Issue 126

ReNew

Technology for a sustainable future

The travel issue

Sustainable travel

the road less ridden

Carrying power
Cargo bikes

Caravans unplugged
PV and battery tips

Buyers guides x 2
Solar PV & DC appliances

Issue 126 January–March 2014
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What's watt: electrical terms explained
DIY: solar cooling & bushfire preparation

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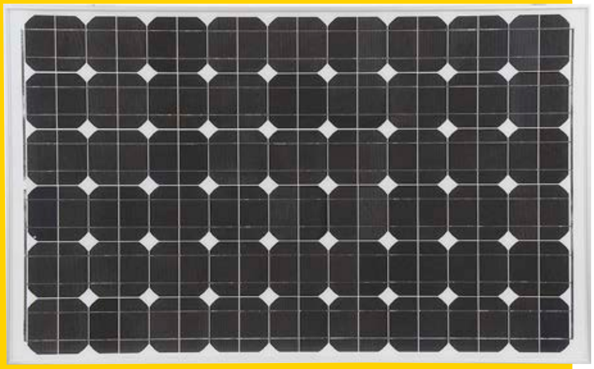

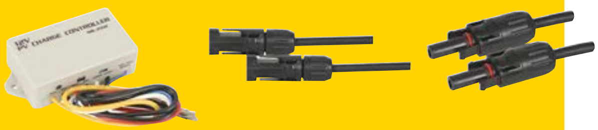

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MB-3690

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ZM-9097 $249
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ZM9088 $599

FROM $29.95

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Cat. MG-4501 $599.00

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Cat. MG-4502 $899.00

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Read more articles at renew.org.au
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Sustainable travel

On the road, off the grid

↑ The solar swagman, one of the *ReNew* reader prize entrants. Read these traveller tales on page 36.

↑ Can a cargo bike replace a car? Page 29.

↑ Solar systems for caravans. Page 50.

← **Cover image: Paul Anthony Judd.** *ReNew* reader Paul Judd's entry in our *ReNew* reader prize on travelling sustainably. In his entry, he writes that he travels by bicycle and train whenever possible, and carbon offsets any international flights. This photograph was taken towards the end of winter at Lake Motosu, near Mt Fuji, on the way to the youth hostel in Fujiyoshida. The next day he cycled the 100+ kilmetres to Tokyo while it was snowing! Page 36.

Guides

↑ Bushfire preparation. Page 82.

Solar panel buyers guide

Reader projects

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. ATA membership starts at $75 and offers a range of benefits. www.renew.org.au

Sanctuary magazine

In addition to *ReNew*, the ATA publishes *Sanctuary: modern green homes*, providing inspiration and practical solutions for a sustainable home. The current issue looks at tiny homes and how we can design for resilience in a changing climate. 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 hosted a series of free 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

As well as advocating to government and industry, the ATA conducts research projects with partners from the government, industry and community sectors. Recently the ATA has been modelling and advising on a range of community solar energy projects. The ATA is also looking at how to make the electricity network costs fairer for consumers, reflecting the demand a consumer places on the network, especially at peak times. www.ata.org.au/projects-and-advocacy

International projects

ATA's Michael O'Connell is back in East Timor working with project partner Mercy Corps to develop and conduct training of local installers, and help set up a call centre for solar system maintenance. For more information and to make a donation to give the gift of light in East Timor, go to www.ata.org.au/ipg

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Contributions are welcome; guidelines available at www.renew.org.au or on request. Next editorial copy deadline: 20 January 2014.

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Advertising is available for products and services relevant to our audience. We reserve the right to refuse, cancel and withdraw advertising at our discretion. For enquiries email adverts@ata.org.au or call (03) 9631 5412.

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Editorial

On the road: treading lightly when you travel

RENEW takes to the road this issue, for our first-ever sustainable travel issue. Choices made when travelling can shed a different light on sustainability. Issues arise of fuel use, of impact on the places we travel to, and the energy and water use of the places we visit. Our route this issue focuses on the technologies and approaches that can help.

Our first stop comes courtesy of *ReNew* readers, with the innovative entries in our sustainable travel competition. We kept expanding the space allocation for this as your amazing stories kept coming, but we had to stop at 4 pages and 14 stories; we apologise to those not included, though we may follow up your stories down the track! From PV-powered river voyages to ingenious water saving to getting by on the smell of an oily family—these are great reads, and great examples of sustainability in practice.

Our journey continues as Olivia Wykes tracks down sustainable places to stay. The criteria were simple: we looked for use of renewable energy and water saving technologies along with a green philosophy. Some were nominated by people in our office and some we found online. Clearly, eco can be a selling point, not just for us, but for the wider online world.

Next, we hitch up the van and consider the technologies that can help reduce energy use when caravanning and camping. Collyn Rivers look at some possible traps for caravan owners using solar PV to power their travel. We examine the range of DC appliances available for van use, the weighty advantages of lithium batteries in caravans and just what you can cook in a solar oven (quite a lot!).

From travel to transport: A team at Swinburne University has plans to manufacture a commercial solar car and they're taking *ReNew* along for the ride, with a series of articles as their design and build progresses. We also 'mythbust' what's possible in EV charging right now, with Bryce Gaton explaining why an EV battery doesn't equal a tank of fuel and just how fast an EV can be charged. And finally on our transport theme: cargo bikes are bikes with built-in carrying capacity, making it possible to cart kids and shopping with ease—and can be a viable car-replacement, as in Adam Peck's case, documented here.

There's much more inside, including all our regulars and three great DIYs. Our basics article explains common electrical terms with the nitty gritty of power, energy and what's watt. Plus, we introduce a new regular section, Living Off-grid, showing off a home that's off the grid for energy and water. We delve into the systems the home has, the appliances they can run and any issues they've had along the way.

Enjoy! We hope you have a safe, sustainable and relaxing summer. Let us know your stories and see you in the new year.

Robyn Deed
ReNew Editor

In *ReNew 127*, out mid-March

- Insulation buyers guide
- Heat recovery ventilation
- A cool-climate build

IN the past few months, the ATA has been busy conducting research and speaking with a number of groups across the country about community renewable energy. More than 1 million homes in Australia now have rooftop solar panels and many people are now exploring further possibilities in larger-scale community-owned projects. The Hepburn wind farm in Victoria, Denmark wind farm in WA and many other success stories overseas have been profiled in past issues of *ReNew*.

With funding from the City of Sydney and the Lord Mayor's Charitable Fund, the ATA is developing an assessment tool for community-owned renewable energy. The tool will give groups guidance on the economics of their project—particularly important in the early stages of understanding feasibility and building community support.

The ATA is also a partner in a program headed by the UTS Institute for Sustainable Futures to develop a strategy to grow the community renewables sector. The Australian Renewable Energy Agency (ARENA) has recently announced funding for the program, which will include a National Community Energy Congress in Canberra next year.

If you are thinking of establishing a community renewable energy project in your area, get in touch with us here at the ATA.

Communities taking control of their own energy—clean and green energy—is the way of the future.

To keep up with ATA news and developments, go to our new website at www.ata.org.au.

