almost all independent energy systems have three basic sub-systems: energy generation, energy storage and energy conversion.

Generation includes photovoltaic (solar) panels, wind and water turbines and generator sets.

Storage is almost always in the form of a battery bank—be it flooded lead-acid, sealed lead-acid or lithium (there are some other chemistries, but these are the most common).

There are two methods of 'coupling' generation sources to the battery bank—AC and DC coupling. To see how they work and the components involved, see the diagrams above.

With a DC coupled system, there will be a charge controller that controls the energy flow into the battery bank from the solar array and prevents battery overcharging. If the battery is a lithium chemistry, it will have a battery management system (BMS) that may be part of the battery itself, or may be external to the battery and replace the charge controller. In AC coupled systems there is no separate charge controller; battery charging is controlled by the inverter/charger.

Energy conversion occurs differently in DC and AC coupled systems. In DC coupled systems, there may be no conversion at all (using energy straight from the battery bank in DC appliances) or it might use an inverter to convert the DC from the batteries to 230VAC for conventional appliances. In an AC coupled system, the PVs feed at least one grid-interactive inverter that converts the DC from the panels to AC; an inverter/charger then controls the flow of energy into the house and into/out of the batteries.

For systems using an inverter, it is common for the inverter or system control gear to sync backup sources such as gensets to the inverter output, so that the changeover to supplementation from backup sources is completely transparent—the system operates just like you are running from the mains grid.

Doing it

So, you've weighed up the pros and cons and have decided that going off-grid is right for you, but you're not sure what the next step is.

ENERGY AUDITING

Firstly, you must know your entire energy requirements, including any water pumping systems, and you need to know how those requirements vary throughout the seasons. For instance, in cold climates, energy use tends to climb in winter as water heating requires more energy to reach required temperatures and many people will use electrical heating for devices such as electric blankets, small personal heaters and the like.

Water heating is often done using gas or solid fuel boosted solar, but it's not unreasonable to use a high efficiency heat pump (or an electric-boosted solar system, depending on your location) for hot water. Resistive heating is very energy hungry and not suitable for use with an off-grid system unless the system has a lot of excess capacity.

Provided the performance issues of the house envelope (insulation, draught sealing etc) have been addressed, it is possible to use high efficiency reverse-cycle air conditioning for heating and cooling. However, it is very important to know how much energy an air conditioner is likely to use, and to allow for that extra generation required when sizing the system—especially the solar array, and especially for the winter months.

Electric cooking is also possible, at least for the cooktop, but again, you must have a realistic estimate of the energy required, especially in winter when more meals are cooked. Lighting loads also increase in winter due to the longer night-time hours, so all of this needs to be understood and allowed for. For more information, see box "Which loads can you run?"

SIZING

If you plan to have no genset backup (and with the low cost of solar panels, more systems are being oversized purely for this reason) then your system must be able to provide the highest likely loads for extended periods of low solar input without excessively discharging the batteries. The system size will depend on your loads and geographical location and typical local weather patterns and is beyond the scope of this article, but these factors must be calculated if your system is to be successful. One thing you may want to consider is optimising solar panel tilt for maximum winter output, particularly when you're building a new house and can adjust the roof design.

For help on sizing your battery bank, see the battery sizing article in *ReNew 123* or talk to a qualified renewable energy designer/installer.

Many people actually adapt to their system's capabilities, rather than expecting the system to be able to provide all needs at all times—if the batteries are running low, owners with such attitudes will simply go into energy conservation mode, using fewer appliances until available energy improves. It's actually not as scary as it sounds, and gives you an appreciation of the energy you use.

CUSTOM DESIGN OR OFF-THE-SHELF?

There are two ways to design a system. The first is a completely customised system using individual components, all sized to suit your needs. The installer then assembles the system on-site or may pre-assemble some sections such as the power panel (which will usually contain the switchgear, circuit breakers and other smaller components).

The other method is selecting an off-the-shelf 'system in a box' which may contain everything required except the generation source. The box is installed on-site, the PV panels or other generator installed and connected and the system is ready to go.

The latter method only works if your requirements fall fairly closely within the parameters of a particular pre-configured unit. Some people will find their needs are easily met this way, but many people won't and will require a fully customised system.

Many installers have pre-sized systems capable of providing a particular amount of energy per day. By pre-configuring systems they can often offer them at a lower cost than a customised system, so shop around: you might find someone offering exactly what you need.

Most people will hire a local solar installer to design a system for them, but it can be helpful to understand the reasoning behind the various aspects of the system design to avoid potential problems later on. You must make sure the installer knows about all of your energy use, including potential increases from planned appliance upgrades or regular visitors. One installer notes that you need to allow for increased usage as children become teenagers!

"One installer notes that you need to allow for increased usage as children become teenagers!"

Once they have all the facts, the installer will probably ask you about some system specifics, such as whether you want an AC coupled or DC coupled system, which battery chemistry you want to use (many installers will only have worked with lead-acid, so you may be restricted on this), potential solar array oversizing for periods of low solar input (to reduce or eliminate the need for a backup genset) and possibly other factors. If you get no feedback from the installer, just a quote with little information, start asking questions!

BATTERIES: THE HEART OF THE SYSTEM

It doesn't matter how many solar panels or what other equipment you have, if your battery bank is not up to the task then the system will fall over. Assuming the system has been sized correctly, then the main battery issue is maintenance.

If you opted for a flooded cell lead-acid bank then it must be maintained correctly—checking electrolyte levels in each cell and topping them up is the main maintenance task.

Other tasks include checking connections for corrosion, but this is far less of a problem for sealed lead-acid batteries and a non-problem for lithium batteries. The latter are still not common in domestic energy systems but their long cycle life and high charge/discharge efficiency makes them attractive, and prices are steadily falling to the point where they are a real alternative to lead-acid batteries.

Depending on chemistry, battery state of

Which loads can you run?

Many people choose to eliminate large electrical loads when they go off-grid. This has the advantage of reducing system size. But an off-grid system can run any load a grid-connected home can, provided the system is sized correctly. So, if you really want air conditioning, a welder or an induction cooktop (the most efficient type of electric cooktop), you just need to install a system large enough to handle that load.

There are two aspects of the system load that need to be considered. The first is the energy used, in kilowatt hours per day. This requirement determines the size of the battery bank and the solar array. The more energy you use, the larger both of those will need to be to both generate and store the required energy.

There is a way to change this equation somewhat, and that's by running large loads at the same time that the most power is being produced—during the middle of the day when adequate sunshine is available. While this doesn't reduce the required array size, it does let you reduce the battery capacity as you are not having to store the energy for the large loads before use.

The other aspect of energy use is actually the maximum power the system is required to produce at any given time. This is the peak power requirement, and it determines the size of the inverter you require.

For example, if you have a 1.5 kW bore pump running from the house system (though we'd recommend a separate solar bore pump), you need to allow for that on top of all other possible loads, as the pump may start at any time. So, if you also have a 2 kW electric kettle, one of the largest loads commonly found in a home, then your inverter must be able to produce at least 3.5 kW continuously, and that's assuming there are no other loads on at the time.

In such a system, a 4 kW or greater inverter is likely to be needed, but also remember that many inverters have a 5, 15 or 30 minute rating where they can produce more power than their continuous rating for that period, so you may not need as large an inverter as the numbers suggest, especially if you are good at timing your usage to prevent large loads running simultaneously.

↑ DC coupled systems use a charge controller, such as this MorningStar TriStar unit. It features MPPT input up to 600V and full communications for system monitoring.

> "Lithium batteries are still not common in domestic energy systems but their long cycle life and high charge/discharge efficiency makes them attractive, and prices are steadily falling to the point where they are a real alternative to lead-acid batteries."

charge (SOC) can be a good indicator as to how the system is performing. If the batteries are regularly hitting close to 100% SOC then the system is producing enough energy to meet demand. If the batteries regularly run for days at a time without fully charging, then energy generation may be a little low. Interestingly, for lead-acid batteries it is best if they reach full charge regularly, whereas lithium batteries are much more tolerant of partial discharge and, indeed, can actually last longer if run at slightly less than a full charge.

Lead-acid batteries shouldn't be discharged more than 10% to 15% of total capacity per day on a regular basis. With lithium batteries you can get away with deeper discharges and hence a smaller total capacity, provided that the generation capacity is enough to ensure that the smaller bank is never discharged below the manufacturer's recommended minimum (which can be as little as 0% SOC, or 100% discharged).

As data collection is a feature of almost all house-sized inverters as well as many charge controllers, almost all domestic-sized systems have quite extensive monitoring nowadays, including energy generated and consumed, battery voltage and SOC and the like. Keeping an eye on this information can help you get the most out of your system, and you can even have the data uploading to the popular pvoutput.org web portal.

DC OR AC

Most systems usually assume a completely 230 V powered home, with energy converted from DC to AC by an inverter. Advantages of this are simplicity of wiring, but it is important to consider having a backup inverter should the main unit fail, potentially leaving you with no power—not even lights.

You might also consider one or two low-power DC circuits to provide lighting. If your needs are small, an all-DC house is possible, although cabling can become expensive due to the thicker cables required for the lower battery voltage compared to 230 V. For more information on using DC appliances, see the DC appliance guide in *ReNew 126*.

IS A GENERATOR NEEDED?

Most off-grid systems include a diesel- or petrol-powered generator (often called a genset). However, with the greatly reduced price of solar panels, including a genset is unnecessary in many systems—it can be simpler and cheaper to considerably oversize the PV array so that it generates adequate energy even on overcast days. Combined with a slightly oversized battery bank or the use of lithium batteries (which can handle deep discharges more readily), an oversized array should allow you to eliminate the need for a genset. After all, producing electricity from a generator is the most expensive way to do it, when the cost of the genset, fuel and 20+ years of maintenance are factored into the equation, and it also has an environmental cost.

Something else to consider is reduced array output from bushfire smoke, which is likely to occur during a time of higher and important consumption for lights, pumps and communications. If you are in a fire-prone area then you might want to upsize the array somewhat to allow for this, or include a reliable backup genset in the system. ✱

Resources

ATA's *Solar Electricity Booklet*
Solar Panel Buyers Guide: *ReNew 126*
Energy Storage Buyers Guide: p. 70 this issue
Battery Buyers Guide: *ReNew 113*
Know Your Batteries: *ReNew 123*
Battery Sizing: *ReNew 123*
Inverter Buyers Guide: *ReNew 122*
Regulator Buyers Guide: *ReNew 121*
DC Appliance Buyers Guide: *ReNew 126*
Your Home: www.yourhome.gov.au/energy

Battery safety

Batteries contain a huge amount of stored energy, so they must be housed correctly.

Batteries should be fitted inside an appropriate lockable lidded enclosure, vented to the outside as they may produce hydrogen gas during charging. While lithium batteries are normally considered safe in this regard, all battery banks should be properly contained and vented.

In some systems the vented enclosure is the room itself, and in these cases no ignition sources such as inverters or battery chargers should be present, This is particularly the case with flooded lead-acid batteries, as these are the most likely to emit explosive gases.

All batteries should have their terminals covered to prevent accidental short circuits from tools and other conductive objects, and the main battery disconnect must be easily accessible.

Battery banks should never rest directly on concrete floors as the cold floor can introduce stratification of the electrolyte (different specific densities as you go from the bottom to the top of the cell) which can affect battery performance and lifespan. Batteries should be placed on wooden bearers or other suitably strong thermal insulation.

Appropriate safety signage must be installed at suitable positions near the battery bank.

All battery banks should be checked regularly (once a month is a good idea) for loose connections between cells and other potential problems.

When working on battery banks, remove all jewellery and wear eye protection.

For a list of applicable standards, see www.yourhome.gov.au/energy/batteries-and-inverters

Off-grid in the tropics
Cool conservation

Designed for the tropics, Andrew Spiers's tropical off-grid home exists to look after this conservation block. By Robyn Deed.

WHEN I call to speak to Andrew Spiers about his off-grid home near Darwin, he's out 'chasing weeds' on the property. It's a conservation block, which Andrew and Helen Spiers bought in 2002 while living in Darwin. They had planned to retire to the block down the track, but it proved difficult managing the land conservation on weekends only. So they decided to build a house and move there before retiring. Thus, Andrew describes the house they built as "existing to look after the block".

An ex-ranger and current educator in sustainability, Andrew's trying to stop the native savannah woodlands from all becoming grasslands. It's a greater risk to the tropical environment than cane toads, he says.

The weeds he's fighting are mainly African grasses, introduced for pastoralists as they're preferred by grazing animals. Australian grasses, he says, have "spent their lives making themselves unpalatable to kangaroos". Kangaroos prefer the African grasses too. That's how Andrew can track down the invasive grasses: they're the chewed patches in between the native grasses.

Images: Robyn McLean

↑ The house design is based on a Beni Burnett design and centres around air flow. Windows are taken right to the corners and thus can pick up breezes from any angle around the home.

Living lightly in the tropics

Within the savannah woodland environment that he's protecting sits a completely off-grid and passively cooled home. The home's design was initiated by Andrew—he has a background in planning and was interested in demonstrating just what's possible, in terms of living comfortably and lightly in the tropics.

He'd started thinking about the design in 2002 when they first bought the block. Over several years, Andrew and his partner Helen went along to what were then called Solar House Open Days (now Sustainable House Days), talking to owners, and going back several times to some houses.

A modern Burnett design

Even more importantly, he says, he also studied the heritage houses designed by Beni Burnett in the 1940s in Darwin.

Burnett was a government architect of Scottish extraction who grew up in South-East Asia. He understood tropical design, but also was able to come up with a compromise to suit the mainly British immigrants. In addition, he was dealing with a town without electricity or running water, so his house designs provided comfort in the tropics without even the cooling effect of electric fans.

A Burnett design centres around air flow, critical to a passively cooled house in the tropics. Andrew's house is skewed from an east-west orientation to pick up breezes which come from the southeast in the dry season and the northwest in the wet. This is something that's been lost in so many Darwin developments, says Andrew. There's no room between the houses for breezes, and orientation just doesn't seem to play a part.

The two-bedroom house is also just one room wide. Andrew says, "In a Burnett house, and in my house, the verandah becomes the house." Any internal walls that block breezes are louvred to allow the breeze through when it's needed.

The 40 solar panels are mounted on frames in the garden, rather than on the roof, for ease of access for cleaning and maintenance.

"Burnett was dealing with a town without electricity or running water, so his house designs provided comfort in the tropics without even the cooling effect of electric fans."

The two-bedroom house is also just one room wide. "In a Burnett house, and in my house, the verandah becomes the house."

The design maximises total air flow across the house and up through the roof. Andrew wanted ridge vents but the builder was concerned they'd let the rain in during cyclones. Instead, the house has 'wind workers' and gable vents. Wind workers are Venturi tubes that work in the breeze to draw hot air out of the roof. They're called wind workers up north as they also work to keep roofs on in cyclones. The house also has a cathedral ceiling for air flow.

Windows are taken right to the corners and thus can pick up breezes from any angle around the home. The windows also completely open, with louvres or roller shutters to close them off against the rain. Many of the windows don't have glass on them—they are just fly screens with shutters.

Andrew and his architect ran into problems getting this house design to pass the building code. Large areas of windows were a stumbling block, because the building rating system assumes all houses in the tropics will have an air conditioner. They did have to compromise and cut back some of the window area. Later though, at a sustainability show, Andrew asked a government planner about this and found out they could have asked for an exemption—but none of the architects, designers or engineers knew this. "They never asked," said the planner.

The house also includes shiny walls and roof to reflect away the radiant heat, and has double-sided reflective foil insulation under the roof cladding. Andrew says it was interesting trying to get this installed to specification—the standard approach of builders in Darwin is to install it right under the cladding without an air gap, so he had to work hard to convince the builder to install it with a gap. I ask about dust build-up on the side of the foil facing up and he says he believes that with the movement of air through the roof space this is less likely.

The final important design element is that there is little thermal mass, except for the thin slate floor. He notes that this is important in tropical climates—you just can't have thermal mass radiating its heat all night. He is frustrated that many developments in Darwin mandate the use of concrete blocks.

Comfort in the heat

Andrew says that the house is very comfortable for him and Helen in the heat. Though they don't have a log of temperatures, he notes that the moving air on hotter nights keeps them very comfortable inside, more than a temperature sensor would suggest.

In fact, they get cold in June and and July, in the dry season, when they sit around in their ugg boots and doona at night—it gets down to about 13 ºC inside.

There is an aspect of acclimatising to the heat, so they do have an air conditioner in the guest bedroom for visitors from down south.

Getting the house you want

The finished house didn't cost more than the standard concrete block houses being built in Darwin. However, it did take four years to get a quote that didn't give them a heart attack.

When first put out to tender in 2005, the building quotes came back at around $700,000, for a house that had been given a preliminary costing of about $250,000 by a retired builder friend. One quote included $53,000 for putting the wiring in the walls, compared to a quote of $3000 for a friend's three-bedroom home. He was told his house design was different and complicated. A common theme emerged, with builders telling him: "You can't afford this design, but we have one you can afford."

In the end, four years after Andrew started looking, he finally found a builder who wanted to specialise in off-grid solar homes and whose quote came in at $460,000;` not too bad given it was four years later and there'd been a building boom (and the house had expanded from one to two bedrooms).

Andrew thinks this difficulty in getting the home you want built is a common experience. When their home opened for Sustainable House Day recently, they got more than 250 people looking through (even though they're 70 km outside Darwin), and many of the attendees were "singing the same song", saying: "You've built what we wanted but were told we couldn't!"

Once built, the home went on to win awards for the builder including the national HIA award in 2011 for most sustainable home. I ask him does he think it's changed things, made it easier for others. He says, unfortunately, no. His builder has built several off-grid homes, but finds it's tricky to find clients like Andrew—ones willing to think outside the square. The home gets used by the builder as a display home and Andrew has had development companies come out to take a look, but many just aren't interested in stepping outside of a formula that's working for them financially, even if it's not working environmentally or providing a quality of life for the people buying the houses. Also, people often don't want something that looks different, he thinks.