Donna Luckman
CEO, ATA

Up front

The Peoples' Food Plan

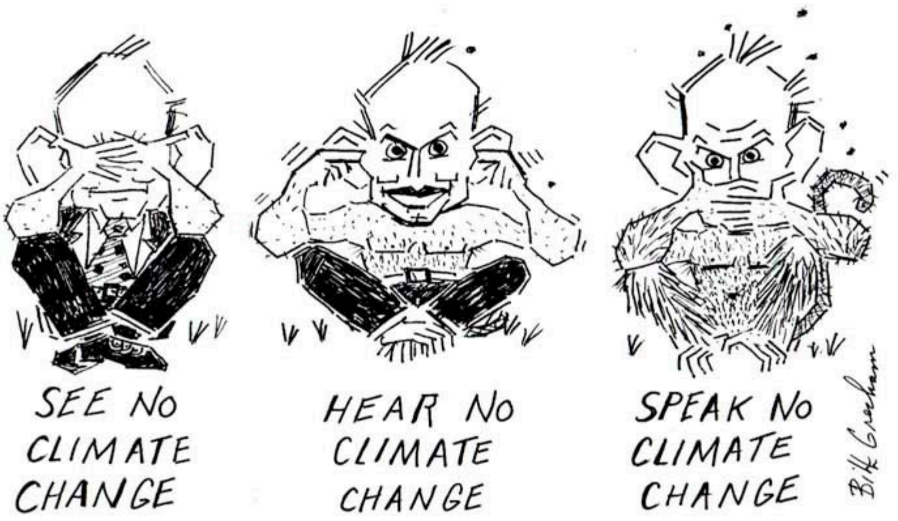
In October 2013, the Australian Food Sovereignty Alliance (AFSA) launched its Peoples' Food Plan, which they describe as "a common-sense approach to a tasty, resilient and fair food system for all Australians".

Based on the values of fairness, genuine sustainability, long-term prosperity and resilience, the plan is drawn from the ideas and experiences of more than 600 people from around Australia.

"Authentic freedom of choice over the food we eat must be a priority in a market economy. This requires clear and adequate labelling of food products and a diverse mix of farming systems that prioritises the wellbeing of our lands, communities and waterways," says the group's spokesperson Dr Rose.

AFSA is a national organisation made up of individuals, community food groups, farmers, social enterprises working in food processing and distribution, food cooperatives, small food businesses and academics.

The Peoples' Food Plan has been created as an alternative to the federal government's National Food Plan. "We want resilience, we want local, we want flexibility and we want diversity not only in the products but also in the landscape. That gives people control, not the dollar, and that's the difference," says Costa Georgiadis on the AFSA website.
www.australianfoodsovereigntyalliance.org
www.fairfoodbrisbane.org



Tu Share

Two Australians have recently created an app that allows people to share much more than just updates and photos online. Tu Share, the brainchild of ex-New Inventors panellist James Moody and Kohei Nishiyama, allows people to easily share (give away) their unwanted things with people who do want them.

Users of the app simply list the items they want to give away. Unlike other sharing websites, Tu Share connects with people already in your network and provides a door-to-door courier service, making it both safe and easy.

Co-creator James Moody says by creating Tu Share, he and Nishiyama aimed to encourage recycling by making it as easy and safe as possible.

"Sharing stuff we no longer need with others is great. It saves money, reduces clutter and is good for the planet," he says.
www.tushare.com


Image: Vicente Villamón

Rubber dandelions

As well as providing a delicious cup of tea, dandelions might also be an excellent source of latex rubber. The Fraunhofe Institute for Molecular Biology and Applied Ecology in Germany is investigating ways to extract large quantities of the rubber from dandelions in a pilot program.

Europe currently relies on imports to supply it with latex rubber; if the pilot program is successful, Europe may be able to become self-sufficient latex producers.

One of the potential uses of latex rubber is in tyre production with the first tyres made from dandelion rubber soon to be tested on roads. So far, the quality of the dandelion rubber is the same as that of conventional rubber.

Other benefits of dandelion-cultivated rubber include cost-effectiveness, easier cultivation and its ability to be grown on land that is not suitable for other crops.
www.bit.ly/1cQ4bTB

Fossil fuel subsidies a barrier to renewable energy

Fossil fuel subsidies are undermining international efforts to curb climate change and promote renewable energy, says a paper released by the Overseas Development Institute (ODI) in November. They also say that these subsidies are failing to help the world's poorest.

The report shows that for every US dollar spent on supporting transitions towards renewable energy, another six US dollars is spent subsidising fossil fuels.

Using data from the OECD, they estimate that the top 11 wealthy country emitters spent a combined total of $74 billion on fossil-fuel subsidies in 2011.

They found that not only were there worldwide domestic subsidies, international financial institutions also support carbon-intensive energy systems. Domestic subsidies include financial assistance to the hard coal sector, tax exemptions for fuel and tax concessions, while 75% of the energy

Designer dirigible

A new airship called the Aeroscraft is being tested in California by its makers the Aeros Corporation. This blimp-like aircraft has recently lifted to the skies in a tethered test, an exciting moment for the developers who have been working on the craft since 2006.

Described as a dirigible, the aircraft is designed to carry cargo, including oversized cargo, with the aircraft itself being roughly the size of a football field.

The Aeroscraft is filled with helium and is powered by three swivelling engines, two on the sides and one in the back.

Unlike a blimp, the Aeroscraft has a rigid outer frame, making it the first craft of this kind to be flown since the retirement of the German Graf Zeppelin in 1940, an airship that flew over one million air miles and made 144 trips across the ocean.

Like a submarine compresses air, the Aeroscraft compresses its helium gas into tanks to change its buoyancy. When the helium is compressed, the buoyancy of the craft lowers and the craft sinks to the ground. At ground level, the craft doesn't land completely but rests on landing pads, allowing it to land on water, ice or ground. The aircraft is very stable at ground level and only a minimal ground crew is required. The application of such an airship is to move cargo to places without an airstrip, such as in remote places like Alaska.

www.bit.ly/Aerostest

projects supported by international financial institutions were based on fossil fuels.

ODI says these subsidies inhibit the development and implementation of carbon-neutral energy sources and they call for a phase out of the subsidies by 2020.

The ODI is the UK's leading independent think tank on international development and humanitarian issues. Their mission is to inspire and inform policy and practices which lead to the reduction of poverty, the alleviation of suffering and the achievement of sustainable livelihoods in developing countries.

www.odi.org.uk/subsidies-change-the-game

Australia's top 20 wind developers

The top investors in wind energy are revealed alongside the lowest investors in an analysis of Bureau of Resource and Energy Economics data by Climate Spectator. The list is topped by much lesser-known energy companies Wind Prospect and Epuron, who have been locating suitable sites with good wind speed and in close proximity to grid infrastructure for over a decade. Interestingly, big names like Energy Australia and Origin Energy are at the lower end of Australia's top 20 wind farm developers.

Climate Spectator also compared the companies investing in gas power projects to find the list is almost reversed, with Energy Australia investing the most in gas projects. Meanwhile, AGL seems to have its foot in both camps, investing in both gas and wind farm technologies.

bit.ly/17GGyxd

Los Angeles city of lights

Move over Paris, Los Angeles is the new city of lights—LED lights. Los Angeles recently completed the installation of 141,089 LED street lights, the largest LED street light upgrade in the world.

Los Angeles follows Las Vegas and Austin in switching to LEDs. The city is expected to save US$7m dollars in electricity bills and US$2.5m in maintenance costs.

www.bit.ly/LAstreetlights

Special subscriber and member prize

From all the members and subscribers who renewed, joined or subscribed from 11 October to 15 November, the lucky winner of the off-grid 30 Watt Solar LED Lighting Kit with USB from Commodore Independent Energy Systems is Pasi Ihalainen, a photographer from Brisbane. Congratulations Pasi!

Up front

Growing green

A *Growing Green Guide* has been produced by the University of Melbourne, the Victorian Government and four inner-city councils to give tips to planners, designers and homeowners on how to grow and develop green roofs and walls.

As cities become increasingly urbanised, the guide urges people to ensure that vegetation and natural landscapes are still considered when they are building their homes. Senior lecturer in urban horticulture at Melbourne Uni, John Rayner, says there are many benefits in growing vegetation on roofs and walls.

"Green roofs, walls and facades that are well designed can help to reduce urban stormwater runoff, increase biodiversity or simply provide more greenery in the city, which is known to reduce people's stress levels and improve mental health," he says.

The current guide is a draft and members of the community are encouraged to review the guide and provide feedback, with the final copy of the guide to be released in 2014. growinggreenguide.org

Carbon-balanced wines

A net-zero carbon wine is hitting the shelves this year. Tahbilk winery is leading the wine industry to a greener future, taking the title of the world's first carbon-neutral winery. In 2012 the winery achieved a net-zero balance of carbon emissions by planting trees and purchasing carbon credits.

The winery was recently rewarded for going green, receiving an international award for its wine quality and carbon-balanced status.

Alister Purbrick, CEO of Tahbilk, says, "At Tahbilk our mantra is that we are 'governed by nature', and my family and I have always felt a strong sense of responsibility to protect and enrich the estate's natural resources."

The road to achieving a net-zero balance has not been easy, with 180 hectares to be planted in a project that began in 1995. The winery also underwent four years of assessments and two audits to gain a better understanding of its carbon footprint and how to reduce and offset it.

Purbrick believes seeking to be more sustainable and aware of the effects of climate change is the future for Australian wineries. "It is very satisfying today to know our revegetation program withdraws 980 tonnes of carbon from the atmosphere annually, a figure we intend to triple over the next five years, increasing the natural biodiversity of the landscape," he says.

A new way of funding community energy projects

The Citizens Own Renewable Energy Network Australia (CORENA) has come up with an interest-free loan system for community groups to install renewable energy. With initial funds gathered through donations, they have recently loaned $12,000 to the first project to benefit from the scheme.

Tulgeen Disabilty Services at Spindler St in Bega, NSW, now has a 4 kW solar system on their Tulgeen cheese packaging facility which employs peoples with a disability, and a 3 kW system on their Training and Education Services day programs centre. The organisation will pay back the loan in three years from savings on their electricity bill.

"All the loan repayments from the Tulgeen project will be used to help fund the next project at another community-serving organisation, then another", said CORENA spokesperson Margaret Hender. "Eventually, when we have funded around 120 such projects, repayments from earlier projects will be enough to continue funding one new project per month for ever, without ever needing more donations."
corenafund.org.au

Flying blind: global climate talks are getting us nowhere

If global aviation was a country, its emissions would be ranked about seventh in the world, between Germany and South Korea on CO_2 emissions alone. Yet despite flying being a growing global contributor to climate change, those emissions are still poorly accounted for and almost entirely unregulated.

Aviation's contribution to worldwide annual emissions could be as high as 8%. And the United Nations' special aviation body—the International Civil Aviation Organization (ICAO)—forecasts significant further emissions growth: against a 2006 baseline, an increase of 63% to 88% by 2020, and 290% to 667% by 2050 (without accounting for the impact of alternative fuels).

So what are we doing about it globally? At ICAO's triennial assembly last month, an agreement was reached to proceed with a roadmap towards a decision to be taken in 2016 for implementation in 2020.

If everything goes to plan, then from 2020 we might see a global "market-based mechanism" (basically, an emissions trading scheme) covering global aviation.

But that outcome is far from guaranteed. So in effect, those international delegates made an agreement to agree, and to keep talking at their next major meeting in three years—and nothing more. Extract from an article by David Hodgkinson at theconversation.com: www.bit.ly/FlyingBlindClimate

Offsetting flights

The only personal action currently available to reduce aviation emissions is to not fly, or to offset your flights by purchasing carbon offsets from initiatives such as the ATA's Community Climate Chest: www.climatechest.org.au.

Letters

Water saving devices

I read the article 'Practices and plumbing—Water saving ways' in *ReNew 125* and would like to add a cautionary note to a couple of the suggestions in the box labelled 'Next steps to save water'.

Firstly, with regards to the suggestion to install flow restrictors and low-flow showerheads: if you have an instantaneous hot water service you should check the minimum flow-rate of the water heater first. It may be that the heater requires a greater flow rate to function properly than the restrictors or low-flow heads allow. Installing these devices without checking could cause no hot water or intermittent hot water problems, or it could possibly even damage the heater.

Secondly, when installing a dual-flush toilet, especially if renovating an older single-flush system, do not change just the cistern, change the pan as well. Older pans have a wider 'throat' and you may find that if you only install a dual-flush cistern, it could take two or sometimes even three flushes to clear properly, therefore negating any water savings.

John Vangiessen

Pollies love hot air

In *ReNew 125*, Richard Keech asked why are we still persisting with policies that favour the burning of gas. Even more to the point, why are we still burning stuff for energy?

The answer is simple. Policies are produced by our governments and politicians who, in turn, are owned and run by 'business as usual'. These worthies make a vast amount of money selling us the stuff to burn and they don't want that to stop. In fact, anyone concerned about us moving towards a sustainable future, and I assume that's all of us, needs to understand that our political system is completely dedicated to obstructing that transition.

Of course, the transition is inevitable but with no thanks to our political system. We may not make it, in which case extinction, so that's something we could thank them for.

Robin Harrison

More methane discussion

The article 'Methane Matters—Is the future electric?' by Richard Keech in *ReNew 125* suggested natural gas was as dirty as coal. I don't share this opinion and reckon natural gas has a role in displacing coal and reducing global greenhouse gas (GHG) emissions.

A letter like this does not permit the luxury to dwell on any particular topic, but I have several points I'd like to make.