This little house has survived a category 1 cyclone that lasted several days, as well as two bushfires and three earth tremors. He's not sure whether it would survive a category 4 cyclone but he thinks that's the reality of living in this area. The house is conditionally certified for a cyclone region; conditionally, because the roller shutters have not been tested under the new building code. He was required to make them inoperable to get full certification!

↑ The inverter and battery bank are located in an insulated section of the vehicle shed, to keep the batteries cool and the potentially annoying cricket-like chirruping of the inverter away from the house.

Off-grid with ease

In terms of the off-grid system, Andrew says he couldn't be happier. The trickiest time is the monsoon season but even then he hasn't ever needed to use a generator. The typical pattern of the monsoon season is that there's little sunlight for three or four days at a time. After four days, the batteries get down to about 80% charge but they don't take long to recharge once the sun comes out. On moderately cloudy days, they find that the system charges faster than on full sun days, due to the effect of heat on the solar panels.

They do have a small backup generator, but the only time they've needed to use it is when the system was put out of action by ants. The tiny (2 mm long) ants managed to chew through the insulation on a metre of wire which meant the solar system wasn't charging the batteries. Ironically, this happened around the time of Sustainable House Day. It was about a week later that the system suddenly shut down because the batteries got down to 50%—he hadn't been checking it (as he usually does every day) as he'd spent so much time showing people the system on Sustainable House Day that he'd had enough of looking at it!

The batteries are now over five years old and are still going well. The system was actually used to power the building of the house. It was much cheaper to go stand-alone rather than connecting to the grid at the time they did, and would be even more affordable now. The system cost them $40,000 which included a 50% subsidy from the government. Recently, a friend had a similar system costed at $23,000 without a subsidy so prices are definitely coming down. To connect to the grid (just one kilometre away) at the time would have cost $80,000.

If they'd connected to the grid they'd also have been responsible for any maintenance of the transformer. His son, who worked in the electricity industry at the time, pointed out there was a large risk of a lightning strike on the transformer, requiring costly repairs (tens of thousands of dollars). As they didn't own it, they wouldn't even have been able to insure against that possibility.

They haven't had to modify many behaviours to live off-grid. In the monsoon, they might think twice about using the washing machine. Otherwise, they have all the normal appliances, such as a fridge, LCD TV and computers, and they run power tools. The only power tool they can't run is a welder as it requires 3-phase power.

Their oven is gas, but they believe that they have enough power to run an electric stove; they just prefer gas for cooking (though they're rethinking that). Their washing machine is a twin tub, which allows them to reuse the washing water for the next wash. Interestingly, when buying one of these, it appeared from the label that the twin tub energy rating was the lowest of those on display. However, on closer inspection, it became obvious that the power consumption was actually lower than the other washing machines. The lower rating was because the twin tub didn't heat its own water and the rating allowed for heating of water using an electric resistive water heater.

In safe hands

A sign of how successful the home has been is in Andrew's wishlist of changes. He says, "The only thing I'd change would be to have manual roller shutters instead of the powered ones; I couldn't get them at the time." Everything else has in fact surpassed his expectations.

That's so lovely to hear, and often unusual for a building project. It seems he'd done his research well. I'd say this conservation block is in safe hands. ✱

Andrew spent a decade and a half as a park planner and ranger, and for the last 20 years has been a lecturer in conservation and land management with Charles Darwin University.

Off-grid technical specifications

- PV: 40 x BP 380J, 17.6 V, 4.5 A
- Batteries: 24 x Sonnenschein 2 V, 720 Ah
- Charge controller: Plasmatronics PL60
- Inverter/charger: Selectronics PS1 6 kVA inverter
- System design/install: Delta Electrics, Darwin

Not flushed away
Water independence

Flush good quality rainwater down the toilet? Not in this Adelaide house, where flushing rainwater is only done in times of plenty. By Melissa Crawford.

WHEN we bought our 1950s classic fibro shack in Port Noarlunga, on Adelaide's southern beaches, the backyard contained two trees, some overgrown hedges and a lot of dry, dusty soil. We planted lemon and fig trees to start our food garden while we planned the house changes.

Minimising our impact on Adelaide's already stretched water supplies (from the Murray River), making use of the intermittent local rainfall (450 mm in a good year) and acknowledging our limited rainwater catchment were key for us. Our renovation included all the wet areas, so it was an ideal opportunity to re-plumb. We decided on a mains-connected system that would allow us to be off the town water supply during times of plenty, but still have backup during the long dry summers. This approach meant we didn't need a huge tank on our small suburban block but we could make use of the rain that falls on our site all winter. We were also able to minimise our stormwater pollution to the nearby sea and recharge the local soil water supplies.

To make the most of our rainwater we created usage zones. As the rainfall becomes more intermittent in September, we gradually cut off each zone to preserve the rainwater for higher priorities.

Of course the priorities will be different for everyone, but we like to use our rainwater in the following order (from most to least important): drinking water; watering the vegie garden; the hot water service, including showering; clothes washing and toilet flushing; the rest of the house.

We needed a plumbing solution to achieve this and luckily my partner had experience with plumbing and a great problem-solving brain! He soon came up with a simple (a key emphasis in everything we do) system of manual valves which allow us to prioritise rainwater to different areas depending on availability and circumstances.

↑ Three secondhand (ex Housing SA) 4500 L galvanised iron tanks are linked to provide water for the house and garden. Rainwater for drinking is provided by a separate 1000 L tank.

Tank for drinking water

We first needed to guarantee our drinking water would never run out, so we installed a 1000 litre rectangular tank that gravity feeds a tap in the kitchen. This tank is fed from the front third of the house roof and is independent from both the mains and the rest of the rainwater system. The minimal head on this tank means the tap runs very slowly, but we soon became used to this. Since being installed six years ago we have never run out of drinking water!

The overflow from this drinking water tank goes into a recycled plastic drum acting as a surge vessel in times of plenty. Dripper irrigation pipe is connected permanently to the drum, automatically distributing water to a native garden area in our front yard whenever the drum fills, thereby recharging the local soil water and again ensuring stormwater does not escape us.

Our house and garden water circuits

Diagram 1 shows the house and garden water circuits we installed.

We installed two water circuits in the house: one supplies the hot water system and the cold tap in the shower, the other supplies cold water to the rest of the house. This is quite different to most housing where there is a single water supply to the hot and cold water circuits in the house.

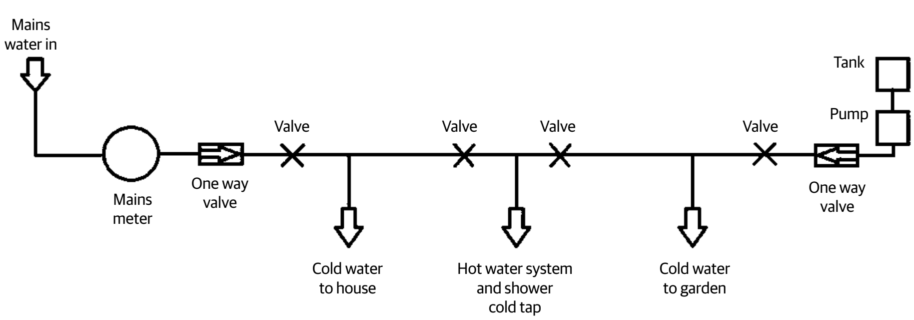
This simple solution enables us to control where the water comes from. Thus, rainwater showers are still available when we are using mains water for flushing and washing clothes. Also installed in the line to the hot water service and the shower's cold tap is a 350 kPa pressure-reduction valve. This serves to even out any fluctuations in pressure from the rainwater pump and has the added bonus of meaning you can turn water on anywhere in the house and it doesn't change the temperature in the shower.

Feed to the vegie garden

The third circuit in our system is the feed to the vegie garden. We have spent many years working towards seasonal eating and vegie self-sufficiency from a suburban house block, so water that plants thrive on is a high priority for us. Our observation is that vegies grow better with rainwater than with mains.

That said, vegies grow much better with mains than no water, so our system has to be flexible enough to allow mains water through when the rainwater has been exhausted. This is achieved by shutting off a valve at the rainwater pump and opening the valve to mains supply. The final part of this retrofit is the inclusion of one-way flow valves that eliminate the possibility of mains water entering the rainwater tanks and, in the other direction, prevent tank water contaminating the mains water supply (a requirement).

↓ Diagram 1: The three water circuits—cold to the house, hot water system + shower cold tap and cold to the garden—are separated by valves that can be switched to enable the feed to come from mains or rainwater tanks, depending on rainwater availability.



Rainwater tank selection

Limited access to the backyard (1.75 m width path beside the house) meant we either had to get a custom rainwater tank built on-site (expensive), crane a tank in (also expensive), build our own ferrocement tank (very time consuming) or source secondhand tanks that would fit down the gap between the house and fence. We decided on the latter.

We estimated the amount of rainfall (with a little help from the Bureau of Meteorology), calculated what we could reasonably collect from our small house and large shed (if only the ATA's Tankulator was around then!), looked at the limited 1.75 m gap and determined that three 4500 L tanks would work best. There was little point in sacrificing more space to add another tank due to the small collection area from our roof.

After some months we had collected three ex Housing SA galvanised iron tanks in good order that would just squeeze through to the backyard—1.7 m in width, so 2.5 cm each side to wiggle the tanks past the length of the house. Once in place, we connected the three tanks together and installed the pump.

The joys of a sunny day in winter!

From the moment the system was up and running we discovered the joys of a sunny day in winter—a rainwater bath heated by our solar hot water system! Heaven. No more feeling guilty using all that water! And the icing on the cake? After the bath, the water all goes directly out to the fruit trees through our dedicated greywater irrigation system (but that's another story). And to top it all off the cost of running the pump is mitigated by our grid-connect PV system.

After several years living with this setup we find we can generally switch the mains water off for about nine months of the year. Of course, given the supply charge, sewerage

↑ Here the mains valve is open (left) and the rainwater valve is closed—these valves feed to the h/w system and the shower's cold tap, so this is a sign there has been little rain here and the rainwater is being conserved for the vegies rather than showering! The two valves were co-located to enable easy access and simplicity when changing the supply between mains and tank water.

charge and 'Save the River Murray' levy, this only reduces our bill by about $5 to $10 a quarter with the mains water turned off, but that's not the point, is it? For us it's about taking personal responsibility for our water use, reducing the stress on the river and using our good quality rainwater where we see the best value.

The only real problem we've encountered was when the electronic controller on the pump died due to water getting in (the pump now has a sturdy cover). One other concern is the continual cycling of the pump on and off as we use water. As mentioned several times in *ReNew* (including this issue, p. 78), a pressure tank connected to the pump would reduce this considerably thereby extending the life of the pump. Had we not just moved on to our next project we would probably have got around to this. Our next project? We are hoping to do a 'green' subdivision to play with a few more ideas we have, like rainwater-scaping. ✱

Melissa and her partner David are lucky enough to have food on the table and money in their pockets, and enjoy solving first-world renovation problems.

Key system components

- three secondhand 4500 L galvanised rainwater tanks linked together
- 1000 L rectangle tank, stand-alone
- 0.75 kW pump with electronic pressure controller
- standard plumbing valves
- 350 kPa pressure-reduction valve
- two one-way flow valves.

Composting toilets
In an urban setting

Jeff Knowles had reservations about putting in a 'long drop' in his urban home, but was pleasantly surprised.

IN 2001, my partner Chrissy and I engaged Strine Design to assist in the design of our new sustainable home in Queanbeyan. Under the leadership of architect and builder Ric Butt, Strine had been responsible for numerous buildings of a deeply sustainable nature in the Canberra area. Many of these included sustainable elements that were not available through other builders/architects at that time—composting toilets being a case in point.

Initially, it must be said, I had reservations (mostly to do with smell and a reputation for being difficult to maintain) about putting in a 'long drop', but several visits to see Clivus Multrum units already installed around the district convinced me that the idea was worth proper consideration. Chrissy was especially keen, due to the water saving and general ecological advantages.

Deciding to incorporate the unit into our home design and actually getting that design through the local council turned out to be two quite separate things. Fortunately for us, our architect Ric Butt had a lot of experience in this area. He'd pioneered the use of the units with forward-thinking councils, even in water catchment areas such as the Googong Dam where it was absolutely crucial for them to work well. He also had ready access to evidence from other composting toilet owners of the minimal maintenance required.

The eventual approval only took two weeks. With written agreement on our part to maintain and service the unit, our council agreed to pass the 'radical design'—which, in fact, represented a return to many concepts that had previously been commonplace in Australian houses in the bush.

The house was duly built and the toilets (one CM10 unit with two separate toilets) were installed. We had them installed partly raised inside and partly submerged outside with a service hatch. This is one way of installing them—it means a couple of steps inside, but not as far to descend to do the maintenance outside.

We obtained wood shavings from the local sawmill and our learning began. Ric's flippant suggestion was to start the composting process by just throwing in a dead possum. Not surprisingly, I couldn't find said deceased possum lying anywhere around, so we finished up using a product from the supermarket called Actizyme.

Actizyme is designed and marketed

"Our council agreed to pass the 'radical design'—which, in fact, represented a return to many concepts that had previously been commonplace in Australian houses in the bush."

as a natural drain cleaner but is also an excellent compost starter. It took me a while to understand that the active microbes in standard food composting systems are the same as the ones in the Clivus Multrum.

That established, we settled in to using the loos—and fielding the inevitable questions from visitors such as "Where is the button?", "Why don't they smell?", "How much water do you really save in a year?"

↑ The composting toilet under construction, with insulation around the edge of the service pit.

The ensuite loo, simplicity itself. Note the wood shavings in the pedal bin at left.

The compost processor—note the warm air feed (white pipe) from the house to keep the compost pile warm and ensure continued composting, especially during the cold of winter.

The council came out to visit a few times in the first few years to check that the neighbours were not affected by smells etc from the toilets and that we were doing the right things by the greywater. Now they occasionally send people to us who need help with the approval or maintenance processes.

The compost itself does not smell. This is something that few people really believe until they are shown the unit and I lift the access hatches.

Inside there is no smell due to the fact that a variable-speed, 12 volt fan is continuously running, drawing any odours away from the internal area. We use wood shavings instead of flushing.

We clean the compost out once a year from the bottom hatch and bury it around trees or use it in other plantings around the garden. We obviously don't put it directly on the vegies or leave it loose on the ground, but otherwise it's an excellent fertiliser.

By some calculations, the water savings can be as much as 50,000 litres a year, based on replacing two dual-flush toilets for a family of four. This is a claim made by Clivus Multrum and we can affirm it now.

Twelve years on, the Clivus Multrum is a vital part of the rich picture that is our sustainable home. ✷

Jeff and Chrissy Knowles are teachers. They can be reached at www.ecofootprints.com.au.

A novel design
Taking advantage of low PV prices

This battery-based solar system is cleverly designed to reliably provide daily energy needs, even on an overcast day, with a smaller battery size than normal. John Inglis from Positronic Solar in Brisbane explains.

WE recently installed a system for a customer who had experienced blackouts of four days due to storms, despite being situated in a well-serviced northern Brisbane suburb. The home office employs four bookkeepers using computers, printers, faxes and phones. The house is an all-electric two-storey suburban house, typical of the brick veneer, tin roof houses built in Australian suburbs since the 1980s. The daily energy use from the electricity bill averaged 13 kWh.

The project design brief was to provide a UPS (uninterruptible power supply) for the home-based business.

Design response

The design takes advantage of low PV panel prices, high storage density of $LiFePO_4$ batteries and advanced energy management.

In the past, battery storage systems have been sized with five days of storage and one day of generation. This made sense when panels cost $10 per watt. At $1 per watt the economics are different.

In Brisbane, a 3 kW_p PV system averages 13 kWh per day. On a fully overcast day, PV produces about 25% of the average, so to provide 13 kWh in overcast weather requires a 12 kW_p array. A 12 kW array will provide surplus power in sunny to poor weather, which can be used for discretionary loads—described below.

We design our $LiFePO_4$ batteries with a 45% SOC floor. Cycling the batteries to 45% allows 4000 cycles—say, a ten-year life if cycled daily. Since overcast weather is covered by the oversized PV array we only need to provide one day's storage.

The customer's 13 kWh per day usage means we aimed for 16 kWh of usable storage

↑ The 12 kW array was split into two separate 6 kW arrays, each connected to its own inverter.

capacity, and so needed a 29 kWh battery. We used Schneider XW inverters which run at 48 V, so that indicated a 600Ah battery.

Our quote to the customer specified 12 kW of ET Solar 200 W mono PV panels, two Trannergy PVI5400TL 4.6 kW grid-tie inverters and a Positronic BI48600XE energy storage system, for a total cost of around $36,000 after STCs. Backup power is provided by the off-peak Tariff 33 power from the grid.

Installation

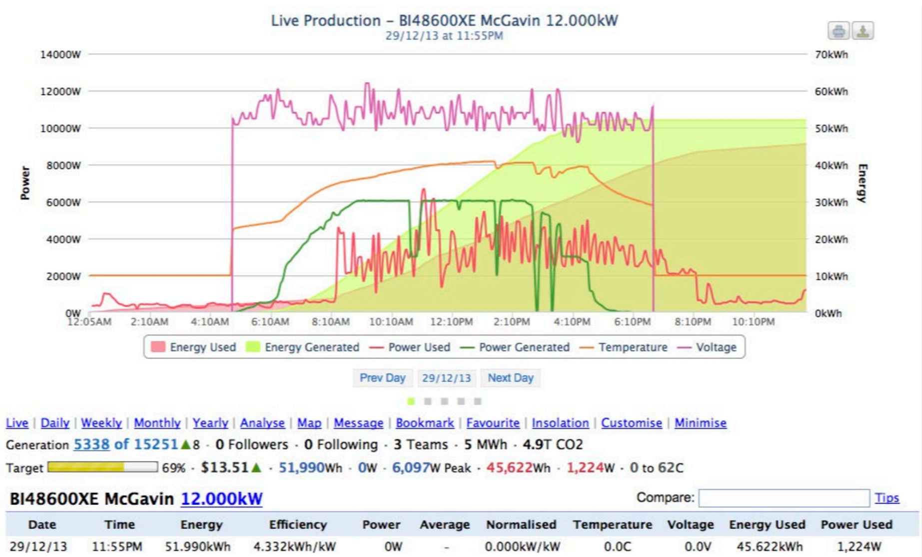
The system was installed in October 2013. The PV array is arranged as two standard 6 kW grid-tie systems, wired to the energy storage system (ESS).