- The article failed to account for the fugitive emissions from coal mines. Coal mines contribute around 5% of Australia's total GHGs. (Note: methane from agriculture eclipses this.) Coal burning also produces air quality issues (particulates, SOx, NOx, etc) that cannot be attributed to combusting gas.
- Peer-reviewed science should be the reference point for energy policy. A web search reveals a number of papers confirming natural gas produces 50% to 70% less GHG than coal, across the total lifecycle.
- Germany, arguably the most energy conscious country on the planet, has quietly built new coal-burning power plants to keep up with energy demand. Denmark, the masters of wind, need inter-country grid connections to ensure they have enough power for the days when the wind does not blow. France reduces GHGs by using more nuclear power. In Spain, the performance of the impressive solar thermal plants is impacted by days of diffused sunlight.
- Distributed power systems are improving, but the grid needs further development to enable multi-source power generation. Battery storage technology is improving. However, batteries cannot help with baseload generation. Unfortunately, all renewables suffer from intermittency and require some form of backup power storage or generation (which is often a hidden cost). If backup generation is required, then gas is a viable contender.
- Exceptionally efficient gas-burning micro-generation units exist, such as the Aussie-built ceramic fuel cell that can produce a household's weekly power and hot water needs from a single BBQ bottle. Compressed gas is also a viable substitute for petrol and diesel.

Much to my surprise, a country which snubbed the Kyoto protocol has had the greatest impact on reducing GHGs. The USA has reduced GHGs by 12% to 13% from its high in 2008–2009. This is mostly attributed to fuel switching from coal to natural gas.

There are 400 million people in India and more in China, who are waiting for their chance to be connected to power. Where will energy of that intensity come from?

I agree electrons are the future and the move to renewables (and multi-source grid systems) needs to be hastened. We also need to be mindful of sustaining coal consumption by ignoring an immediately available lower emissions alternative, that is, gas.

Dougal Mactavish

The central point of my article was that the climate impact of gas is probably much greater than generally reckoned because of flawed assumptions about leakage and GWP (see references at media.bze.org.au/nogas.pdf). In responding to the threat of climate change, I think that any new fossil-fuel infrastructure should be avoided; it's probably less problematic to see a few more years of use from an ageing coal plant before retirement than see a whole new suite of gas-based assets being built.

Richard Keech

A different solar approach

My letter is in response to the discussion on increasing system load in Q&A in *ReNew* 125. In 2000 I installed a 900 W off-grid

Reverse solar hot water system flow

Regarding David Gobbett's article, 'The well-monitored solar hot water system', in *ReNew 125,* thanks for the article and particularly the graphs. I investigated this issue on my thermosiphon hot water system. We were getting a big hot bath for the kids in the evening, but if we waited until the morning, we only got a big warm bath. My system was well-insulated, so I was left wondering, "where is all the heat going?" I did some searching on the net and found that our type of hot water system actually reverses flow at nightime, so small amounts of water in the tank go backwards through the collector panels and lose heat.

The reason for this is the collector panels radiate heat to the cold night sky and become colder than the ambient air. This makes the water in the panels heavier than the water in the piping, causing it to sink downwards—causing a thermosiphon flow opposite to the daytime direction.

I checked this on my system. Late at night I went up into the roof (my tank is above the panels, but inside the roof). I felt the piping between the tank and collector panels and it was very warm for about one metre, meaning the hot water was moving out of the tank, downwards to the panels.

The solution? I went back to the web (the best internet sources that I found on this subject were from the University of New South Wales) and found the solution is to sit the tank higher. For every 100mm that the tank is higher than the collector panels, reverse flow decreases dramatically. I did this to our system and now our hot water system is too hot. We need to install a tempering valve to cool it down! It wasn't that easy to separate the tank and raise it higher. At our place I put the panels on the verandah roof and the tank propped up on timber above the ceiling in the roof space.

Jeremy James

Photo: lowerenergyliving.com.au

Jeremy, thanks for your comments and information. That is interesting that you have actually observed the reverse circulation. It does seem counter-intuitive since I would expect the denser, cold water to stay in the panels, and the warmer, less dense water in the tank to stay higher. However, heating and cooling of water close to the inlet and outlet pipes might affect this. I discovered a research paper by Michaelides et al (2011) which suggests that "night losses [are] one of the most significant sources of energy loss in thermosiphonic systems". I'm yet to read the article in detail.

If reverse thermosiphoning is occurring, it's an interesting question of how to overcome it. The page at www.bit.ly/thermosiphoning clarifies a little—suggesting the bottom of the tank must be well above the top of the panels. That article also supports use of a non-return valve (gravity type not a spring type). I wonder whether the main problem with my system is that the fairly low slope of my roof means that the panels are sitting too high relative to the tank, and would be better if lowered somewhat. I'll look into this some more when I have time. I might have to call on a nephew who is a plumber!

David Gobbett

solar system. As my household grew with more appliances and people, I sought advice on fixing the power supply issues.

The solution provided was to get a bigger 5.5kVA generator with a larger 40A, 24V battery charger, as well as to increase the battery bank size and add more solar panels to make it a 1500W system. The unfortunate outcome of this was that we were spending an average of $30 a week on fuel for the generator in winter (probably $50 at today's prices).

Then, when we went on holidays in winter 2006, one of our children left a computer on. The battery bank dropped down and the inverter switched off, but the 24V fridge kept running the battery bank down. When we got home two weeks later the batteries were dead.

So I did the opposite to advice. I put in two banks of small 2V, 275Ah gel batteries which I set up like a vehicle auxiliary battery system, with the fridge on the main battery bank and the rest of the house on the auxiliary bank.

I got a 2000W (quiet) generator and small 7A, 24V (200W) battery charger and changed back to a 900W solar system. With the remaining 600W of panels I set up a separate solar system with 4 x 6V lead-acid batteries (400Ah) and a small 600W inverter. There is also a 3.5A, 24V battery charger which I switch on overnight after cloudy days. In winter I run the generator once every two weeks—at 4.5 litres of fuel for 5 hours of runtime it costs about $3.50 a week. This gives the 600W solar system a rest on these nights.

The negative of this setup is that half the battery bank size for the house means quicker discharge on big loads. The positive is, if a computer gets left on again the auxiliary battery bank drops down and the inverter switches off, but the fridge has its own battery bank. During the daytime the house battery bank charges up again with no problem.

Roslyn Bell

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
Portable energy system in a cube

When it comes to mobile power generation, most people will reach for the generator as they are compact, but they are also noisy, polluting and bad for your health and the planet.

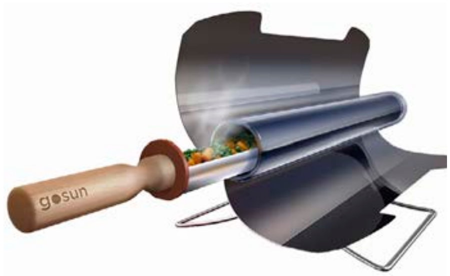
While solar power is probably the cleanest option, most solar power systems are not exactly portable.

The iKube is a complete solar power system that folds up into a cube sized at under 1.3 metres on each side. You simply roll it into position and open up the solar array, which folds out in stages to form a huge 9 m², 1.4 kW solar array.

Inside the box that supports the array is a 3 kW sinewave inverter, storage battery and all the usual solar power system components. The 245 Ah, 48 V sealed lead-acid battery gives the iKube around 10 kWh of energy storage capacity, although it is recommended that you don't exceed 7 kWh for long battery life.

The iKube weighs in at around 550 kg and can simply be rolled into position by two people. It can also be moved by forklift, and special trailer options are also available.

RRP: $12,500 inc GST plus delivery. For more information, contact Harmonic Energy, PO Box 1181, Thornbury VIC 3071, ph: 1300 766 199, contact@i-kube.com.au, www.i-kube.com.au



02
A very portable solar oven

We have looked at a lot of solar cookers over the years, but the GoSun Stove is the first to be based on an evacuated tube.

The oven consists of a 610 mm long evacuated tube with a 58 mm internal diameter and 76 mm external diameter. Inside this you slide a cooking tray which holds the food to be cooked or liquid to be heated. The tube is mounted between a pair of folding parabolic reflectors that concentrate the sunlight onto the tube, but also fold up to protect the tube when not in use. A carrying handle also doubles as support legs for adjusting the oven to face the sun.

The GoSun can accommodate up to 1.4 kg of food or 1.6 litres of hot beverage. It has an estimated heating capacity of 230 watts and can reach temperatures as high as 371 °C. Meals can be ready to eat in as little as 10 minutes.

There will also be a GoSun Mini, a more compact version for camping and similar uses.

The GoSun Stove comes with a two-year warranty on the tube which covers the cost of a replacement tube regardless of how it gets broken! The other components are guaranteed from manufacturing defects for one year.

RRP: US$279, $129 for the Mini. The GoSun Stoves will be released early 2014, but are available for pre-order now. For more information and to order go to www.gosunstove.com

03
Putting a spotlight on efficiency

Many homes and businesses use track lighting but until now the most common option has been halogen lamps. These are just as inefficient as any other halogen, so high-efficiency alternatives have been finding their way into the market.

Brightgreen, makers of a number of LED-based retrofit and downlight fittings, recently released the TR700, a direct replacement for standard halogen tracklights.

The TR700 features an integrated universal track base and has the driver built in, so replacing the old fittings is a simple job in many cases. The TR700 has a rated power consumption of 10.5 W and a total light output of 720 lumens, giving it an efficacy of 69 lumens per watt—so it matches the light output of a 50 W halogen bulb using only 20% of the energy.

The lights are available in 40° or 60° beam angles, a CRI of 83 and colour temperatures of 3000 K and 4000 K, providing warm and neutral options. Rated life is 70,000 hours (lumen maintenance rating is 40,000 hours) and they come with a three-year warranty.

RRP: $99. For more information, contact Brightgreen, PO Box 1400, Collingwood VIC 3066, ph: 1300 672 499, info@brightgreen.com, www.brightgreen.com

04

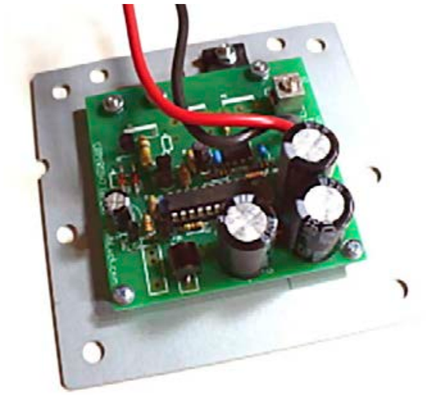
Non-polarised DC circuit breakers

Direct current (DC) circuits need circuit breakers rated to break DC, due to the much greater degree of arcing and ability of DC to sustain that arc. There are DC breakers already available, but many are polarised types, meaning they must be wired with correct polarity or they can fail. The new standards for solar installations (AS/NZS 5033:2012) require that all DC breakers are of the non-polarised type, meaning they can be wired either way without problems.

Jaycar Electronics, and their wholesale arm Electus Distribution, now have two-pole non-polarised DC breakers available for the installer or DIYer. There are three models available—10 A, 550 VDC (cat number SF4154), 16 A, 1000 VDC (SF4157) and 20 A, 1000 VDC (SF4159), so there should be a breaker to cover most array sizes.

The breakers are standard DIN rail mount types and so are compatible with the vast array of DIN rail enclosures and accessories already available through electrical equipment suppliers.

RRP: $32.95 for the 10 A unit, $39.95 for the 16 and 20 A models. For more information contact Jaycar Electronics, ph: 1800 022 888, techstore@jaycar.com.au, www.jaycar.com.au or Electus distribution, www.electusdistribution.com.au



05

The simplest solar hot water

Solar hot water systems are great, but split systems can be complex and the plumbing messy and expensive. However, there is another solution: to heat water directly from solar PV (photovoltaic) panels.

The advantage of such a system is simplicity. There's no plumbing between the tank and roof and no pumps or sensors to fail. The PV panels are simply wired, via a controller, directly to one element in a twin element tank, or the single element if using the tank as a preheater for the main hot water system. With the loss of feed-in tariffs for grid-connected systems across most of Australia, using your PV-generated power directly allows you to offset expensive grid power—much better than getting paid almost nothing by the energy company.

There are not many controllers of this type on the market; the most readily available is the Solar Hybrid Hot Water Controller from Techluck in the US. This controller is an MPPT unit that matches the PV panel voltage to the tank element, so no element changes are required.

The controller is supplied as a complete circuit board with instructions, and you simply fit it inside a suitable box and wire it up.

RRP: $266. For more information and to buy, contact Commodore Australia, ph: (03) 5795 1567, sales@commodoreaustralia.com.au, www.commodoreaustralia.com.au. Also see www.techluck.com

06

Smaller Sandens

Heat pump water heaters are by far the most efficient electric water heater as they only use electricity to move heat from one place to another, rather than generating heat directly. Sanden heat pumps are some of the most efficient of all the heat pumps, and they use CO_2 as a refrigerant—which has the lowest greenhouse gas effect of all available refrigerants.

However, up until now, if your hot water needs were small, then the 315 litre Sanden heat pump would have been too large. But now there are two smaller models aimed at those homes with lower hot water needs, such as in one- or two-person households.

For medium-use households, the 250 litre would be ideal, while the 160 litre Sanden would cover the needs of low-use households—it is aimed at replacing 80 to 150 litre electric water heaters that are usually powered from peak power electricity, costing a small fortune to run. By replacing them with a heat pump, running costs can be reduced by up to 75%, or even more.

RRP: None set as they are usually sold directly to plumbers and builders. For more information, contact Sanden International, 6/17 Willfox St, Condell Park NSW 2200, ph: (02) 9791 0999, sales@sanden.com.au, www.sanden-hot-water.com.au

Products

07

Non-toxic simple wood treatment

There are many low-toxicity wood treatments on the market, including eco-friendly resins and oils. However, they usually need re-applying every year or so. For large areas of wood this can be time-consuming and expensive.

Eco Wood Treatment is a low-toxicity water-based timber stain and preservative for use on previously untreated timbers. It is supplied as a powder composed of natural substances from minerals. It contains no solvents and leaves no harmful residue in water or soil.

You simply mix the powder with water and apply directly to clean wood only once for the life of the timber. It soaks in and gives the wood a silvery patina after time, making the wood resistant to rot and fungal attack, even if buried in soil. It is ideal for new or untreated wood, weatherboards, decks, fences, posts, doors and windows, wooden planters, garden surrounds or anywhere wood is subject to the outdoors. The treatment works on all wood types, including fir, cedar, pine, spruce and even tropical hardwoods. It is available in original clear as well as seven coloured tints—black, brown, green, blue, red, yellow and orange.