The ESS uses AC coupling and the battery management system (BMS) regulates the output of the Trannergy inverters relative to the battery state of charge (SOC).

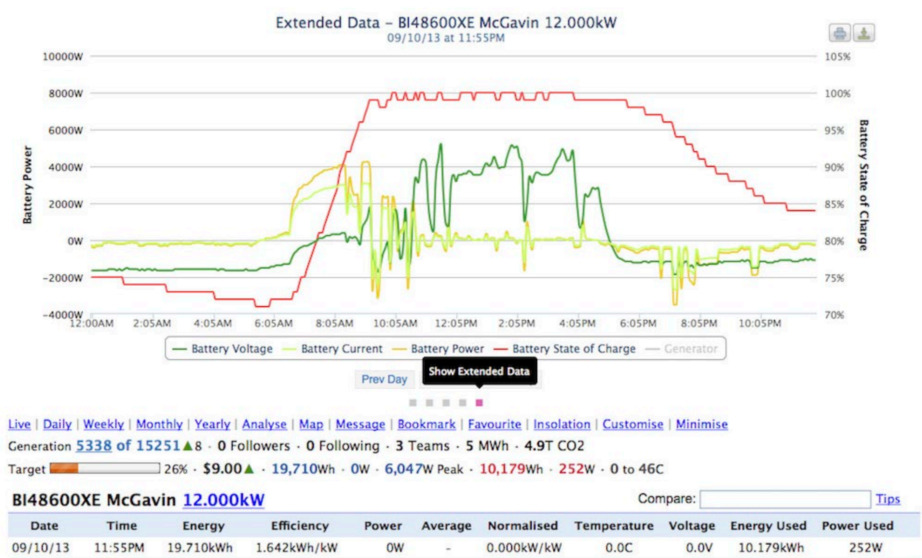
The hot water system was removed from Tariff 33 and connected to the ESS 'dump load' circuit, which is enabled when the battery is fully charged; this uses excess PV generation which would otherwise be wasted as, in Queensland, battery systems are not able to export to the grid.

Tariff 33 was connected to the ESS 'generator' input which is enabled when the battery SOC drops to 40%. The generator

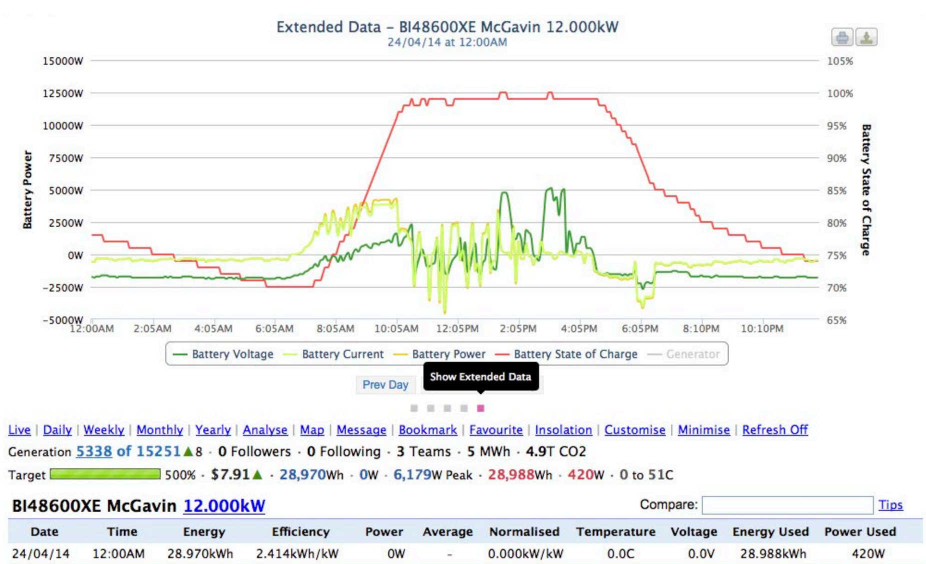
→ System data from 29 December 2013, a hot day, taken from the PVOutput web portal. Note that power consumption was still quite high after sunset, when the array had stopped generating.



→ The energy system also uploads extended data to the PVOutput web portal, including battery voltage, current flow and state of charge.



→ Here you can see how quickly the battery state of charge recovers after continual overnight discharging. Note how battery voltage stays quite stable as it discharges at the end of the day—a feature of lithium batteries.



input is disabled when SOC reaches 80%. A change-over switch was fitted to enable grid connection in case of a fault in the ESS.

The ESS was connected to the PVOutput web portal to enable logging of PV, energy use and battery state at five minute intervals.

The customer soon discovered that in sunny weather there was an excess of power during the daytime and started using the previously under-utilised air conditioning in the hot Brisbane summer. In fact, they installed three more air conditioners and the daily energy use in hot weather climbed to around 20kWh.

On 29 December 2013, a particularly hot day, they used 45kWh. They did buy 13kWh of Tariff 33 on that day, from 9.30pm to 12 midnight.

In March 2014 they installed a swim spa, which was connected to the second 'dump load' circuit.

There are two dump loads on a Positronic ESS. Dump load 1 is generally used for hot water and is enabled when the battery is at 100% SOC. When the hot water load drops off, dump load 2 is enabled and runs for five hours or until SOC is 80%.

Energy use has risen closer to 30kWh/day. The energy management feature of the Positronic ESS has allowed discretionary use of excess PV-generated energy for 'luxury' items, such as air conditioning and the spa without cycling the battery or burning fossil fuel.

The system has proven to be weatherproof. Brisbane experienced a week of nasty weather at the end of March 2014, with the 27th being particularly dark. The battery was at 50% at dawn, the PV only delivered 7.3kWh during the day and by 6pm the ESS was calling for a recharge. Tariff 33 came on at 11.05pm and supplied 20kWh to the battery and loads until 3am the next morning. The next few days were still pretty wet but no more Tariff 33 was needed.

The Positronic ESS is supplying about $800 of electricity per quarter, having required only 30kWh, or $6 of Tariff 33 since installation. Because it is grid connected there is still an electricity bill for the daily supply charge. Systems for off-grid use are identical to those used on-grid. All ESS are supplied with generator start terminals, so if in the future the customer cuts the cord to the grid adding a generator to replace Tariff 33 is straightforward.

The complete system. The ESS (energy storage system) makes for a very neat installation, quite small for 29kWh of battery capacity.

Living with the system—the owners give their thoughts

Since installation in 2013, the system has been very easy to live with. We haven't really had to make changes to how we live. Visitors don't notice or even realise we are off-grid. Probably the main adjustment we've made is to use high-load appliances during the day, such as the dishwasher, washing machine and oven. On days with inclement weather we are also more particular about what gets turned on. We are fortunate that in operating a business from home we can actually use what is being generated during the day.

An example of one experience: One night we were going about our usual routine and a storm came and went. At one point, we noticed it was very dark outside and we stopped to look—the whole neighbourhood, except us, was blacked out.

When it came time for the change-over to the battery system, I was a bit anxious for the first month and kept a constant watch on what was being used versus generated. John kept telling me not to be frightened to use our air conditioning, as we weren't using anywhere near the full capacity of the system.

It is only since we bought the swim spa that we've had to be more aware of what appliances are turned on at the one time. As we had the system sized to meet our needs before the swim spa, we now have to keep in mind that our system only has a 6kW maximum output; with a 4kW heater and multiple 2kW pumps, it definitely requires some thought before use.

After-sales service has been fantastic. Whenever we have had an anomaly with the system, a phone call or email to Positronic was responded to very promptly. All in all, we are very happy with the system and have no hesitation in recommending it to others.

Our major appliances are:

- 520L Westinghouse cyclic defrost fridge
- 140L Westinghouse bar fridge
- 160L Fisher & Paykel chest freezer
- 280L resistive electric hot water system
- 65L Neff electric oven
- Chef electric ceramic cooktop/stove
- 10kW LG reverse-cycle aircon (living room); 2.6kW Kelvinator inverter reverse-cycle split system (main bedroom)
- two 2.6kW Kelvinator inverter reverse-cycle split systems (one in each office)
- 8kg AEG front-loader washing machine
- Dishlex dishwasher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No wires
And too much power!

Kevin White describes his off-grid home in Queensland as a renewable energy 'power station', with more energy than they can use!

'Noddy' did his duty, day in and day out. We were always delighted when guests asked, "Did your solar panels just move?"

↑ 'Noddy' with four 80 W panels tracking the sun.

IT all began with eighty-three acres in southeast Queensland, an almost clean slate, up for sale by a good friend who'd fallen in love and was emigrating. Suddenly we had acquired a property with a bit of everything—dairy pastures running out to steeply treed hills, peaking at a ridge before descending into remnant rainforest; a 300-foot hill rising from the flats completes the picture.

Buying the property was the easy bit; deciding what to do with it was more evolution than plan. The flats had been used for grazing so we decided to continue that. In went cattle yards and a reasonably large shed—your shed can never be big enough! We decided to build a studio within the shed as temporary accommodation while we planned our build.

As ex-yachties who'd swallowed the anchor for the country life, we knew we wanted to maintain our independence. The 'reasonably large shed' had plenty of roof area to supply a water tank and there was plenty of fallen timber nearby for heating.

We wired the studio for both 12 and 240 volt power. We had no idea where on the property we wanted to build so we didn't consider getting a quote for grid power at the time. However, we did get a telephone connection put into the shed.

At that time (just a few years ago!), solar panels were a rather costly item, so for our interim system we decided to mount four 80 W panels on a frame and have them track the sun for peak efficiency, along with using an MPPT charge controller and 400 Ah of Trojan T105 batteries.

Being an ex-electronics tech I built the tracking system—from an old C-band satellite dish mount, coupled to a homemade tracking controller. 'Noddy' did his duty, day in and day out. We were always delighted when guests asked, "Did your solar panels just move?"

With 12 volt LED lighting, a modest 12 volt fridge/freezer, 12 volt entertainment devices, a laptop and a pot belly stove (with a year's worth of cut timber), my tolerant wife Gudrun spent over a year living in our temporary home while I went to work in Antarctica for a year.

During this time there was only one 'lifestyle' failure in the system—the 12 volt pressure pump switch failed but a kind neighbour had this running again within the day. We can honestly say during this time, and after, we never lacked for convenience living with such a minimalist setup. I guess the only thing we had to forgo was ironing clothes. Pity really!

Building location is often not just a matter of power and water needs. These days access to communications can be just as important. We were some 15 km from the telephone exchange so ADSL was out of the question, and there was no mobile coverage on the flats where the shed was built.

Well, if the mountain won't come to... We placed a 3G router and antenna on the top of our hill, pointing at a mobile tower some 30 km away. This could then beam wifi internet access down to the studio meaning Gudrun could continue her university studies in my absence.

Over the next year of long-distance dreaming and thinking we came up with the closest thing to a plan that we'd ever had. We'd owner-build at the top of our hill where the views were fabulous, there was always a gentle breeze—and we could get internet!

Roof with 5.25 kW panels (21 x 250 W).

> "We've had no power interruptions since commissioning, even though we've seen the lights in the valley below disappear on numerous occasions due to grid outages."

Checking with the utility company we had a quote of nearly $40K for a grid connection. That made the decision to use stand-alone solar easy. Construction materials were also easily decided, taking into account the exposed location and the possibility of bushfires. We settled on sandstone block and steel.

The house would face slightly east of north, ideal for both views and solar collection. Afternoons in our area are frequently cloudy so we optimised for peak efficiency in the mornings.

Thirteen months after my return from Antarctica the house was built and we switched on our power station. With the help of *Understanding Renewable Energy Systems* by A&C Thorogood and assistance from Lachlan O'Shea of Lockstar Energy, we had a system supplying more energy than we could use.

The system: 5.25 kW of panels, Sun-Earth Quasi's chosen for efficiency and positive power tolerance, a Midnite MPPT charge controller and 600 Ah of Rolls Surrette batteries at 48 volts. We went with the Midnite charge controller as I liked its integration on the net. While the battery bank is light for the size of solar array it's been keeping up with our needs nicely. Generally we don't see a depth of discharge over 30% (SOC 70%), in spite of running a business server computer 24/7.

In the 16 months since the system was commissioned, we've run a generator for four hours, and that was probably unnecessary. At that time the Outback VFX3048 Inverter synced the transfer beautifully, with our server oblivious to the changeover.

We run a business from home so our server runs a PABX connected to our fixed line down on the flats. This is connected via wifi, so again there's no wires running up the hill. We've had no power interruptions since commissioning, even though we've seen the lights in the valley below disappear on numerous occasions due to grid outages.

Too much power

We have had one major issue: getting used to having so much power! Being accustomed to living on a yacht and then on a minimalist system we just couldn't get used to leaving appliances switched on or on standby. This brings me to the idea that energy efficiency is not just technology, but rather attitude, expectation and practice.

Charge controller, inverter and isolators.

Naturally appliance selection is key, including efficient refrigeration, lighting, computing and entertainment systems. This is so much easier than just a decade ago. Despite vast improvements in appliance efficiency we seem to see average energy needs soaring. Is the problem here attitude and expectation?

We too still have a lot of work to do. Although we use a sustainable fuel for heating—timber from our own property—sadly it's not heating water for us. Presently we're using bottled gas for cooking and water heating, about 135 kg per year. Running a keypad temperature controller on the instant gas water heater reduces gas and water consumption, with no need to mix cold and hot water to get the ideal shower. Still, it'd be nice if we could use the excess capacity of our solar array to heat stored water when the batteries are on absorb and float cycles. We had left space for a solar hot water system on the roof; surprising how long it took to realise we had a means of heating water already there!

Speaking of the roof: insulation of R2.3 under the roof and R3.5 above the ceilings, along with wide eaves, ceiling fans and large openings on the south aspect maintain a cool environment in hot weather. Sitting atop our hill there's always a welcome breeze in summer.

Frustrations with the build? Having to build to an energy efficiency code that didn't give us any points for generating our own power or location. Indeed, to gain a 6 Star rating we were obliged to fit ceiling fans in our patios. This gave us one more Star! Now how can adding an electrical appliance increase energy efficiency, I ask? Are we back to a discussion on attitude, expectation and practice again?

I'll leave that for you to answer. In the meantime, I've got a hot water system to improve... ✱

Kevin is an IT and comms consultant who has worked in a multitude of places and technical capacities, including in energy management. www.ontoit.biz.

Off-grid round-up
The power of many

Here are just a few more stories of people going off-grid around Australia, highlighting some of the pros and cons. Compiled by Robyn Deed.

Off-grid community

IN JACKEY'S Marsh, Tasmania, there's a whole community of 35+ households all living off-grid. There's no electricity transmission at all into this remote mountain valley.

The valley reflects the evolution of off-grid. Many people came here for an alternative lifestyle in the 80s and embraced the lack of grid power. When they were offered a grid connection in the 90s, no one wanted it; besides, they were already set up off-grid.

Rosemary Norwood and her husband Sean run off-grid eco accommodation here, powered by micro-hydro and solar. Rosemary says, "Over time, people's power systems have become more sophisticated, particularly as solar panel prices have dropped." Most households use solar, plus there are about six micro-hydro systems (Pelton wheels or larger Platypus Power engineered systems), and three or four households using wind turbines.

Many of the systems started out using old tractor batteries or recycled lead-acid batteries from Telstra.

Max Herron, Rosemary's neighbour, says the recycled Telstra batteries used to be easy and cheap to get hold of, but they're harder to get now. He says, "It's a bloody shame if they're just being discarded. They fail Telstra's stringent tests, but they're still good for household use." He has three banks of 500 Ah batteries that he's been using for 10 years. He's had two cell failures in that time.

Mind you, he says he struggles with generation and needs to use the petrol generator to keep the batteries charged during cloudy periods. He runs it three or four nights a week in autumn and winter. He has solar panels as well as two 200 watt wind turbines from Jaycar that he bought as an experiment.

He says, "Wind could be good if you had wind! The wind speed just isn't enough here in the valley." (For good wind generation, it also usually pays for the turbine to be at least 20 metres high, and at least 10 metres above any obstacle within 150 metres. For more info on wind turbine siting, see *ReNew 122*, 'Doing Small Wind Right'—*Ed.*)

The biggest drain on Max's system is his fridge/freezer, but the upside is that it doesn't draw as much in winter. His energy use per day averages around 10% of the battery capacity.

Most households get their heating and hot water using wood-fired systems. There are a couple of solar hot water systems, and some gas heaters. Cooking is generally via wood or bottled gas. Max says, "We don't run elements."

Rosemary's Forest Walks Lodge has been running off-grid for five years. They need to use their generator around 5% of the time in autumn, when the creek is dry after summer so the micro-hydro system can't run, and the days are wet and overcast, so the solar panels aren't generating much. However, once the creek is flowing again by late autumn, they can generally run without the generator until the next autumn. They are conservative with their energy usage when the micro-hydro system isn't running. And they never allow guests to use hairdryers! Their heating needs are small when it's sunny, given the passive solar design of the lodge. When I call it's a chilly but sunny 9 °C day and inside it's around 24 °C, without heating.

You can read more about Forest Walks Lodge's micro-hydro system in *ReNew 120*.

Image: Off-Grid Energy Australia

Not using the iron as much as I used to!

ANDREW Bishop's household was forced to go off-grid even though they're only a 15-minute drive from the Adelaide GPO. But it's been the "best decision ever," he says. "There's no power bill and it works. The only thing is I'm not using the iron as much as I used to!"

To connect to the grid on their landlocked site at Devil's Elbow in the Adelaide Hills, a neighbour's transformer needed to be upgraded, but that proved difficult to negotiate. He says, "Suzy and I weren't green people, but we've ended up that way."

The house is in a valley, so it needed shade-tolerant hybrid panels (which combine the attributes of thin film and crystalline panels) to allow for the partial shading until 9 or 10am. The system powers a washing machine, fridge, two TVs, radios, stereos, LED lighting, computers, ceiling fans and a dishwasher.

The components are 24 Dupont Apollo C-Series tandem junction hybrid solar panels (3.4 kW), two SB1700 SMA 1.7 kW solar inverters, an SI5048 SMA inverter/charger and 16 SB6/330 Ah Battery Energy Australia sealed gel batteries. He's found that the gel batteries are maintenance-free. The system cost them about $36,000, after a $5600 rebate for STCs, about two and a half years ago. The system was designed and installed by Off-Grid Energy Australia, following a full audit of energy use.

The house has hydronic heating running off a gas boiler, with the electric pump connected to the off-grid system, but it's expensive to run off bottled gas ($500/month) so they avoid using it. Instead, they use a slow-combustion heater, with occasional extra heating from their reverse-cycle air conditioner, running off a petrol-powered generator, for half an hour or so (needed about three or four times each winter, when the fire has gone out). They only use the air conditioner for cooling about twice a year, as the house is well insulated, and they're in a good location for cooling breezes.

Off-grid works but can have challenges

Two case studies illustrate that there can be challenges with living off-grid, particularly due to sizing and maintenance issues.

1/ MAX Emeny's family went off-grid in 2006, when they bought a rural property in far north Queensland and found that getting mains power was going to cost $70,000.

The system they started with cost them $31,000 for 14 x 160 W BP panels, two PL40 regulators, six Exide Energy Store 4 V batteries, 1800 Ah @ 100hr rate, Latronics 3000 W inverter, Stanbury Scarf 70 A AC battery charger, plus some sundry components. They also purchased a Lister 10 kVA generator for about $11,000.

Using the system, they run a fridge and chest freezer full time, the biggest continual drain as they are in the tropics. They have all the other standard domestic appliances, apart from an electric kettle and toaster. Cooking is gas and they have an Edwards 300 L solar hot water system, with AC boost off the genset.

The generator has averaged 175 hours per year in eight years, but that's partly because they used it for welding to build the house—Max doubts it would do 50 hours per year now, so less than one hour per week; it uses approximately 2 L of diesel per hour. They use it mostly in the summer wet season. Winter is a good time for power production and, in addition, the nights are cool so the refrigeration doesn't use as much energy.

Max notes that they have to be careful about their energy use. For example, they aim to use the washing machine when it's sunny. He says, "You can't just turn a lot of lights on to work at night or plug something like a microwave or compressor in without thinking about it."

He says he wouldn't go off-grid if he didn't have to. They've learned to live with the system, but it's "still a bit of a pain". He says, "People considering off-grid need to really understand how it works and the costs long-term or they may be unpleasantly surprised."

The specifications of the system indicate that there are options for increasing capacity/productivity, but the system is currently meeting the owners' needs, so they see no need to spend money on changes. However, they have stated that when the time comes for a new battery bank they will look at other possible upgrade options.

2/ MIKE Murphy from Crystal Springs, near Walpole in WA, has a system that was commissioned in 2005. It was recently upgraded in an attempt to improve performance as the backup generator was being run more often during winter and the batteries were running down more quickly.

With rebates, the original cost was much the same as connection to the grid. The system was also attractive as it didn't involve power lines across a neighbour's property, the district suffered regular power failures and it fitted in with their sustainable lifestyle aims.

However, the system has required more maintenance and caused more stress and problems than was anticipated. For example, the original lead-acid batteries required frequent monitoring and maintenance; these have now been replaced with sealed gel batteries. The original inverter/charger burnt out and had to be replaced. Various generators have been used and discarded due to excess noise and technical problems, but they've found the current Honda 300 generator quiet and efficient.

Mike says, "In hindsight a larger system should have been installed using a supplier who offered a better backup service." Changes in lifestyle were not anticipated in the original design. Power usage, particularly of computers and the TV, increased, and there was increased use of kitchen appliances not included in original estimates.

The growth of trees on their own and a neighbouring property have reduced sunlight on the panels during winter. Mike thinks the system should have been placed higher to avoid this problem or other measures taken to improve northern exposure during winter.

The total cost of the system including replacements and the recent upgrade is now more than double what it would have cost to connect to the grid originally.

Mike says: "It would have been cheaper and less stressful to connect to the grid except for the advantage of having a stand-alone alternative system which is more environmentally friendly and in keeping with other lifestyle values."

Image: Off-Grid Energy Australia

Generator-free first-timers

ROSEMARY and Vic Morgan had always been interested in the idea of living off-grid, with the final push coming from economics. When they moved last year to a property in Oakhampton, near Maitland in NSW, they found that it was going to cost only a little bit more to go solar than to connect to the grid.

As first-timers, Rosemary says, "it was a bit scary to go off-grid—we didn't know much about it." They researched on the internet and found there weren't that many companies offering completely off-grid systems. The company they chose, Off-Grid Energy Australia, are located in South Australia, but they found the distance didn't matter. A local agent did the energy auditing and two people from the company drove over from South Australia to do the installation (which took about a day and a half)—and the company has always been available on the phone for queries.

When working out the size of the system, the agent "looked at every appliance, down to the tiniest thing," Rosemary says. An air conditioner for the bedroom is included in the calculations, but they haven't installed it yet and now think they may not need it as the house stays cool.

The system doesn't include a backup generator, so they're completely fossil-fuel free for their electricity. It includes 24 x Trina TSM-250W polycrystalline solar panels (6 kW total), an SMC6000 SMA solar inverter, an SI5048 SMA 5 kW inverter/charger and 24 x A602-850 Sonnenschein sealed gel VRLA batteries (39 kWh). The system is sized for around 13 kWh in summer and 6.5 kWh in winter, with five days of autonomy. The batteries can regularly handle a SOC of around 70% to 80%, with occasional deeper cycling.

After 12 months, they're starting to feel more relaxed about the system. It's worked well for them. They regularly check the charge of the batteries, which generally stay around 95% to 99% SOC. They did have one stretch of seven cloudy days in winter which they got through by being "sensible" about their energy use, though the batteries did get down to 60%. They've also had one hiccough with the inverter a few months after installation; Off-grid Energy helped them over the phone and then flew in with a replacement part once it became obvious it wasn't going to right itself.

They use bottled gas for heating and cooking (including an outside pizza oven which Rosemary strongly recommends) and they have an electric-boosted solar hot water system. The best thing about the system is "no more bills", says Rosemary. "We've had a few neighbours wishing they'd gone this path too!"

Power to the music

NICKNAMED the Sunflower, this portable off-grid unit aims to help the Australian music industry 'think greener'. Designed and built at Southern Cross University, NSW, with the help of Creative Environment Enterprises, it's being used to make music festivals more sustainable.

Project leader Dr Barry Hill says, "As a musician, I've performed at many music festivals around Australia in locations where no power is available. The soundscape of festivals in these natural landscapes is dominated by the sounds of diesel and petrol generators that distract from the music as well as polluting the environment."

In early 2013, the system had its first outing at the Byron Bay Blues Festival, powering one of the festival stages. Currently, with advances in audio technologies and the use of LED lighting, it can power a small festival stage (covering lighting and 'front of house'—foldback speakers, guitar amps, mics and the like), with a system based on a 1.2 kW PV array, an 800 Ah lithium battery bank and 3 kW inverter. The 'petals' of the Sunflower can tilt for optimum orientation to the sun, and the whole system, weighing 1300 kg, is mobile.

The power draw from a small stage with the latest audio technologies and energy-efficient LED lighting averages around 2000 watts—this system can run from 8 to 12 hours without charge and up to 20 hours with good solar input during the day. The project is still developing, with aims to showcase sustainability in a raft of ways for festivals (including composting toilets, greywater and power input from a kinetic dance floor!). The system's next appearance is at Vivid in Sydney in May 2014, where it's being used to power 'Ray', a 7-metre interactive light sculpture, intended to highlight the impact one light can have on a family living in energy poverty.

scu.edu.au/arts-social-sciences/index.php/93, www.vividsydney.com/events/ray

If you go down to Phillip Island today, you're in for a bit of a surprise ...

AS WELL as the Penguin Parade on Phillip Island, Victoria, you might be lucky enough to catch a glimpse of the 'Pengloo'. You can also see it on John Safran's Facebook page, where he dubs it a CIA Illuminati pod.

In fact, it's anything but—rather, it houses a stand-alone power system for a penguin weighing station for use in penguin research.

Being an environmentally sensitive area with lots of penguin burrows, there was no easy way to get mains power to the station. SAPS housed in the Pengloo (designed by Energy Connections) was a cost-effective alternative. The igloo shape helps deflect the intense winds common in this spot, particularly important as they couldn't use concrete footings. The steepness of the roof is to increase winter power generation from the solar panels, and the spikes are to stop birds perching on top and messing up the panels!

The system uses two Suntech 250 W panels, four 240 Ah Neuton batteries, an Outback FM80 charge controller and a small inverter for running laptops.

The batteries are wired for 48 V to supply the communications equipment. A 48 V to 13.8 V DC-to-DC converter provides power (via a cable) to the weighbridge located about 60 metres down the cliff, on the main path the penguins use to return to their nests. An RFID chip in tagged penguins is read and the weight and penguin ID are sent via CAT5 back up to the Pengloo. This data is stored there before being sent to the main research centre, approximately 500 metres away, via a transmitter on a pole atop the Pengloo (not fitted in photo).

It should soon be tracking penguin weights across the seasons—so long as the penguins don't duck under the bridge (they've had to install barriers to keep them on track!).

Alice Schinzig describes how their off-grid system has surpassed expectations

LUKE and I and our two young children (aged one and three) live on a farm, out of Kojonup, WA. Our decision to have off-grid power was purely financial and practical. There were no services to our home site and the initial cost to get our new home connected to the grid was ridiculous. It was not borne out of a romantic notion of living self-sufficiently, but we knew that it would be practical and would work. Our builder (WA Country Builders) discussed this with Great Southern Solar and there was never any doubt over what we were doing.

Our system comprises 18 Tenesol 235 W PV panels mounted on Conergy Sun Top III roof-mount framing, a Selectronic SP PRO SPMC 481-AU interactive inverter, an Outback FLEXmax FM80 Solar Controller, 24 BEA sealed lead-acid batteries configured as one 48 V, 705 Ah bank and a Gentech 9 kVA generator.

Great Southern Solar designed the system in early 2013. Their manual says it was designed to service an average AC daily load of 10.1 kWh in summer and 10 kWh in winter, with supply autonomy of 2.3 days and an average battery bank depth of discharge of 30%.

The system cost less than $40,000, fully installed and set up, less solar credits—147 STCs @ $23/STC = $3381.

After a year off-grid, we don't really think about our energy use anymore. Luke can still run the welder at night while I'm in the house working on the computer or boiling the kettle.

Our energy use was never extravagant, but we haven't made any sacrifices or changes to how we do things. Also, because it's a new house, it's built to a 6 Star energy rating so the energy required to run the home is less. The new appliances are also more energy efficient, which I guess has made a difference. I think that the greatest testament to our system is that we don't even think about it anymore. We do have a backup generator, but we have never used it!

We have a gas stove/fan-forced oven as well as a microwave, electric toaster, electric kettle and dishwasher, and we use a gas hot water system. All our electric appliances are connected to the off-grid system and, apart from the stove/oven, dishwasher and HWS, are all appliances we brought from our other grid-connected house. It seems to be most surprising to people that we do have an electric kettle and toaster and we can use this while watching TV or using the computer.

So far, the system has surpassed our expectations. I had expected to make some compromise in the things we do, such as the timing of appliances etc. To be honest, our water supply is more of a worry than our power (we are completely reliant on rainwater). I do not hesitate to encourage others to do the same.


Keep the sun up
after sunset.
Carolin R., teacher
BOSCH
e.Key
BOSCH
Language: English
Country: Australia
For us it's the details that make the difference. At Bosch we like to think: What would make your life easier? Hence we are introducing the BPT-S 5 Hybrid. It combines high efficiency inverter technology and lithium-ion batteries to store the power generated by the solar system and make it available day and night. Also our new BPT-S string inverters were developed to make things easier. They can be setup easily and fast with a unique RFID "e.Key" card and work with touchless gesture control for easy and reliable operation. The "hard facts" are convincing too: High efficiency rates, up to 4 MPP trackers, and an integrated data logger, just to name a few.
That's technology made by Bosch. Read more at
bosch-power-tec.com or bosch-solar-storage.com
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Invented for life

More flexible energy systems
Energy storage buyers guide

There has been a steady increase in the number of ready-to-use energy storage systems available. In this mini-guide, we take a look at the options so far.

The Solari Energy SolaGRID is completely self-contained and can be used in on- or off-grid applications.

PROVIDING electricity to off-grid homes has always required the use of a suitably sized battery bank for energy storage.

In recent months, there has also been a lot of interest in energy storage for homes with a grid-connected solar system—whether for avoiding export at times of excess solar generation (see box), load shifting (buying energy when cheap, storing it and then using it to offset energy use at more expensive peak times) or for supply backup, for times of mains power grid failure. The latter is especially important for users with critical needs, such as telecommuters, people with medical appliances and the like.

Both on- and off-grid storage systems need a battery bank sized to suit the requirements. This is coupled with energy generation equipment such as solar panels, a charge controller, an inverter and various other components.

There has been a move in recent years towards storage systems that contain the batteries and other components in a pre-configured 'storage in a box' module that is simply connected to a generator such as a PV array. These sorts of pre-configured energy storage systems are the focus of this buyers guide. We have included any unit that contains a battery bank and associated safety gear, as well as at least one other system component such as the charge controller or inverter.

We do not cover individual batteries/cells, as they have their own buyers guide, the most recent of which appeared in *ReNew 113*.

Pros and cons

There are several advantages to this sort of 'storage in a box' system. Firstly, installation is usually quick as much of the wiring between components has been done. Secondly, it often makes for a neater system as many components and their associated wiring are enclosed in a single cabinet.

There are some disadvantages too, including less flexible system sizing—most suppliers have a few standard battery bank sizes that they offer. However, storage units may be modular so that multiple units can be used to make up the required capacity.

For off-grid systems, it's critical to have enough energy generation and storage to meet your needs, so these are more likely to be of the traditional type with a separate battery bank and other components, unless your needs fall within the specifications of one of the pre-configured boxed systems.

On-grid viability

For on-grid solar systems, energy storage may or may not be economically viable when you factor in the cost difference between off-peak and on-peak power, feed-in tariffs versus cost of electricity, the cost of replacement batteries and the system maintenance required.

The financial viability depends on your intended use, chosen system and available electricity tariffs, but given that the cost of energy is probably only going to keep rising, while the cost of renewable energy equipment keeps falling in real terms, many people may decide that it is worth the initial expense.

Community benefits of batteries

Adding battery storage may also benefit your local community. Drawing from batteries in the early evening reduces your demand on the grid at a peak time, which helps your electricity supplier delay expensive capacity upgrades. Also, power line voltage in some streets rises when everyone is exporting from their solar systems at the same time. If the voltage gets too high, solar systems cannot export and solar generation is wasted. Battery

↑ The Bosch Hybrid system looks more like a domestic appliance than an energy storage system.

systems help your exporting neighbours to share your local infrastructure.

System features

'Storage in a box' systems may have very different features, capacities and included equipment. Batteries may be lead-acid (usually AGM or Gel sealed units) or lithium batteries, usually lithium iron phosphate, more commonly called $LiFePO_4$ or 'lifepo'.

The batteries will have some form of charge controller (often called a regulator), which controls charging of the batteries to prevent overcharging. This may be a typical lead-acid charge controller or a full battery management system (BMS) in the case of lithium batteries, as lithium batteries are more likely to be damaged if they go over or under specific maximum and minimum cell voltages. The BMS may be off-the-shelf, or a proprietary design.

Also included will be safety equipment such as main battery fuses or circuit breakers, temperature sensors for battery monitoring, and current monitoring equipment such as a current shunt or sensor. The system may also include other balance-of-system equipment such as the inverter, either stand-alone or hybrid. A hybrid inverter can act as a stand-alone device connected to batteries, or it can act as a grid-interactive inverter, or a combination of the two (the Selectronic SP Pro is a typical example).

Monitoring and the displays provided will depend on the equipment used in each system, but almost all modern renewable energy equipment has provision for at least a remote display, or datalogging and data export to either proprietary or generic web portals, such as pvoutput.org.

Lead or lithium?

Your preference of battery chemistry will affect which systems are available to you. Many people prefer lead-acid batteries because they are a tried and true technology that they have experience with. Lithium batteries, to many people, are a bit of a black art, but they are maintenance-free and are cared for by the system BMS, so you actually don't need to avoid them just because you have no experience with them.

The other concern with lithium batteries is lifespan. As they are quite new, at least to the renewable energy industry, there is a concern that they have not proven themselves. But lithium chemistries have proven themselves elsewhere (almost every rechargeable device you own uses lithium batteries of one form or another) and that knowledge has flowed into the battery management systems used in renewable energy equipment, so there is no reason to believe that lithium batteries, especially $LiFePO_4$ batteries, which are considered the most robust of the lithium chemistries, will not perform as expected in household use.