Available in two sizes that mix to make 4.5 or 22 litres of solution.

RRP: NZ$35 for the 4.5 litre pack, $152 for the 22 litre pack. For more information or to buy, contact Harm Less Solutions Ltd, New Plymouth, Taranaki New Zealand, ph:+64 6 755 2552, www.harmlesssolutions.co.nz. Also see www.ecowoodtreatment.com

08

Shower head that times your shower

We have seen many different designs of shower timers over the years but they all have one problem—they are useless if you forget to use them.

The Uji showerhead, created by Tufts University graduates Brett Andler, Sam Woolf and Tyler Wilson, takes a different approach. The timer is built into the showerhead, so it starts when you first turn on the shower. The Uji contains coloured LEDs with a tiny water turbine generator to drive them. When you turn on the shower the colour starts off as green, steadily progressing through to red to remind you how long you have been in the shower.

There will be two versions available—a low-flow model for people looking to maximise their environmental impact reduction and a full-flow version for those interested in saving water, energy and money without reducing their shower experience.

RRP: $50. The Uji will be available for pre-order shortly. Interested parties can contact the designers via the Uji website at www.ujishower.com

09

Portable power without the fumes

The need for a portable power source for off-grid, intermittent use is quite common, but most people resort to a petrol or diesel generator. Aside from the fumes, noise and hassle, gensets are about the most expensive way to generate electricity there is.

The Yeti1250 portable solar-powered generator from Goal Zero is designed to provide power for temporary low-demand applications such as caravans, motorhomes, camping, sheds and shacks.

It consists of an enclosure housing a 100 Ah sealed lead-acid battery, a 12 V 20 A MPPT charge controller and a 1200 W inverter. Included in the package is a roll cart for easy portability, two 30 W solar panels, carry bag and cables. Also available is a second battery kit (including connectors) to double the storage capacity, a solar add-on kit that includes two 30 W panels, carry bag and cables, and a tripod for mounting four panels. Maximum solar array size is 240 watts.

There are two 10 A solar charging ports and a 20 A power socket charging port. Outputs include two 220 VAC power sockets, several different 12 V port options and three USB ports.

RRP: $2200 for the Yeti1250 kit, $620 for the additional solar kit, $417 for the battery kit and $170 for the solar tripod. Available in Australia from Off-grid Energy, ph: 1300 334 839, info@offgridenergy.com.au, www.offgridenergy.com.au

10
A fairer phone

The majority of mobile phones have one area where they are not so smart and that's in their environmental and ethical credentials. The components in most phones come from a range of suppliers, with little accountability along the way.

The Fairphone is an attempt to address these issues by creating a smartphone with full accountability along the supply chain, from where the minerals that make the components are mined, to how the phone is made and what the workers are paid.

For the technically minded, the Fairphone specs include dual SIM slots, Android 4.2 as its OS, a MTK6589 quad-core 1.2 GHz CPU, 1 GB RAM, 16 GB of system storage and a micro SD slot for storage expansion. It operates on the 2G/GSM 850/900/1800/1900 MHz and 3G/WCDMA 900/2100 MHz bands. Dimensions are 126 x 63.5 x 10 mm and it weighs 170 g.

Other features include a 4.3" 960 x 540 pixel screen with Dragontrail glass, 8 MP rear camera with stabilisation, 1.3 MP front camera and a 2000 mAh replaceable battery. For environmental reasons, headphones and a charger are not included as standard.

The Fairphone is being sold on pre-order, with the first 25,000 almost gone. It is currently only available in Europe, although a freight forwarding company can solve that problem.

RRP: €325. For more information, email info@fairphone.com or go to www.fairphone.com

11
Safer stripping

Paint stripper is caustic stuff: it attacks your skin and the fumes can cause lung irritation. And the alternative—using abrasive paint-removal methods such as sanding—are an absolute no-no when working on older homes that may have toxic materials in their paint.

Livos Australia has recently released TAKETI paint stripper. Although it is still a caustic product, it is based on renewable resources and all ingredients are fully declared. Livos says the stripper is very economical, is ready to use out of the tub and works on saponifiable dispersion paints, oil paints, amd natural and synthetic resin varnishes.

Using it is much the same as other paint strippers: apply the stripper liberally, spray with water and leave for a few minutes. Paint is then ready to remove with a scraper or putty knife.

TAKETI comes in a 1 kg tub, which will cover up to 8 m², depending on application.

RRP: $34.75 for a 1 kg tub. For more information and materials safety datasheets, contact Livos Australia, 6 London Drive, Bayswater VIC 3153, ph: (03) 9762 9181, www.livos.com.au

12
Wilderness calendar

Most people buy or are given a calendar every year, but many don't stop to consider the environmental aspects of all that paper and printing.

The Wilderness Society's 2014 Wilderness Calendar features 12 stunning full-colour wilderness photographs chosen to represent Australia's beautiful landscapes.

The calendar is printed with soy-based inks on 100% post-consumer recycled paper that is certified carbon-neutral and processed chlorine-free. Binding is with WIRO metal spiral binding.

The calendar measures 255 x 352 mm, with a picture size of 217 x 295 mm surrounded by a 15 mm white border. Weeks start on Monday.

If you don't mind paying more for a much larger calendar, then check out the 2014 Tarkine Extra Large Calendar from Rob Blakers Photography. This 14-page calendar measures 560 x 640 mm and features 13 stunning images from Tasmania's magnificent and endangered Tarkine wilderness. Photography is by Rob Blakers with an introduction by Bob Brown. The high print quality makes the images suitable for framing as art prints.

RRP: $25 for the Wilderness Calendar. From the Wilderness Society, ph: 1800 030 641, info@wilderness.org.au, www.wilderness.org.au.
RRP: $74.95 for the 2014 Tarkine Extra Large Calendar. From Rob Blakers Photography, ph:(03) 6223 2537, www.robblakers.com

Who needs fossil fuels?
Making the solar car commercial

Swinburne University designs a Mad Max-inspired car that could survive in a post-apocalyptic world devoid of fuel or power, writes Clint Steele.

SOLAR cars have been around for more than 30 years. Most *ReNew* readers will have seen at least one story about the World Solar Challenge, the solar car race from Darwin to Adelaide (including in the last *ReNew*!).

Solar cars now readily make this journey every two years. In fact, it may have become a bit passé. There was a time when the event would gain considerable attention, but now it seems less of a challenge and more of a hobby for those with the desire and technical know-how, and the media is less interested.

Perhaps it's time to take solar cars to the next level.

The idea to make a commercially viable solar car—one that can be sold at a profit and so allow for a sustainable business—is not completely new. There is the Venturi Eclectic, for example (see box at right).

Of course, there's a lot more needed than an idea to make something happen. Experience, expertise and commercial nous are essential.

This is the first article in a series about a group of Australians (solar racers, engineering students and business investors) working together to develop a locally produced solar-powered sports car for road use.