Lifecycles of both lead-acid and lithium batteries can be very long, several thousand charge-discharge cycles, but lithium batteries are capable of withstanding more cycles at greater depths of discharge, at least compared to most lead-acid batteries, so they can be expected to have somewhat longer lifespans.

However, systems using either technology should provide battery lifetimes of up to 10 years provided that the system is appropriately sized to the intended usage and load profile (how much energy is used, and when).

Each system listed in this guide specifies the available storage capacity, and suppliers should be able to provide estimated battery lifespan versus depth of discharge information when requested.

Sizing your system

Off-grid systems must be sized to meet all electrical loads and to provide the appropriate number of days of backup for periods of low energy generation (such as cloudy days in winter). See 'Off-grid Basics' on p. 45 for more information on this.

For on-grid systems, the capacity required will depend on how long you need (or want) to run your house for without mains power or, if you are primarily using the system for avoiding export or load shifting, how much energy you want to shift.

System design and sizing is very important for an effective and reliable system—if in doubt, get advice from a qualified installer.

AC or DC coupling

When looking at renewable energy systems you will hear the terms 'AC coupled' and 'DC coupled'.

DC (direct current) coupling is the traditional system used in off-grid systems. The energy generated, such as from PV panels, feeds directly into the batteries via a dedicated charge controller. This means the generation/storage is independent from the AC side of the system, which may not even include a DC–AC inverter (but usually does).

Alternating current (AC) coupling involves the PV panels feeding one or more grid-interactive inverters. Without a grid

Avoiding export

If you've got a grid-connect solar system, a key benefit from adding batteries is to minimise the amount of electricity you export to the grid.

Solar systems installed in the last couple of years typically attract only a low rate for these exports via a feed-in tariff (FiT) of 6 to 8 cents per kWh. Householders typically pay many times that amount for electricity they import from the grid.

If you are not consuming much electricity during the day, it makes sense to store your solar generation to use when you come home. Even if you are home during the day, you may be exporting more than you expect because your consumption fluctuates as appliances switch on and off, and solar generation varies as clouds pass. Batteries can smooth out these fluctuations, resulting in less export and greater benefits from your solar generation.

"Consumption fluctuates as appliances switch on and off, and solar generation varies as clouds pass. Batteries can smooth out these fluctuations, resulting in less export and greater benefit."

connection, the inverter(s) wouldn't operate, so an inverter/charger is connected to the battery bank to provide the equivalent of the mains grid. All current into and out of the batteries goes via the inverter/charger, so there is no direct DC feed into the batteries from the solar panels. Because many inverter/chargers can also connect to the mains grid, AC coupled systems can be used for both off-grid and grid-connected systems. Most of the systems listed in the accompanying table are AC coupled systems, as they are designed for use in both off-grid and grid-interactive modes.

Both methods have some advantages and disadvantages. DC coupled systems using MPPT charge controllers will harvest slightly more energy than AC coupled systems as there is only one level of energy conversion between the solar panels and the battery bank, whereas AC coupled systems have two (first by the grid-interactive inverters, then by the inverter/charger).

DC coupled systems will generally cost less as the charge controller is usually cheaper than a grid-interactive inverter and off-grid inverters are simpler and cheaper than inverter/chargers (assuming the system doesn't include a genset for backup charging).

AC coupled systems are generally more suitable for larger installations and those where expansion may be required. New generation sources are simply coupled to the AC side of the system using either one of the existing inverters (if spare capacity is available) or an additional grid-interactive inverter.

Examples of both types of system can be seen in the diagrams in the 'Off-grid Basics' article elsewhere in this issue.

Warranties

As you would expect, system warranties vary by supplier and component, but you should look for at least two years (and preferably five years) on the inverter and other equipment, and at least two years on the battery bank.

Battery lifespan is likely to be more than the warranty implies, provided that the system has been correctly sized and the batteries do not undergo regular excessively deep cycles.

A few terms

Capacity at discharge rate: This is given as a C rating, where C stands for the capacity of the battery. So a C10 rating is the battery capacity divided by 10. So, a battery rated at 1100 Ah C100 will have that capacity when discharged at 11 amps for 100 hours. This rating is important for lead-acid batteries as their capacity varies depending on the rate of discharge. Lithium batteries have a fairly fixed capacity regardless of discharge. Determining which C rating to use depends on the battery cycle depth each day. If the system discharges over a number of days then the C100 rate would be used. If it cycles every day or two then C10 would be used.

Depth of discharge/State of charge: Depth of discharge refers to how much capacity is used per cycle. If a battery undergoes a DOD of 10%, then 10% of its rated capacity is used. State of charge indicates the charge remaining and is effectively the opposite of DOD. A battery with a DOD of 20% has a SOC of 80%.

BMS: Battery management system. These are primarily used on lithium battery banks to prevent over charging or over discharging of individual cells, which can damage them.

Inverter: The device that converts the DC power from the battery bank (for off-grid and back-up systems) or the solar array (on-grid and hybrid systems) to mains AC power.

Continuous output rating: This refers to the power rating of the inverter and determines what loads can be run on the system. A system may have an inverter with a 3000 W continuous rating, which may be able to produce 4000 W for 5 minutes and 8000 W for 5 seconds (for starting motors and the like).

Charge controller: In a DC coupled system, the solar array charges the battery bank via the charge controller, which prevents the battery bank from being overcharged. It is a simple form of BMS, although many charge controllers now have quite complex functions and can be a complete BMS.

MPPT: This stands for maximum power point tracking, and refers to the system grid-connect inverters and some battery charge controllers use to get the most energy out of the solar array by running it at the voltage that allows it to produce the most power.

Maintenance and upgrades

Because most of the system is pre-configured and the batteries are normally low maintenance or maintenance free, there is not much to do as far as looking after your system. Each finished installation should come with instructions on any maintenance or checks that need to be done, such as keeping batteries and components clean and free from insect and animal infestation, and checking for loose battery connections.

With internet connectivity of the system, the owner may not need to concern themselves with monitoring at all. The system supplier can simply take a look at the system remotely and check for any problems that may be occurring. Minor glitches may even be able to be fixed remotely, without the cost of a site visit. Such are the advantages of modern communications technologies!

System upgradeability depends on the system itself—some are modular, and you can double system capacity just by adding another module. If you are planning to extend the system in the future, ask about this ability.

As battery technology is entering a new phase of rapid development, the batteries your system comes with may be obsolete when they are due for replacement. If your system has lead-acid batteries, you may be looking at a switch to lithium batteries in the future, so check whether the system can handle batteries of a different chemistry. If not, you may be stuck with lead-acid batteries for future upgrades unless you replace other parts of the system, adding expense to an otherwise simple task of battery replacement.

Off-grid vs on-grid

When looking for your new energy storage system, bear in mind that some systems are designed specifically for off-grid use while others are designed for grid-connected homes, and some will be able to do both, so you may not be able to get the brand/model of system you prefer in the application type you require. However, the supplier may be able to provide a customised unit for your needs. ✸

Other resources: for batteries, Battery Buyers Guide in *ReNew 113*, Know Your Batteries and Battery Sizing in *ReNew 123*, and Off-grid Basics in this issue on p. 45; for inverters, Inverter Buyers Guide in *ReNew 122*; for charge controllers, see Regulator Buyers Guide in *ReNew 121*.

Brand	Model	Used for (on-grid, off-grid or both)	Capacity @ discharge rate	Continuous output rating	Battery brand/ model/chemistry	Included equipment (charge controller, inverter etc)	Price	Warranty	Comments
Aussie Batteries and Solar 3/64 Sugar Rd, Maroochydore QLD 4558 ph: 1800 853 315 info@aussiebatteries.com.au www.aussiebatteriessolar.com.au	24 V 1.5 kW Pre-wired Off-Grid Kit	Off-grid	Total capacity 16.8 kWh@C100, designed for 3.9 kWh@C100 3 days autonomy	3000 W	Giant Power 12 V 350 Ah AGM batteries @ C100	6 x 250 W 24 V Trina panels, mounting, roof & board isolation, etracer 60 A charge controller, HRC fusing, Must Power 3000 W inverter/charger, 4 x 280 Ah 12 V AGM batteries, metal battery bank box, pre-wired board, signage kit, wiring	$8900	Inverter, charge controller – 2 year full replacement manufacturer's warranty. Batteries 5 year warranty, first year full replacement and a 48 month pro-rata replacement warranty	We specialise in pre-fabricated off-grid kits
	48 V 3 kW Pre-wired Off-Grid Kit		Total capacity 33.6 kWh@C100, designed for 7.8 kWh@C100 3 days autonomy	3000 W	Giant Power 12 V 350 Ah AGM batteries @ C100	12 x 250 W 24V Trina panels, mounting, roof & board isolation, etracer 60 A charge controller, HRC fusing, Must Power 3000 W inverter/charger, 4 x 280 Ah 12 V AGM batteries, two metal battery bank boxes, pre-wired board, signage kit, wiring	$14,400		
	48 V 4.5 kWh Pre-wired Off-Grid Kit		Total capacity 43.2 kWh @C100, designed for 10 kWh@C100 3 days autonomy	6000 W	Giant Power 6 V 450 Ah AGM batteries @ C100	18 x 250 W 24V Trina panels, mounting, roof & board isolation, 2 x 60 A etracer charge controller, HRC fusing, Must Power 6000 W inverter/charger, 16 x 6 V 450 Ah AGM batteries, two metal battery bank boxes, pre-wired board, signage kit, wiring	$23,300		
Aussie Solar ph: 1300 794 110 info@aussiesolar.com.au www.aussiesolar.com.au	TM5000	Hybrid, on/off-grid	5–20 kWh	5000 W	Panasonic AGM, LC-T12105 lead-acid	Converter, switch box, battery bank, sensor, cabling	$8295	5 years converter and switch box, 2 years battery	AC couples to any new or existing grid solar system
Harmonic Energy ph: 1300 766 199 contact@i-kube.com.au www.i-kube.com.au	iKUBE F150	Off-grid	10.80 kWh@C10	2400 W	Ritar/RA6-225SD/ sealed lead-acid	Solar panels, collapsible framing system, charge controller, inverter/charger and batteries	Starting at $11,500	Component based	
	iKUBE F50		2.70 kWh@C10	800 W			$3,995		
Magellan Power 64 Bushland Ridge Bibra Lake WA 6163 ph: (08) 9434 6621 admin@magellan-power.com.au magellanpower.com.au	GPSS-100kVA-400kWh	On-grid	435 kWh	100 kW	Kokam/KBM255 2P14S/lithium cobalt manganese nickel oxide (LiMnNiCoO2)	Three-phase four-quadrant IGBT-based bidirectional inverter; programmable current control; communication options including modbus RTU (USB/ RS485), modbus TCP (ethernet), DNP3 (ethernet), inbuilt website (ethernet); battery management system		2 years	Australian designed and manufactured. AS4777 compliance. 3-phase inverter and lithium manganese nickel oxide (LiMnNiCoO2) batteries. Suited to applications including frequency and voltage regulation, peak load management, reactive power compensation, RAPS, solar smoothing, diesel reduction.
Off Grid Lithium Power ph: 0420 948 757 info@offgridlithiumpower.com www.offgridlithiumpower.com	LTSS43002U	Grid-tie, peak shift and off-grid modes	4455 Wh	3 kW	LiFeTech Energy XPS series, LiFePO4	Power cabinet with master controller, MPPT solar charger and grid tie inverter. Can accept from 1 to 6 modular battery packs.	TBA	Minimum 3 years extended warranty option	
	LTSS86002U		8910 Wh						
Positronic 2/214 Leitchs Rd Brendale QLD 4500 admin@positronicsolar.com.au www.positronicsolar.com.au	Positronic ESS	Both	5 kWh to >100 kWh 4000 cycle life	2.5 kW single-phase to 54 kW three-phase	LiFePO4	Schneider XW 6 kW (multiple units if required), battery management system, load management system, data logging	$10,000 - $100,000	5 years on inverters, 2 years on batteries	AC coupled system, utilising either Conext or Trannergy inverters on greenfields. Can be added to existing grid-tie systems.
RF Industries ph: 1300 000 734 www.rfisolar.com.au	SONY IJ1001M	Both	1.2 kWh, 48 V nominal modules	50 A/2.5 kW maximum discharge current/power	SONY, Fortelion, Lithium iron phosphate	Battery management unit purchased separately	POA	To be advised	6000 cycles to 100% depth of discharge, with 80% capacity retained. Compatible with CAN-Bus enabled inverter/chargers from SMA, PowerRouter, with other brands approved soon.
Robert Bosch Pty Ltd ph: (03) 9541 5555 www.bosch.com.au	Bosch Power Tec BPT-S 5 Hybrid	Both	3.1 kWh (@70% DOD) 4.6 kWh (@70% DOD) 7.0 kWh (@80% DOD) 8.8 kWh (@80% DOD) 10.6 kW (@80% DOD) C rating: 4.4–6.6 kWh = 1C 8.8–13.2 kWh = 1/3C		Li-ion (Li-ion NiCoAlO2)	Integrated system including: PV inverter battery converter battery management system batteries	On request	5 years standard, extendable to 10 years. Current special offer: all systems come with a 10 year battery warranty	The BPTS Hybrid complies with very high safety standards and has a safety certificate as a whole system.
Selectronic Suite 5, 20 Fletcher Road Chirnside Park VIC 3116 ph: 1800 006 474 www.selectronic.com.au	myGrid	Both	MG0240A - 8 kWh	3.0 kW	Sonnenschein 330Ah 6V Solar Block Gel batteries	Battery enclosure DC battery cables DC battery sense cables Pre-assembled battery interconnects Selectronic SP PRO interactive inverter Batteries Dual-pole 250A DC circuit breaker	Call your nearest supplier	3–8 years	All capacities are at C100 rate. The myGrid Energy Centre includes everything you need except for your renewables. Includes integrated battery circuit breaker with optional remote shutdown. Quality German batteries included in each kit. As an added bonus each SP PRO inverter sold as part of a myGrid Energy Centre will receive an additional 12 months warranty.
			MG0240B - 16 kWh	3.0 kW					
			MG0241A - 8 kWh	4.5 kW					
			MG0241B - 16 kWh	4.5 kW					
			MG0481A - 16 kWh	5.0 kW					
			MG0481B - 32 kWh	5.0 kW					
			MG0482A - 16 kWh	7.5 kW					
			MG0482B - 32 kWh	7.5 kW					
			MG1201A - 40 kWh	7.5 kW					
			MG1201B - 80 kWh	7.5 kW					
			MG1202A - 40 kWh	20.0 kW					
			MG1202B - 80 kWh	20.0 kW					
			MG1202C - 160 kWh	20.0 kW					
Solar Farm Kits 1/12 Oak Ave Surfers Paradise QLD 4217 ph: 1300 695 928 info@solarfarmkits.com.au www.solarfarmkits.com.au	SFK Lithium or AGM	Off-grid and hybrid	10 to 78 kWh	3 to 12 kW	SFK 1000 Ah lithium or SFK 410 Ah 6V to 2V 1750 Ah AGM	60 to 80 A charge controllers, 3 to 12 kW inverter/chargers, SFK model BMS system all ready to go, plug and play including solar array and roof or ground mounts	$10,050 to $79,000	10 years on electronic products, 25 years on solar panels, 15 years on lithium cells, 5 years on AGM	Complete kits including solar array, ready to plug and play
Solari Energy ph: (07) 3166 9598, (03) 9017 1010 info@solarienergy.com.au www.solarienergy.com.au	SolaGrid ESS 10	Both	10.9 kWh @ C10 usable 12.2 kWh @ C20 usable 705 Ah @ C100	4.6/6 kW: stand-alone versions 5 kW: grid-coupled version	BAE / 6 PVV 660 / valve regulated lead-acid gel (non-spillable)	Inverter/charger, battery protection (overload) AC protection and distribution, forced ventilation (fans) and thermostat	From $16,925 to $26,018 ex-GST	System 5 years, batteries 3 years	Fully customisable to suit your system requirements
	SolaGrid ESS 20	Both	18.5 kWh @ C10 usable 21 kWh @ C20 usable 1190 Ah @ C100		BAE / 8 PVV 1200 / valve regulated lead-acid gel (non-spillable)		From $25,097 to $34,190 ex-GST		
Vulcan Energy Pty Ltd 43-45 Dover Drive Burleigh Heads QLD 4220 ph: (07) 5593 7773 mail@sunsink.com.au www.sunsink.com.au	Sun-Sink	Mainly for on-grid systems as time shifter, can be used in all 200-600V PV configurations. Including hybrid and off-grid.	5 kWh or 10 kWh nominal, actual capacity is higher	3 kW nominal 5 kW maximum	Headway LiFePO4 10 Ah 38120S	DC/DC buck-boost, firmware configurable parameters. Sensing and SCADA and remote triggering.	5 kWh $3500 10 kWh $6500 Serviced lease model (annual fee 10%)	Not applicable (serviced lease model)	Serviced lease model provides low upfront cost, limitless lifespan and accountabilty for electricity distributors.
ZEN Technologies Pty Ltd 33 King Street Norwood SA 5067 ph: 1300 936 466 enquiries@zenhomeenergy.com.au, www.zenenergy.com.au	ZEN Freedom PowerBank	Both	10 kWh and 20 kWh	5.0 kW	ZEN BOS3 (3rd Generation Advanced Battery Operating System). 16 x lithium iron phosphate 400 Ah	Grid-connect battery backup control module, maintenance-free batteries, battery enclosure, battery fuse, AC panel	POA	Battery warranty 2 years, control system warranty 5 years	Ideal for people in rural, remote or bushfire-prone areas where disruptive and costly power shortages or blackouts are an issue.

Keeping the water flowing
Remote pumping buyers guide

Moving water is a requirement on nearly every remote and rural property. We take a look at the different types of pumping systems and what pumps are available.

ON MANY rural properties, pumping water is critical, whether it be for watering stock, irrigating crops or providing potable water for household use. Mains power may not be available on the property or the pump may be far removed from the house, so these pumps often require an alternative energy source, such as solar panels or wind power.

For both rural and non-rural off-grid properties, off-grid pumps are also often used for circulating water, for example in a remote-coupled solar hot water system.

These pumping requirements may also be critical to the operation of a farm business. Such off-grid pumps thus need to be reliable, easy to maintain, long-lived and cost-effective.

So what are some of the features of pumps that need to be considered? Firstly, different tasks require different pumps: for example, the pump for drawing water from a well or bore will be different from a pump to circulate water through a hot water system. Secondly, the amount of water and the height it needs to be pumped to (the 'head') also vary from site to site, and the pump needs to cater for these requirements.

To meet these variations in pumping requirements, there are many different types of pump on the market. These include the well-known windmill-powered bore pumps, solar bore pumps, reticulation pumps and pressure pumps. There are also numerous types in each of these categories, adding to the confusion in choosing a pump.

This guide looks at pumps designed to be powered from renewable energy sources—solar, wind and water. It includes DC electric pumps as well as pumps directly driven by wind or water power.

Photo: Carbon Management Solutions

↑ A typical solar pumping setup. This one is using a submersible pump to draw water from a dam.

Although 240 volt pumps may at first appear an obvious choice due to low cost and the wide range available, they require AC power to operate, necessitating the use of batteries and inverters or expensive solar pump controllers. These increase system cost and complexity, an unsuitable characteristic for remote pumping. In addition, there are so many shapes and sizes of 240 volt pumps on the market that it would be impossible to cover them all in our table.

Pumping terms you need to know

Before beginning your search there are a few terms you should understand: head, lift and flow rate.

Head, also called **pumping head**, is how high the pump can push water above itself. It is not the total distance up a hill, only the vertical height component. In a bore pump it also includes the depth from the pump inside the bore to the surface.

The total pumping head also includes a component for the frictional loss due to viscous effects produced by the internal surface of the pipe. A smaller diameter or longer pipe will have greater frictional losses, which will reduce the maximum possible pumping head for a given flow rate. The smaller the pipe, the greater the frictional loss and the lower the pumping head for that flow rate. This needs to be allowed for when calculating head values.

Lift (also called **suction head**) is generally how far a pump can raise water from below it (and also includes frictional losses)—almost the opposite to pumping head. A pump's lift rating is usually a lot lower than its pumping head rating, and some pumps cannot lift water at all. Some surface-mounted bore pumps lift water from a deep bore by using injection tube systems, eliminating the need for submersible pumps.

The **flow rate** is the volume of water that the pump will move over a given time period. For electric pumps, the flow rate depends on several factors, including the amount of electrical input power, the head and lift the pump must deal with and the diameter of the pipes connected to the pump.

For wind-powered pumps, wind speed is also a factor in flow rate. For water-powered pumps, the available flow of water and the height it falls from (also called the drive head) will be the main determinants of performance.

Powering the pump

DC PUMPS

There are a large variety of pumps made to run on extra-low-voltage DC power supplies. Some are meant to be run from battery systems, while others will run directly from solar panels via a maximiser, a device which matches the load of the pump motor to the panels.

The pump usually consists of a DC motor, either electronically commutated (brushless) or brushed, connected to a pump head of some kind.

Some pumps, such as submersible bore pumps, have all of the components in a compact package, while others have them mounted separately and coupled via a shaft or drive belt.

AC PUMPS

Some pumping systems designed for solar or remote energy sources use AC pumps. The solar panels feed a special controller/inverter which then drives the pump with AC power. These types can be expensive but are usually quite reliable and will be more efficient than most mains-powered AC pumps.

WIND-POWERED PUMPS

You can pump water with the wind in a number of ways. The most well known is the use of a low-speed, high-torque wind turbine to drive a mechanical pump directly at the base of the turbine tower. This is a tried and proven pumping method, providing water to farms and remote buildings around the world for over a century.

Another way of pumping with the wind is to use an electricity-producing wind turbine to drive an electric pump directly. The pump must be well matched to the characteristics of the wind generator.

A third method is to use a wind turbine to compress air, which can then be used to drive a pump of some sort, such as an air-lift pump. Two examples of home-built compressed air pumps appeared in *ReNew 66*.

WATER-DRIVEN PUMPING

It may sound strange, but running water can indeed be used to pump water, and to quite high heads. A relatively large flow at low pressure, such as the diverted flow from a river or stream, is used to pump a much lower volume of water to a much higher head.

Such pumps, known as 'ram' pumps, can operate continuously, completely unattended, for months or even years before maintenance is required. If you have a reliable source of flowing water or a water source with even a small head, then a ram pump may be ideal.

Types of pump

CIRCULATION PUMPS

These are used to circulate water through a closed system, such as a remote-coupled solar hot water system where the tank is lower than the panels. While many can withstand high

↑ Maximisers, such as the AERL Pumpmax, match the solar array to the pump motor for maximum pumping from the available energy.

Maximimising your solar pump

A maximiser, or maximum power point tracker, is an electronic device used with solar panels that enables a pump or motor to keep operating in conditions of cloud and low light levels.

Many pumps will simply stop when a cloud causes the solar panel output to reduce. This happens because the pump motor places too high a load on the panels and their voltage drops dramatically, thus reducing their output power. The maximiser works by preventing this and will allow the pump to keep operating, thus pumping more water than it otherwise would.

If you are installing a solar-powered pumping system, then you really should consider a maximiser in the system. Most pumping suppliers have them and they range in price from less than $100 to over $1000, depending on their power handling capabilities and features.

Some pumps require a special pumping controller in order to operate, and usually come bundled with one as a complete package. Usually the controller is designed to work with a specific motor or series of motors, and so the overall efficiency of such a system can be quite high.

system pressures, making them suitable for use in mains-pressure systems, they can also be used for purposes that do not require high differential pressure across the pump, such as transferring water between rainwater tanks. However, circulation pumps are generally not suited for pumping to high heads.

GENERAL-PURPOSE PUMPS

These include all sorts of small and large pumps. They are often used for moving water or other liquids from one place to another over relatively short distances and at low pressures and heads, such as from a dam to a storage tank. While bilge pumps (usually used for pumping out the bilge of boats) may appear ideally suited to such tasks as moving water from one tank to another or in water fountains and low-pressure irrigation, they are not designed to be run continuously and so generally are unsuitable for many uses.

PRESSURE PUMPS

These pumps provide the equivalent of mains pressure water to a house from a water tank, dam or other reservoir.

Pressure pumps usually come complete with a pressure switch that allows them to run only when the system pressure drops below a certain level. They are normally used in conjunction with a pressure vessel or tank that acts as a pressure reservoir (containing a 'bubble' of compressed air). This helps maintain an even system pressure and reduces pump cycling (on-off cycles), thus reducing pump wear and energy use.

If you plan to install a pressure pump, we highly recommend installing a suitably sized pressure tank, for the reasons mentioned above. With pressure tanks, the larger, the better, and for a domestic whole-of-house system, something in the range of 50 to 100 litres would be a good starting point.

BORE PUMPS

Submersible bore pumps are generally

Photo: Misal Technologies P/L

↑ The Billabong ram pump range from Misal Technologies lets you pump water with water!

cylindrical in shape, with a wire mesh screen intake at one end. They are mounted inside the bore itself and can pump water at relatively high flows and to high heads. They usually pump to a water tank or dam for storage, but may also pump directly to a pressure tank to provide a direct mains pressure water supply.

Most bore pumps can pump silty water without damage, though regular maintenance will need to be carried out.

Another type of bore pump is a remotely coupled piston pump, where a pump at the bottom of the bore is connected to the driving motor at the surface by rods and couplings.

For shallow bores, a surface-mounted pump with good suction capabilities can be used. For deeper bores, an injection system can be used.

What to look for

Like most things in life, you get what you pay for with pumps. The more a pump costs, the higher the quality is likely to be. However, you don't always have to spend a small fortune to get a pump that will do the job.

Things to look for in a pump include the use of non-corrosive fittings and components, particularly stainless steel, as this is very strong and long-lasting. However, aggressive bore water can damage lower grades of stainless steel, so pumps with plastic components or higher grade stainless steel such as 316 grade, may be required.

Pumps known as positive displacement pumps will generally have higher efficiencies than centrifugal types, especially when pumping to high heads, so if getting the most out of your solar panel pumping system is important to you, then these are a good choice.

Many pumps are available in either a combined pump/motor package, or as a separate pump on its own—ideal if you already have a suitable motor and want to save some money. Others may come with solar panels, maximiser and wiring harness—indeed, the variety of options is almost endless, making it very difficult to compare prices and specifications.

What's available

The pumps are listed in three separate tables—wind-powered pumping systems, water-powered pumps, and solar and DC pumps.

Many of the pumps listed in the solar and DC pumps table come as pumping packages, including solar panels and, sometimes, a maximiser/controller. If panels are included, this is detailed in the comments column in the table.

The wind-powered pump table also includes those systems that just consist of a pump pipe, rods and buckets etc, without a wind turbine or tower. These can usually be attached to any standard water-pumping windmill, but can also be used in conjunction with an electric motor and solar panel system. ✱

The pumping guide tables are available online at www.renew.org.au/pumping-guide

DIFFICULTY RATING: ★★★☆☆

Home-grown shelving
Making the most from a drought-struck tree

Victoria's recent drought had a devastating effect on trees in many Ballarat gardens, but John Petheram found a silver (or amber-coloured) lining.

THE first trees to die in our garden in the recent drought were introduced species such as the silver birch and other shallow-rooted species accustomed to moist soil conditions. Although we prefer native species and hadn't personally planted these exotics, it was sad to see 30-year-old trees just curl up their leaves and die, despite our efforts to keep them alive with greywater.

Three alder trees were the next to go. In cutting the first two for firewood, I was impressed by their amber-coloured timber. The third alder to die had a straight trunk, three metres long with a diameter of about 40cm so I asked a forester friend, Mark Stewart, to cut this into planks on his portable saw. I was amazed at the skill Mark used to get the very best out of this rough old log that had never been pruned for timber use.

We cut most planks about 30mm thick and as wide and long as the log allowed, plus some 10 x 10cm square pieces for table legs and smaller planks 20mm thick for lighter furniture.

The remaining timber was cut into 30x15mm strips to use as spacers in the drying stack.

We carefully built up the drying stack on a level surface, with spacer strips between each layer of planks. We used heavy planks, bricks and stones to weigh down the final 40cm deep stack. After four years drying under our house, the planks reached 13% moisture (measured using a borrowed meter)—dry enough to use.

Although I had cut the planks with the aim of making a table, when the planks were ready for use my office bookshelves were bowing badly, so I decided to make a simple bookcase instead. The 25mm thick shelves were perfect to take the weight of all my office work. I had the timber dressed at a small joinery for $75 and put the bookcase together with the help of Horace, my 95-year-old ex-carpenter neighbour, using simple hand tools.

The final product is a bit rough in places because of branches and knots, but the stain came up well and it looks okay from a distance! It's very satisfying to use furniture that came from our garden and labour.

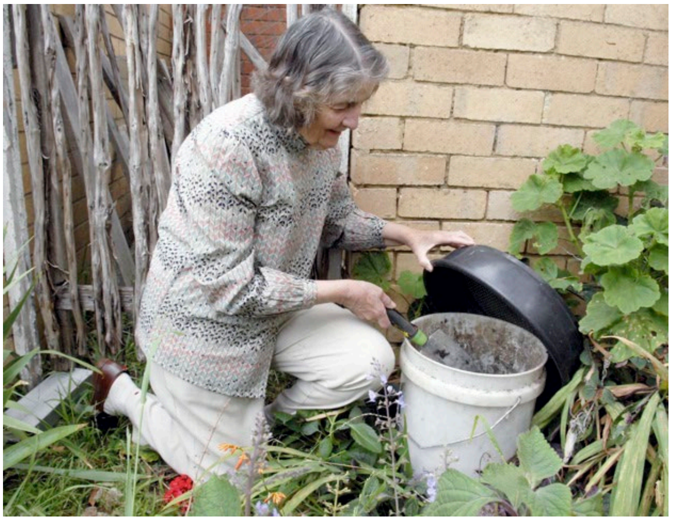
At least this 100kg of carbon will remain well sequestered in my house while I'm around. ✱

John Petheram is a Ballarat resident and member of BREAZE (Ballarat Renewable Energy and Zero Emissions).

The dead alder trees in the garden (top left), the sawn logs (left), and the finished bookshelf in the trees' place in the garden, with John's wife, Nicky (below).

Simple rubbish reduction
A DIY no-care worm farm

Discarded plaster or paint cans get put to good use in Valerie Yule's simple and cheap worm farm.



Valerie's simple worm farm costs almost nothing to make and can be used almost anywhere.

THIS simple design for a homemade worm farm is rat-proof and fits a small shady space. It suits a family of four, as the worms eat the kitchen scraps so fast!

All you need are two empty plaster or paint buckets or cans, often thrown out from building sites, and two cheap plastic garden sieves. Builders and plasterers at a building site will usually be happy to give you the used cans rather than throw them into a rubbish skip.

Place one can in a depression in a shady space on damp ground. Put a sieve on top. Cut the bottom from the second can. Place the can on the sieve. Top it with the second sieve (if there are very clever rats around, weight this sieve with half a brick, so vermin can't lift it).

The sieves stop rats, mice and blowflies getting in, but allow worms perfect freedom to come and go.

Start off the worm farm by putting some damp earth with a few worms into the top can. They will multiply quickly, so there is no need to buy worms.

Then all you do is add your kitchen scraps (except bones) to the top can. Worms don't like citrus, eggshells or tea leaves much, so put those in your compost bin instead. After a few weeks, you'll have made rich fertiliser for the garden. Just lift the top can off and take out the fertiliser (full of worms) from the bottom of it. You can also take rich worm tea (from the worm poo) from the bottom can.

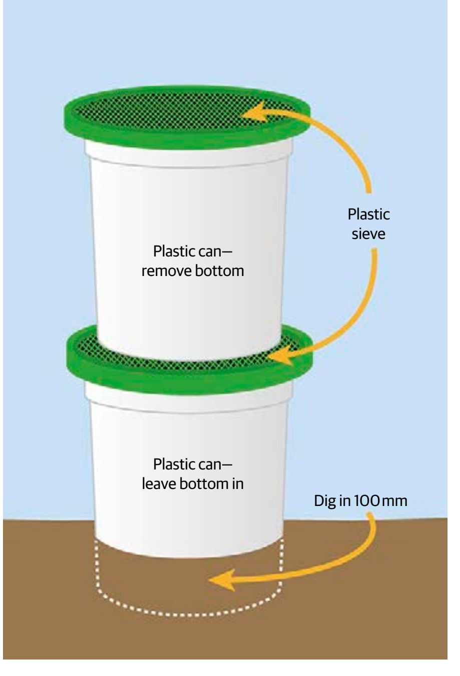
Shift the worm farm around the garden if you like, but keep it in a well-shaded spot—a cooked worm farm is a sad and smelly thing.

Apart from the fantastic fertiliser, having a worm farm reduces your waste: only bones and packaging need go out in your rubbish or recycling bins. Your compost bin (or heap) will also have fewer food scraps in it and so will be less likely to attract rats. As an added bonus, the worm farm also stops the used plaster cans from going to landfill; these plastic cans are useful as gardening buckets, too, and for making liquid manure.

It's amazing how quickly the worms reduce the scraps to earth, so the worm farm is hardly ever full. And with a well-run worm farm there's no smell.

Friendly neighbours in flats could share a worm farm or you could even keep this farm on a balcony in a flat.

Perhaps councils could promote or sell these very cheap worm farm kits, as well as the more expensive commercial worm farms that many sell already. Everyone could afford one!



All you need is a couple of old buckets and two garden sieves.

Making heat while the sun shines
Integrated hot water and heating

Chris Ogilvie explains how he has integrated his solar hot water and hydronic heating systems, even taking advantage of the excess heat in summer.

OUR solar hot water system looks like most other split systems, with the collectors on the roof and the tank at ground level. But its design has a number of differences to a typical system—and it also feeds into our hydronic heating system, integrates with a wood-fired boiler and stores excess heat in the rock base beneath our house. It's all integrated, simple and efficient!

Non-pressurised tank with mains pressure water

The first thing to note is that our system uses a non-pressurised hot water tank, yet still provides mains pressure water. We don't actually use the fluid that circulates through the tank and evacuated tube collectors on the roof—that fluid is instead used to heat mains pressure water via a heat exchange coil when a hot water tap is turned on.

The tank is connected to the solar collectors with an inlet at the top and exit at the bottom. The fluid (water with a non-toxic anti-corrosion agent added) is pumped from the bottom of the tank up to the collectors and, once it is very hot (currently 90 °C), it is pumped back down to the top of the tank.

The heat exchange coil is a 45 m long 20 mm diameter copper pipe coil fitted internally near the top of the tank.

This design means even when the collectors are only producing small quantities of high temperature fluid (e.g. during patchy sunshine), there's still sufficient hot fluid stratified at the top of the tank, ready for use in heat exchange. I've never had to use the electric booster—although we do have twice the recommended area of collectors for the size of our tank!

↑ Chris's house, located near Coromandel Town in New Zealand, has 9 m² of hot water collectors mounted between UniSolar PV panels. These are 'U-tube' type tubes, with the circulating water contained within small copper tubes inside the vacuum tubes.

Advantages of this system

An advantage of my system is that it gives an 'easy life' to both the solar collectors and the tank. They're not subjected to changing pressures or to fresh mains water, instead using the recirculating system fluid. For the tank in particular, I see no reason why it shouldn't last indefinitely.

Both cold and hot water taps in the house run at the same mains supply pressure, thus reducing a number of problems, e.g. the shower temperature doesn't fluctuate.

Legionnaires disease is also not an issue, as the household water is fresh mains water, not stored in the hot water cylinder. There is no need to heat the tank to 60 °C periodically as in other systems.