↑ A proposed design for Swinburne University's solar car, the Solaris. Surprisingly to many, one of the biggest challenges in car development is the sealing of doors. The clamshell design makes this a bit easier.

The power of solar

Imagine a car that will keep on running as long as the sun keeps rising each day. No matter how far you are from the nearest service station, you can keep driving. That's the strength of the solar car: complete freedom.

Not only can you keep on going, you know that there is no question of pollution while you drive. Standard electric cars need power from somewhere and this might be a renewable source or not. With a solar car, there is no doubt: it's clean.

That was the idea from the chairman of Aurora Solar Racing: a Mad Max-inspired car that could survive in a post-apocalyptic world devoid of fuel or power, and designed to show to the world just how powerful solar power can be.

It is intended that the solar car will look and handle like a sports car, with respectable take off and tight handling, to counter some of the common stereotypes about solar cars (slow, poor handling, more like a golf buggy than a real car) and so demonstrate the wider potential of solar power. The plan is that this is a car that could be used for doing the shopping, but also for more exciting things.

The discipline of engineering

Aurora Solar Racing has more experience in solar car racing than most other organisations. On a shoestring budget, the team has competed around the world with innovation and determination to make things work.

But making a car that can run on the road also needs a lot of engineering discipline and dedicated time. Since 2012, Aurora has been working with a team of engineering students at Swinburne University to refine the design of Aurora's latest solar racer into a commercially viable road-going sports car: the Solaris.

Strategic design

The defining challenge of a solar car is the efficient use of energy to generate speed. At best, a solar car can expect 1.25kW of power. Compare this to the maximum power of a medium Australian sedan (250kW) or a small computer (0.1kW). A solar car is closer to a computer than a regular car when it comes to power.

"At best, a solar car can expect 1.25 kW of power. Compare this to the maximum power of a medium Australian sedan (250 kW) or a small computer (0.1 kW). A solar car is closer to a computer than a regular car when it comes to power."

To make the most of the power available for the Solaris, the following strategic design decisions were made:

- weight below 250 kg to reduce rolling resistance.
- no heating—the driver will likely drive on warm days anyway, but on those cold days with enough sun they will need to dress warmly.
- no cabin cooling—a system to efficiently cool the driver alone will need to be developed. This will likely be a spot cooling system so that there is no energy wasted on cooling the cabin. However, development is still needed to find the final form. This will hopefully result in valuable intellectual property that will provide further income for the venture.
- a CdA (the effective measure of aerodynamic drag) below 0.2 to keep wind drag to a minimum.
- hub motors with a power of 20 kW each and an efficiency of 98%—this reduces the weight by having no transmission between the motor and wheel and the high efficiency makes the most of the limited power available.
- a 66 kg battery pack with 15 kWh storage—this allows the car to store energy when cruising or stationary and then release it in a fast large burst for acceleration.
- a body made of carbon fibre—carbon fibre is not cheap, but it offers excellent mechanical properties such as strength and stiffness for its weight.

The Venturi Eclectic

The Venturi Eclectic is a low-speed solar-electric 'city car' fitted with both solar panels and plug-in charging. With a battery range of 50 km, a top speed of 50 km/h, and three seats, it has been described as a 'golf buggy on steroids' and is primarily intended for city driving. The solar panels extend the range by 7 km a day. It can even be charged from a personal wind turbine when parked! Of course, because Australia has no quadracycle or equivalent registration class, it couldn't be used on the road here.

The road ahead

There are still many other challenges to face related to ride, handling, comfort, speed, manufacturability, safety and more. These will all be topics of future articles. If there is anything specific about the development of a solar sports car that you want to know then please contact *ReNew* with questions via renew@ata.org.au. These will be passed on to the team and responded to in later issues. ✱

In the next issue—the power train: sunshine to wheel rotation.

Clint Steele is a senior lecturer in the Faculty of Engineering and Industrial Sciences at Swinburne University.

EV charging demystified
All your EV questions answered

Getting energy from moving electrons is not so easy to see or understand. Bryce Gaton answers some of the common questions about EV charging.

BURNING things to produce heat, light or movement has been with us a long time. From toasting goannas over a fire, to gas lighting in Victorian times and burning petrol in a combustion engine: we can easily see and relate to this form of energy release and use.

On the other hand, getting energy from moving electrons is not so easy to see or understand. A consequence is that more than a few myths and misunderstandings have sprung up about the use and capabilities of electricity as a power source for our cars.

In this article I hope to dispel a few of these myths—as well as probably starting other debates about the capabilities and limitations of electric vehicles!

← There are several different charging plug types in use for EVs. Here you can see a J1772 plug being used to charge a converted Hyundai Getz.

To sum up

EVs are vastly more efficient in using energy to move a vehicle, but a battery pack simply cannot pack the punch per kilogram that each litre of fossil fuel does. (A second conclusion is that we are incredibly wasteful of the energy in our petrol tanks.)

Question 1: Why can't I get the same distance from an EV battery pack as I can from a petrol tank?

This comes back to why fossil fuels are so popular as an energy source: they are a really energy-dense material that is packed full of energy waiting to be liberated!

To explain why a battery pack is not the equivalent of a full fuel tank, consider the figures in Table 1, showing battery pack sizes and ranges as an equivalent number of litres of petrol. Even the Tesla with its 750kg battery pack only contains the equivalent energy of 8.95 litres of petrol.

That being said, looking at the last column, a standard petrol car at 10L/100km uses something like 5.5 to 8.5 times the amount of energy an EV uses to cover the same distance!

Vehicle	Battery pack size	Approx battery pack mass	Vehicle range	Equivalent litres of petrol in the battery pack	Equivalent L/100km
Tesla model S	85kWh	750kg	484km	8.95L	1.85
Nissan Leaf	24kWh	294kg	175km	2.5L	1.43
Mitsubishi iMiEV	16kWh	200kg	150km	1.7L	1.13
Blade Electron (Hyundai Getz conversion)	16kWh	185kg	100km	1.7L	1.7
Petrol car at 10L/100km	475kWh (equivalent)	NA	500km	50L	10

Table 1: Manufacturers' battery pack sizes and ranges as an equivalent number of litres of petrol.

Notes:

Calculations are based on the average litre of petrol containing 34.2 megajoules per litre (MJ/L). Converting this to watt-hours (Wh)—the normal measurement unit for electric cars—given 1W = 1J/sec, 1 hour = 3600 sec, this equates to 34.2 x 10^6 / 3600 = 9500Wh or 9.5kWh.

Vehicle range: the actual range for Nissan, Mitsubishi and Blade EVs appears to be closer to about 80% of these published figures. Tesla EVs, however, seem to be fairly close to their stated range.

"You can charge any commercially available EV from a standard household power point ... but it depends how fast you want to charge your EV."

Question 2: Can I cover the surfaces of my EV with solar panels and never need to plug it in to recharge?

This requires us to look at two other questions first: firstly, how much energy can you get from solar cells placed on a car; and secondly, how much energy per kilometre does a road-registered EV use.