Integrated with hydronic heater and a wood-fired burner

The tank is also connected to the hydronic heating pipes in our floors. A standard manifold and pump setup draws hot water into the pipes from a quarter of the way up the hot water tank and returns it to the bottom of the tank. It is set so that when the temperature at the base of the tank rises to 40 °C the system turns on and remains running until the sensor a quarter of the way up comes down to 40 °C.

It is ideal for running my hydronic floor heating—it supplies water at the right temperature and pressure, on call.

A wood-fired burner is also integrated to heat the water in the tank with an inlet in the bottom of the tank.

Any issues?

A leak in the heat exchange coil (the only place where the potable water and non-potable tank fluid could meet) would cause mains water to flow into the tank, due to the pressure difference, not the other way around, so that is not an issue.

A header tank is needed to top up the level of the fluid circulating in the system—this may not be convenient in some houses.

Frost could be a problem in colder areas. You can add anti-freeze/corrosion inhibitor to the fluid that circulates through the tank and collectors, but you'd need quite a volume. Alternatively, you could use a dump valve to bring fluid from the tank into the panels if the temperature gets too low.

Stagnation and storing summer heat

Stagnation can be a problem in solar hot water systems in summer, when all the water in the tank is fully heated, so the pump stops the water circulating. In this case, the panels boil and a bit of steam goes up the vent pipe.

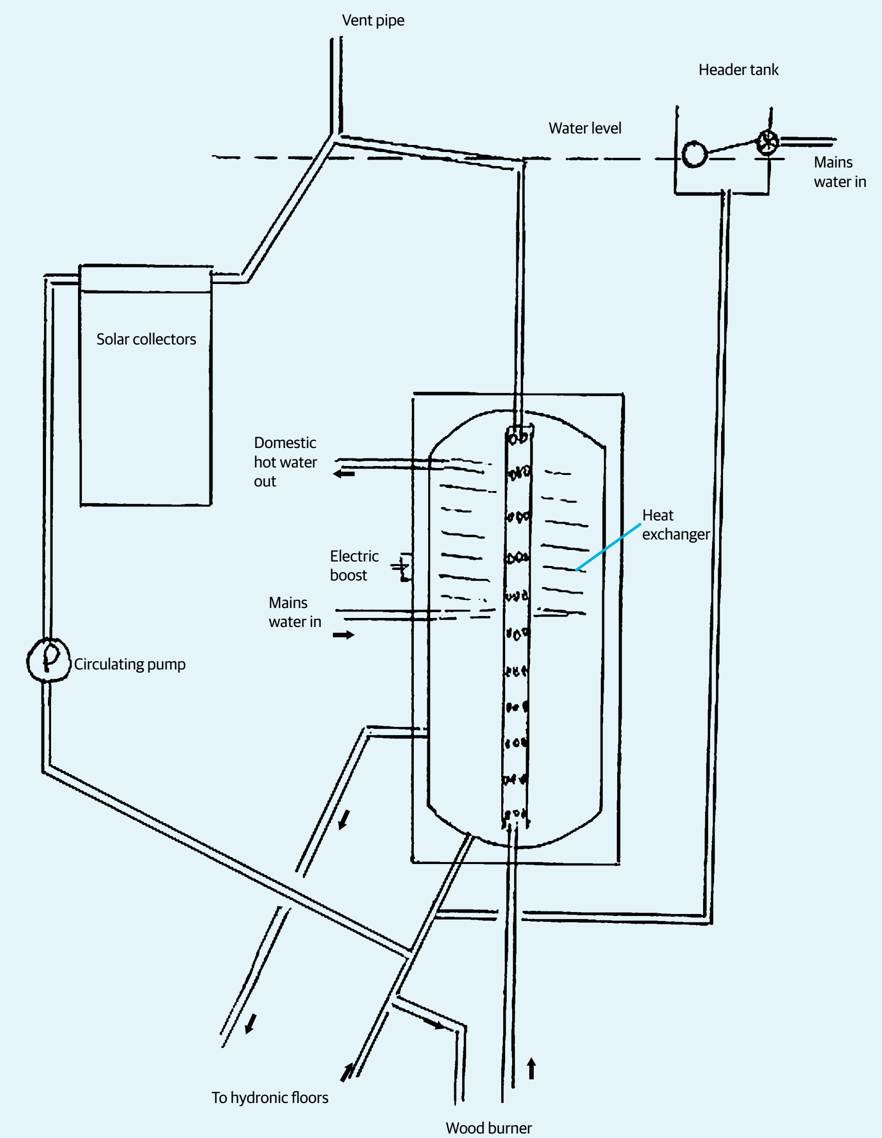
To prevent stagnation in summer, I keep the hydronic heater pumping system running all year, but direct the heated water to loops of pipe on the rock base below the gravel fill our house is built on. This absorbs the excess heat and slowly releases it for most of the winter.

Stagnation will also happen if the power goes off, as the pump is no longer circulating the fluid. If there is a power cut, it will just steam a bit—and I now have a generator so power cuts will be even less of a problem!

Other tank design features: dispersal of heated water

Down the centre of the tank is a length of 50mm PVC tube (rated for high-temperature industrial use), drilled with 10mm holes about every 100mm. It sits over the inlet tube from the wood-fired boiler at the bottom and is held in place at the top by the solar inlet tube. The solar inlet tube has a diffuser upside down on the end of it (like a funnel with a plate with small holes drilled through on the wide end) to slow the incoming water.

The PVC tube disperses the incoming water into the cylinder at the point where the temperatures are about the same. So if the tank is, say, half full of hot water (which is stratified in the top half), and a new batch of hot water is pumped in from the collectors, it will flow down the tube until it meets colder water, at which point it will flow out through the holes and add to the hot. Likewise for hot water coming up from the boiler—it is less likely to get diluted by the colder water on the way. I have no way of testing if this actually happens, but it does appear that way, although I am naturally biased!



↑ Figure 1. The system diagram of Chris's hot water and hydronic heating setup. The 400 litre copper tank was custom-built by a local New Zealand manufacturer to Chris's specifications and to comply with standards current at the time for council approval.

Improvements and other notes

It turns out that the tank insulation, installed to manufacturer's requirements, does not meet my standards! Even though the tank is in a box (in our kitchen) packed with pink batts, its walls run a degree or two hotter than ambient temperature. Water at 90°C cools to 65 or 70°C in a matter of 18 hours or so.

And then there's all that excess heat in summer which I'd like to do more with. A good project would be to use it to drive an air conditioner, or power a fridge or freezer, or even generate electricity! ✱

Warning

Solar hot water systems can produce scalding hot water. We recommend you use a licensed plumber to do all pipework, but if you decide to DIY, be very careful when working on such systems. Never work on the system when the tank or solar collectors contain hot water.

Shop with the ATA

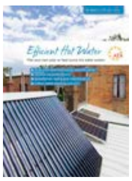
Books, kits and energy-efficient devices

These are just some of the products available in the ATA Shop. To browse the full range and place an order go to shop.ata.org.au, or fill out and return the form at the bottom of the page.

3 W LED strip light

Price: $28

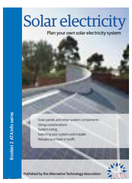
A 30 cm long, stackable LED strip light. Demonstrates high efficiency at over 90 lumens per watt. Multiple lights can be linked together to make a longer lighted strip.



Efficient hot water booklet

Price: $5/$8

This new edition of our popular booklet helps you plan your hot water system. With updated and expanded content on solar hot water systems, it also includes a chapter on heat pumps and other energy efficient hot water options. It is available as both a pdf and print booklet.



Solar electricity booklet

Price: $5/$8

This recently updated booklet is now available for download as a pdf or in print. It includes infomation on solar panels and other system components, siting considerations, system sizing and feed-in tariffs.

Power mate lite

Price: $125

The essential tool for measuring energy use. As well as instantaneous power, it displays energy used and the cost per hour, quarter and year, greenhouse gas production and some more technical figures such as power factor, frequency and VA (volt-amperes).

18 W LED outdoor bulb

Price: $49.50

At over 80 lumens per watt, this Par38 bulb is an energy-efficient replacement for the 150 W bulbs commonly used in driveways and outdoor entertaining areas.

eKo smart meter display

Price: $149.50

The eKo in-home display allows you to view your home's energy usage and costs when paired with an enabled smart meter. Note: this version can only be used in Victoria.

Sanctuary: modern green homes issue 27

Price: $11.95

Sanctuary's winter 2014 issue features a living, kitchen and bathroom renovation special, a beach house extension, expert heating article by Alan Pears and advice on choosing an architect. Plus plants that shade and can be eaten too.

Valvecosy

Price: $20

An elegant solution for a largely overlooked problem, this insulating cover is designed to fit neatly over the pressure/temperature relief (PTR) valve on your hot water service. It reduces heat loss, conserves energy and saves you money.

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The Pears Report
The war on renewable energy

With neighbouring Asian countries investing millions or billions of dollars in renewable energy and energy efficiency, Alan Pears reflects on Australian policy in 2014.

LIFE is certainly interesting in Australia in 2014. What is most tragic is that our leaders seem to be uninterested in having transparent, balanced processes to work things through to a consensus position that is in the interests of society.

Every inquiry or audit seems to be stacked with partisan people, and has inadequate process to allow consensus to be built. Every announcement is full of PR spin and provides little information, much of which is selected to support a particular view. This is a serious challenge for democracy. Of course, in the energy sector, we're used to this kind of behaviour.

Science also seems to be in disrepute. We are paying a high price for the lack of scientific training of our leaders and their advisers.

I visited China recently for an APEC sustainability workshop. I was the only westerner present at the invitation-only session, which made me feel very honoured. I was given the task of explaining Australia's renewable energy policy to the attendees: they were all completely bemused. I then had to sit and listen as they took turns telling the group about the hundreds of millions or billions of dollars they were all investing in renewable energy and energy efficiency.

Appliance efficiency

A recent report on Australia's appliance energy efficiency program (at www.energyrating.gov.au) provided some great news, however. From a base year of 2000, the program is cutting greenhouse gas emissions by 13.5 million tonnes annually at a cost of minus $119 per tonne avoided (based on purchase and operating costs over appliance lifetime per tonne of emissions avoided). By my estimate, it is saving $3.2 billion on energy bills each year, $2.7 billion of which is saved by households. That's around $300 per household on average. Just think, the average annual energy bill of $2000 could have been $300 higher! If we look at carbon pricing as part of a broader package, it is quite clear we can deliver a lot of abatement at zero or low cost by using a combination of policy tools.

Electricity developments

Things are moving fast. On the one hand we have even more aggressive attempts to kill renewable energy and energy efficiency. But on the other hand, the incumbent industry is beginning to fragment and shift, as players come to accept the futility of trying to hold back the tide.

Apparently the Western Australian and Queensland governments, and the networks they own, are now subsidising fringe-of-grid consumers by more than a billion dollars a year. Two of their network operators have announced that they will help people in these areas go off-grid. It will save their governments a lot of money.

There may be a role for local governments to take over existing grids and manage a transition to microgrids. Network operators can offer services such as maintenance, monitoring and sale of equipment to make a profit—as I suggested in my column in *ReNew 123*. I hope there's a nice big cheque in the mail in recognition of my advice!

This is not news. In its 1991–92 annual report, the State Electricity Commission of Victoria pointed out that residents in rural towns cost 50% more to supply than they paid, while rural outlying homes cost double what they paid. Most state governments have maintained these subsidies for political reasons.

The retailer sector is also undergoing rapid change. A number of community groups are serious about setting up not-for-profit energy retailing businesses. And some new business models are appearing, such as the (presently) Victoria-only PowerShop. Check out the blog on PowerShop's website for some interesting views on the direction of energy markets.

The Productivity Commission and the federal government are keen to see more privatisation of the electricity industry. PV, shifting off-grid, investment in large renewable energy projects, energy efficiency and demand management all do that: so why is the government opposed to them? The government's Green Paper is due out in May, so it will be interesting to see what position it takes.

RET review

This review's design is a clear declaration of war on renewable energy by government on behalf of the incumbent electricity industry. It will be very interesting to watch the attempts to manipulate economic analysis and policy objectives to fit the outcome.

I have made a submission to the Inquiry pointing out that renewable energy policy operates within a broader context, and that, "On the one hand we have even more aggressive attempts to kill renewable energy and energy efficiency. But on the other hand, the incumbent industry is beginning to fragment and shift, as players come to accept the futility of trying to hold back the tide."

when this is considered, a stable RET is a sensible and financially responsible policy—as concluded by the 2012 Climate Change Authority Review.

From the limited information available, the Emission Reduction Fund will cost around $12 per tonne of avoided emissions. This alone justifies a RET if its net cost is under 1.2 cents per kilowatt-hour—which most agree it is. While the incumbent industry wants to shift to a (lower) target based on the actual percentage of 2020 electricity sales, keeping the existing fixed target is very important for investor certainty. The industry itself has argued strongly for a fixed target in the past, when that option suited them. They can't have it both ways.

Indeed, the uncertainty created by this review has unnecessarily increased the cost and difficulty of meeting the 2020 target by undermining investment. That extra cost should not be counted against the RET: it is an outcome of poor policy.

A 2009 report by the Australian Academy of Technological Sciences estimated that air pollution from coal-fired power stations cost Australians 1.3 cents per kilowatt-hour. The RET reduces this cost.

The decline in electricity demand is largely due to a range of separate factors and policies implemented by government such as successful energy efficiency programs (which are saving consumers much more than any RET cost); the high exchange rate driven by the mining boom that has made Australian industry uncompetitive; and big increases in electricity prices caused by unnecessary investment in electricity network infrastructure. So why is the RET blamed for these impacts on the incumbent electricity industry?

The electricity industry is supposed to be a competitive market. The incumbent industry can choose to invest in renewable energy and other emerging technologies to make profits from the RET—as they have done in the past, and WA and Qld network operators seem poised to do. They can even write off losses from existing infrastructure against profits from new activities.

The present high electricity costs are outcomes of their decisions. Independent consultant Bruce Mountain estimates that networks need not have spent about $20 billion of the $40 billion invested over the past few years. If they had saved this money, electricity prices would be at least a cent per kilowatt-hour cheaper: this would have offset much of the claimed RET cost for consumers.

So when we look at claimed costs for the RET, we see they are small compared with the outcomes of many other decisions, some taken by governments, and others by existing industries. On this basis, the RET looks like good value for money. It is also positioning Australia for a better, more competitive future.

In any case, how many Australians outside the energy sector would see the RET over-achieving as a bad thing? For decades, surveys have shown that most Australians want an efficient, renewable energy future. Governments and the industry has chosen not to deliver what we want. This is their chance to catch up.

We must remember that change usually brings challenges, creates winners and losers, and can even create some short-term costs. But just think where we would be if the government had helped Telstra's landline business to block the rollout of mobile phones and the internet. ✱

↑ In contrast to the 'war on renewable energy' in Australia, China is planning to install 14 GW of solar this year. This building is in one of the Chinese eco-cities currently under development, as described in *ReNew 127*.

Alan Pears has worked on sustainable energy issues since the late 1970s. He is one of Australia's best recognised and most highly awarded commentators on sustainable energy and climate issues. He teaches part time at RMIT University and is co-director of Sustainable Solutions, a small consultancy.

Q&A

Do you need to know how to fix radio buzz from LED bulbs, or why you're seeing a voltage rise when you add a fridge to your battery-based electrical system? Ask *ReNew* your question via renew@ata.org.au.

A Q&A about a Q&A

Q —

I have two follow-up questions to the Q&A section in *ReNew 125*.

Firstly, regarding LED bulbs and radio buzz: If building a new home and planning to use LEDs throughout, what precautions would be needed so that there was not interference with other electric devices? Other than being a nuisance if other electric devices are affected, are there any negative effects on humans from this extra electromagnetic radiation that one needs to worry about in relation to LEDs?

Consulting an electrician might be a reasonable response, but not in my case. I am very rural and have not had much success in the past trying to get information on modern materials or methods. I need to educate myself so I can then make sure tradies do the right thing.

Also, I have heard that there is a better way than the standard wiring layout in a home to decrease the potential negative effects of living within a constant electric field. I am not really sure of the details, but it's something along the lines of not running the cables around the house through the walls as is standard but rather running them in straight lines through the roof and then dropping down to power points, etc. Does that make any sense?

Secondly, regarding electric instant water heaters: Assuming one is either going to have an instant gas or instant electric water heater (potentially tied in as a backup to solar at some point in the future if water volume use can ever justify it), is one more efficient than the other? Does having grid-connected solar (producing excess power) and LPG as fuel sources impact the decision?

—Ann L

A —

If the bulbs and fittings are properly C-tick tested then there shouldn't be a problem, but I have seen units with C-tick marks that cause interference, so it seems some units are being falsely labelled or the testing system is lacking. You are best to stick with brand-name bulbs like the Brightgreen range, Philips, Cree etc. That should mean you avoid problems, but if there is some buzz present then it can usually be easily fixed with clip-on ferrite beads which simply clip over the power cables as close as possible to the fitting.

The EM radiation from noisy lights and appliances isn't powerful enough to affect biological systems. Mobile or cordless phones are by far the most risky devices that most people use due to the close proximity when in use; a laptop with wifi sitting directly on your lap is another one—there has been some concern over that in the past although nothing conclusive.

The wiring layout depends on the electrician. Often homes will have one or more loops in the walls. Usually homes that have been rewired will have cables running in the ceiling instead, as it is easier to rerun them there. Either way, there isn't going to be much difference as the main issue is the amount of current running through the wires. The magnetic field is directly proportional to the current, and in your house the electric field will be very low as you are only dealing with 240 V, which is low as far as electric fields go. The main concern with magnetic fields in homes come from close proximity to street transformers, as many older ones are not well shielded. The same can be said for the old rotating disk mains meters found in older homes.

Instantaneous electric is generally more efficient at getting the energy in the fuel into the water. The losses are higher in gas systems; for electricity almost all the heat is transferred to the water. But that doesn't include the overall fuel cycle or the greenhouse gas emissions equation, which depend on the source of electricity. If using coal-fired power, gas will have lower emissions; if using renewables, then electricity is better. If you have PVs producing excess, then electricity is probably the better bet, provided that your hot water use coincides with high PV output, i.e. during the middle part of the day, say 10 am to 4 pm. One advantage of gas is it gives you a second fuel source, so if you have power failures you still have hot water.

—Lance Turner

Inverter voltage problem

Q —

My home electrical supply is a stand-alone 24 V DC/240 V AC system, incorporating a 1500 Ah battery storage bank. One of the panel arrays actually features on page 54 of *ReNew 119*.

The system is capable of handling all our power needs in all weather and seasons without having to resort to any generator backup. I do, however, have one problem that I am sure an electrical engineer will be able to advise me on how to overcome.

I imported my 1500 W pure sinewave inverter from India and it has been in use since 2004. While the unit has worked faultlessly, it had one downside and that was the output was 210 V not 230 V. For years I did not worry too much about it as our refrigeration is gas and other than somewhat slower power tools I used around the house from time to time, 210 V served the purpose.

I recently decided that with the rapidly increasing price of gas I would invest in an electric domestic fridge and knew I would need to deal with the voltage problem to avoid damaging the fridge motor. I contacted a transformer manufacturer in NSW who built me a 210 V to 240 V step-up transformer, which I hard wired to the inverter output. The house power is now 240 V on the dot.

However, I first decided to try out a small bar fridge in the house (borrowed from my large mains-powered workshop located nearby). It works perfectly, except for one thing: the line voltage starts to progressively climb when the fridge is switched on. It was only by sheer fluke that I discovered this as I was checking the line voltage for another reason. I then did some careful monitoring and testing and proved that the fridge was the cause of the voltage hike—it actually reached over 300 V and was still climbing. I obviously disconnected everything else during the tests and the fridge was not damaged. It is now back keeping beer cold in the workshop.

I want to put an electric fridge into service in the house and need to resolve this voltage problem. Could someone please help with what the reason is for the voltage rise and what I can do to stop or neutralise the voltage build-up? I have some theories, but if I can avoid wasting time experimenting it will be very helpful.

—Brian Lambert

A —

As the voltage is determined by the inverter, I suspect something in the fridge is creating electrical noise that is feeding back to the inverter and confusing the voltage feedback circuit. You need to put a meter on the output of the inverter before the transformer and you will see what I mean. The transformer is a simple fixed turns ratio unit so it can't be the problem. Voltage can't 'build up' in an AC circuit as the voltage actually reverses 100 times a second, but the magnitude of the waveform can increase if the inverter's feedback circuitry is being affected somehow.

If the inverter voltage is still steady and the output of the transformer is rising, then it means your meter is lying to you and is probably being affected by electrical noise.

I would put a suitably rated filter between the output of the transformer and the house, or even between the inverter and transformer. They are cheap and readily available and it may well filter enough noise to stop the problem. Jaycar Electronics part number MS4001 may do it, although attenuation on that starts at 1 MHz, which might be too high. I have used some from an eBay supplier that are really nice; their lowest frequency 10A filter is at www.ebay.com/itm/130456040955

—Lance Turner

Brian has since informed us that the filter fixed the problem—*Ed.*

Microinverter advantages

Q —

Can you please tell me the pros and cons of using AC solar panels versus DC solar panels?

—Tim Clarke

A —

For a grid-interactive system, both have some advantages. AC panels (with attached microinverters) mean that all the wiring can be done by a suitably knowledgeable electrician and there is no DC wiring or disconnects etc required. All of the panels operate independently too, so if one fails or is shaded, it doesn't affect the others. Further, if the mains fails or there is a problem with the house, such as a fire, the highest voltage on the roof is that of a single panel, provided the mains is disconnected. The datalogging of the separate inverters also lets you see the performance on a per-panel basis.

With DC panels and a string inverter, the inverter is away from the high temperatures of the solar array (assuming it isn't mounted on a sunny wall, as in some systems I have seen) so the inverter runs cooler and is likely to have a long lifespan. However, modern microinverters use electronic components that are more heat resistant than previous models (e.g. ceramic capacitors instead of electrolytics), so the thermal advantage of a large single inverter is less than it used to be.

So, with progressing tech, microinverters are starting to gain advantages over the traditional way of doing grid-interactive systems (although not everyone in the industry agrees with this). We will be looking at the advantages of microinverters in a coming issue of *ReNew*.

—Lance Turner

Small fridge needed

Q —

We're looking for a small fridge/freezer that will fit under a benchtop, about 950mm high. We have had a Vestfrost fridge/freezer for perhaps five years and it's worked a treat. Our solar system provides 2 kW of power. Is there any model, I wonder, that you would recommend? I'd greatly appreciate some help.

—Sally Meredith

A —

That is basically bar fridge size. Vestfrost make one that size, the CW150R, which is rated at 330 Wh (0.33 kWh) a day, but it's not available here in Australia that I could find. There are a few from other manufacturers that size which would do, but they seem very expensive, such as the Liebherr under-bench models.

There is also the Fisher and Paykel Cool Drawer, see www.fisherpaykel.com and the Haier HBF165W (though the latter isn't listed on the Haier website now, only the 130 version is; see www.haier.com.au).

The best way to find the most energy-efficient devices (although sometimes model numbers are out of date) is the Energy Rating website. See www.energyrating.gov.au.

Another possibility is a fridge made for marine use. They usually run from 12/24 V DC and are very energy efficient as they are made for battery systems. Examples are the Vitrifrigo units (www.12volttechnology.com.au/74-vitrifrigo) and there are various others.

—Lance Turner

Alternatives to car cigarette lighter plug

Q —

In the DC Appliance Buyers Guide in *ReNew 126*, Lance Turner wrote that cigarette lighter plugs are not a reliable system and should be avoided. Hmm, yes, quite—within three years I have had 100% failure for what I had thought was a clever idea, including meltdown at the socket for a laptop power appliance. This and a wee camping shower water pump were the two main things I used.

I have an inverter (which is how I now power the computer), but I prefer the silence at our bush retreat, so avoid use of it where possible. The article alerted me to alternative systems so I am now thinking of chopping off the cigarette lighter plugs on existing appliances and putting on new plugs accordingly. In words of one syllable or less, could you provide specific advice on what would work best, and how please?

—Angus Morrison-Saunders

A —

I have used the Merit plugs with good success so far—they are rated to 12A continuous, more short-term. They are available from automotive or electronics stores and usually use screw terminals, so there's no soldering required.

There are other high current connectors such as Anderson connectors, but they are more expensive and may need soldering or crimping—though they can handle larger currents.

Another possibility is the Powercon connector from Neutrik, available in 20 A and 32 A versions. While designed for AC, they should be fine for DC use provided that equipment is powered down when plugging or unplugging.

—Lance Turner

Write to us

We welcome questions on any subject, whether it be something you have read in *ReNew*, a problem you have experienced, or a great idea you have had. Please limit questions to 200 words.

Send questions to: renew@ata.org.au

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Advertiser Directory

Easy thermal control
Using old thermostats

Julian Edgar shows us how to make good use of an often overlooked but useful component—the thermostat.

NEED to control a fan, heater or pump on the basis of temperature? It's a common requirement that can be achieved with an electronic circuit using a thermocouple or thermistor input. But much cheaper and easier is to use a thermostat salvaged from a junked consumer item. Whether you need to switch at room temperature or at 200 °C, the thermostat doesn't have to cost you a cent.

→ A working thermostat made from the innards of a frypan controller, a salvaged knob and a new box.

How thermostats work

A thermostat is an adjustable temperature switch. Nearly all thermostats that you can salvage work in a similar way.

A special piece of metal—called a bimetallic strip—is the foundation of the design. As its name suggests, this strip is actually two different metals laminated together. The two types of metal have different expansion rates, so as they are heated, one metal gets longer faster than the other. This causes the strip to bend. When it has bent far enough (i.e. it's got hot enough!) it breaks the connection between two electrical contacts, turning off the circuit.

To allow the temperature at which the thermostat switches to be adjusted, a threaded rod is often used to vary the distance between the electrical contacts and the bimetallic strip.

As you can imagine, in this type of design the electrical contacts open and close very slowly. In certain applications this could cause arcing, so better thermostat designs use a 'snap action' approach, where a small leaf spring causes the contacts to quickly snap open or closed once the trip point has been reached.

Another type of thermostat uses a remote-mount bulb. This comprises a small copper cylinder (looking a bit like a short pencil) connected to the main switch mechanism by small-bore copper tube. The tube and bulb are filled with a liquid or gas that expands as it gets warm. This fluid pressure activates the switch.

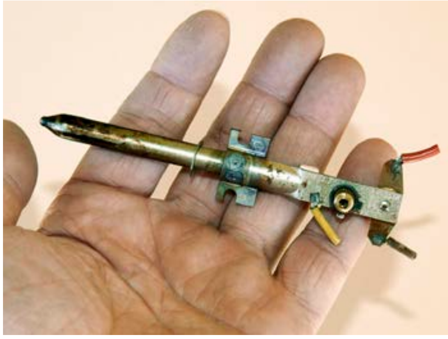
Common consumer goods in which bimetallic strip thermostats are used include oil-filled electric space heaters, electric frypans and clothes irons. Remote-mount bulb thermostats are used in old electric water bed heaters. Table 1 shows the characteristics of each of these types of thermostats

← Waterbed thermostats use a remote sensing bulb and can be adjusted accurately in a 25–50 °C range.

Selecting a thermostat

If you salvage every old clothes iron, electric frypan controller, water bed heater control box and oil-filled heater that you see thrown away, in no time at all you'll have more thermostats than you know what to do with! So let's take a look at the characteristics of each design.

→ Inside this frypan controller is a high quality, adjustable thermostat. These can be used to sense temperatures in the 40–200 °C range.



↑ This is what the thermostat inside a frypan controller looks like. The stainless steel probe can be inserted through the wall of a pipe or into liquids and the thermostat can be adjusted to trip at temperatures from about 40 to 200 °C.

Frypan

Electric frypans (and electric woks) use a thermostat that's integrated into the module that plugs into the handle. The module has a knob on it (for setting the temp) and a stainless steel probe, about the length and a bit smaller in diameter than a little finger.

These thermostats sense from about 40 to 200 °C. Their design makes them suitable for applications where the probe needs to remotely sense temperature, e.g. by being pushed through a grommet into a pipe. The hysteresis (difference between switch-on and switch-off temps) is fairly small and they react quite quickly.

Both 'snap action' and 'slow moving' types of thermostats are used in frypans, with younger models more likely to be the 'snap action' type. It's very easy to tell if you're salvaging a snap action thermostat: hold the control box up to your ear as you slowly turn the knob. If you hear a satisfying 'click', you know you're getting the better type. (And it's fun to watch people's faces when you do this—they think you've confused a frypan controller with a radio!)

↑ Every electric iron has a thermostat mounted inside. These snap action thermostats can be used to switch at temperatures from about 60 to 200 °C.

Clothes irons

Electric clothes irons also use bimetallic thermostats. Despite being controlled by a knob or lever placed on top of the iron, the thermostat is mounted deep inside the iron—one end of the bimetallic strip is actually bolted to the aluminium baseplate. These thermostats are of the 'snap action' type.

Thermostats from irons react more slowly than frypan thermostats. (This is good if spikes in temperature need to be ignored.) As a result, their hysteresis is also larger.

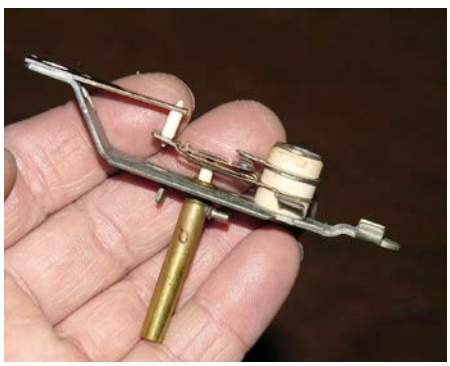
Typically, these designs are suitable for sensing temperature from about 60 to 200 °C. As they don't use a remote probe, this type of thermostat is useful when the temperature of the general environment needs to be sensed.

Oil-filled electric heaters

Like clothes iron thermostats, oil-filled heater thermostats are designed to sense the temperature of their environment—they also don't have a sensing probe. These thermostats are sensitive, have small hysteresis and are ideal for monitoring room temperature variations.

Water bed heaters

Water bed heater thermostats use a remote bulb, allowing the sensing of temperature away from the thermostat. They can be set very precisely in the 25 to 50 °C range, have small hysteresis and high sensitivity. However, the bulb may be too bulky for some applications and the sensing tube cannot be altered in length.



↑ The thermostats from oil-filled electric heaters are generally snap action types that work in a 5 to 50 °C range.

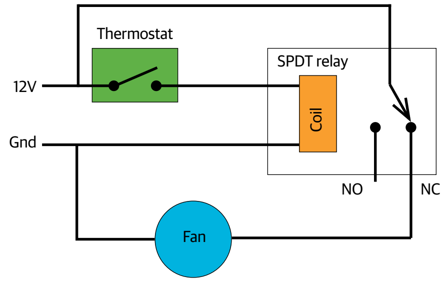


Figure 1. Most thermostats are 'normally closed' designs—they open when the temperature rises to the setpoint. But by using a double-throw relay it's possible to turn on something when the thermostat opens—here a 12 V fan is switched on at temperatures above the thermostat setpoint.

Using thermostats

Nearly all thermostats open when the trip-point is reached. This is because in their original application they control heating elements that need to be switched off when the temp rises sufficiently. In other words, they're 'normally closed' designs. Only the one pair of contacts is provided, so how do we turn something on (rather than off) when the trip-point is reached? This is easily achieved with a double-throw relay. Figure 1 shows the wiring.

Conclusion

From operating something as simple as a fan that switches on when it is hot, to controlling a solar water heater pump, the thermostat need not cost you a cent. ✷

Warning

Thermostat wires typically run extra-low voltage, e.g. 12 volts. However, the appliances they control may run on 240 volt mains power. Please beware as modifying mains voltage equipment is dangerous and is restricted by state-based licensing regulations. If there's any doubt, play it safe!

	Electric frypan	Clothes iron	Oil-filled electric heater	Water bed
Temperature range	Wide, 40–200 °C	Fairly wide, 60–200 °C	Narrow, 5–50 °C	Narrow, 25–50 °C
Hysteresis	Small	Large	Small	Small
Sensitivity	Medium	Low	High	High
Action	Many not snap action	Most snap action	All snap action	All snap action
Sensing	Short stainless steel probe	Whole thermostat	Whole thermostat	Remote copper bulb

Table 1. Thermostats from commonly discarded consumer goods are available with a wide range of characteristics.

ATA member profile
The environmental advocate

Household solar installer Aaron Lewtas talks to Jacinta Cleary about persuading households and government to a more sustainable way.

SURFERS are intrinsically passionate about environmental issues and Aaron Lewtas is no exception. "I've always been interested in our environment and involved in outdoor activities. Living in Torquay I do a bit of surfing, go camping and hiking, so I think that's given me a bit of an appreciation for the natural environment." Aaron is an ATA business member and an advocate for sustainability, both at a personal and professional level.

In 2007, buoyed by the early efforts of Hepburn Wind, he and other residents of the Surf Coast area in Victoria started researching the viability of a community wind project. While the project wasn't possible, with Victorian Government planning laws being the final obstacle, the group had united over their concern for climate change issues and the Surf Coast Energy Group was formed. Aaron is the organisation's president.

The community group is a lot like the ATA, campaigning on issues that impact household sustainability, raising awareness on climate change and holding events. "We get around 70 to 100 people at our winter film screenings. It's a great way to engage and educate people," he says. The group recently met local federal member of parliament Sarah Henderson to discuss the government's Renewable Energy Target review, and state member Andrew Katos to discuss wind planning laws and the sale of the Alcoa Anglesea power station, an issue important to local residents. "We try to educate politicians about the benefits of green jobs to the economy—I think that's the best hope we've got."

When he's not out lobbying members of parliament, Aaron runs his own solar

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installation business Green Energy Options. The business regularly gives to ATA's International Projects Group, with a panel donated to an East Timorese community for every system installed locally.

A lot has changed on the "solarcoaster" since he started operating three years ago, with changes to feed-in tariffs and household solar rebates. He says the biggest shift has been households optimising their systems for "self-consumption", in response to lower feed-in tariffs and the increasing cost of mains power. "With Victoria's feed-in tariffs set at 8c a kilowatt hour, a lot of customers are paying 30 or 35c a kilowatt hour when they purchase their power, so if they use their power directly from solar they're offsetting the higher cost." His business now specialises in microinverters to help optimise customers' solar PV systems. Around 70% of his clients now opt for microinverters, which allocate an inverter to each solar panel module, rather than just one central inverter to an entire system. He's also fielding a lot more enquiries about battery storage, for both off-grid and grid-connected battery systems.

Funnily enough, Aaron's own 2.5 kW solar system doesn't have microinverters as it was installed before they hit Australia. His energy-efficient home at Torquay was built four years ago with north-facing living areas, double glazing, a concrete slab, big eaves and a solar hot water system. Aaron and wife Holly worked with their local builders to make

↑ Green Energy Options owner and Surf Coast Energy Group president Aaron Lewtas, and daughter Ruby. He's seen some big changes on the 'solarcoaster' since he started his business, including the uptake of microinverters and more interest in battery storage options.

the home as environmentally sustainable as possible. "I had to push a little bit, some of the builders like to stick with what they know. They end up being quite accommodating on these things in the end."

It seems Aaron would be very experienced at persuading builders, householders and politicians to a more sustainable way—it's what he does day in, day out.

Visit the Surf Coast Energy Group at www sceg.org.au

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