SOLAR ENERGY COLLECTION BY A CAR

If you're at the equator, at midday on 21 March or 21 September (that is, with the sun directly overhead), the spot you are standing on receives 1000 watts of solar power per square metre. This gradually reduces as the sun's rays fall at increasing angles to the Earth's surface: that is, in the morning and evening, at increasing distances from the equator or at different times of year. In Melbourne, this equates to 4.6 kWh per square metre per day when averaged over one year. For Sydney, it's 5.1 and Brisbane 5.4.

If we are lucky, we can manage to cram two square metres of solar cells onto the horizontal surfaces of a typical small sedan. Given that current solar cell technology converts approximately 14% of the sun's energy to electricity, if this car is driven in Melbourne where it receives 4.6 kWh on average per day on its solar cells, and converts this to electricity at 14% efficiency we will collect 4.6 x 2 x 0.14 = 1.29 kWh of electrical energy per day, on average.

This is an overestimate, as solar panels need to be tilted towards the sun to achieve their maximum efficiency but optimising the angle on a moving car would be impossible. The actual result for horizontal panels would be about 20% less. In addition, this calculation doesn't take into account battery charging losses, temperature derating etc. However, we can use this figure as a starting point.

To sum up

If you park and drive a solar-covered EV in full sun all day, and travel less than about 6 to 8 km per day (a bit more in summer, much less on cloudy winter days), then you might never need to charge your EV from the grid. However, if you travel that little you could probably do without a car altogether and walk everywhere! It makes much more sense to have solar panels on your home or business premises.

ENERGY USE PER KILOMETRE

Table 2 shows the energy use per kilometre for three production EVs, ranging from 135 to 200 Wh/km (see second column).

Note that these values are an estimate only as the actual energy use per kilometre depends on driving conditions, accessory use, speed and a myriad of other factors. Leaf and iMiEV values are from the *Green Vehicle Guide*; the Tesla value is from their website.

PUTTING IT TOGETHER

The final column in Table 2 shows the kilometres that could be travelled in each of the three production EVs, assuming 1.29 kWh of energy from the roof-mounted solar panels and the rated Wh/km of each of the EVs. The distance is in the range of 6.45 to 9.56 km—not a lot, and in fact likely to be an overestimate, given the issues noted with optimising panel angle, charging efficiencies and driving conditions.

EV	Wh/km	km travelled on 1.29 kWh
Tesla model S	200	6.45
Nissan Leaf	173	7.46
Mitsubishi iMiEV	135	9.56

Table 2: Energy use by EVs (column 2) and the resulting kilometres able to be travelled assuming 1.29 kWh (1290 Wh) of energy available.

↑ This level 2 charging station from ChargePoint can be installed in homes or businesses and allows EVs to charge at up to 30 amps. It isn't a charger, but rather a smart controller with some good safety features that prevent the lead becoming live unless it is plugged into the car.

Question 3: Do I need to have a special charger to be able to charge my EV at home?

The short answer is no. You can charge any commercially available EV from a standard household power point. The one minor exception is the Nissan Leaf that needs a 15 amp power point. However, for most houses, it is not expensive to have a 15 amp power point installed.

The slightly longer answer is: it depends how fast you want to charge your EV. To explain this better, Table 3 shows the four levels for charging EVs in Australia. The levels and how you can implement them are explained below.

LEVEL 1 CHARGING

Level 1 charging is via your standard power point. A full charge will take 6 to 12 hours, depending on the vehicle. The charging lead

Photo: automotive.com

← The Nissan Leaf comes with two charging ports. A J1772 socket is on the right. The same plug is used for charging at levels 1 to 3. The socket on the left is the CHAdeMO.

provides 240V electricity from the power point to the vehicle's on-board charger.

Provided you are happy with this sort of charge time (usually overnight) you do not need to install anything to charge your EV.

LEVEL 2 CHARGING

If you want a faster charge time, this is still possible at home by installing a level 2-capable lead. Like level 1 charging, the charging lead provides 240V electricity from the power point to the vehicle's on-board charger. Charging time is generally 4 to 6 hours.

Level 2 charging leads are no more difficult for an electrician to install than an electric oven or air conditioner, but for older houses the extra load may require an upgraded power cable from the street. Make sure you get a proper assessment of your household electrical system before having one fitted.

LEVEL 3 CHARGING

In Australia, level 3 charging is provided using the same J1772 plug that supplies the EV at level 1 or 2. However, level 3 can supply up to 80 amps charging, which is generally beyond the capacity of a household power supply. If you have a very large incoming supply cable, or the desire to install one, you could still have level 3 charging in your home.

Just like level 2, for level 3 charging, you would require an electrician to install a dedicated circuit breaker and suitable cable between the house's circuit breaker box and the charging point. With virtually all level 3 charging installations, the cable between the pole on the street and your house will not be adequate and would have to be upgraded by your energy company. Your main house meter may also need to be upgraded.

Should you have a factory or other commercial premises, installing level 3 charging should be no more difficult to install than level 2 charging at home.

CHADEMO CHARGING ('FAST CHARGING')

To charge above 80 amps requires the use of a different charging plug and system. 240VAC power is converted by the CHAdeMO charger to DC that is fed directly to the vehicle battery pack. These chargers can supply DC current direct to the battery pack at up to 120 amps. As a result, using a CHAdeMO charging system requires significant electrical supply capacity and infrastructure costs: it's best left to the big end of town.

Level	Car inlet plug type	Maximum current	Approximate time to charge an EV from 20% to 100%
1	J1772	10 amps (AC)	6–12 hours, generally overnight e.g. can be 12 hours for a Leaf.
2	J1772	32 amps (AC)	4-6 hours
3	J1772	80 amps (AC)	2-3 hours
CHAdeMO DC charging	CHAdeMO	120 amps (DC) at up to 500V DC	iMiEV to 80% charge in 13 minutes Leaf to 80% charge in 20 minutes (values as quoted by E-station)

Table 3: EV charging levels in Australia.

Question 4: Why can't I charge my car in the time it takes to fill my fuel tank?

A lot of this answer is given by the answer to question 3. You can (almost) now—but there are not a lot of fast charging CHAdeMO systems out there... yet. The main point is that with home charging being so easy, there has been little call for fast charging at this stage of EV adoption. On the other hand, once fast charging is rolled out to the main highways, taking an EV on an interstate trip will finally be viable.

Question 5: Do I pay a premium for the electricity for my EV?

Charging an EV at home is no different to running an air conditioner. There is no way your household meter can know you are charging an EV instead of running an air conditioner. Therefore the price you pay to charge an EV is no different from what you pay for any other household electrical use.

Take note though: if you have a time-of-use electricity tariff, the cost of running an EV will depend on when you choose to charge it. For some people, the cost can be four or five times greater for daytime charging compared to an overnight off-peak charge.

On the other hand, if you charge from public charging points you will inevitably be paying peak rates for the electricity, plus the provider's margin. Best to leave public charging as a backstop or emergency thing rather than rely on it for everyday recharging. *

Bryce Gaton is a member of the Alternative Technology Association's Melbourne Electric Vehicle Branch.

End of article quiz:

1. On an average day in Melbourne, how much electrical energy will 1 m^2 of conventional solar panel capture per day?
2. What is the average Wh/km of a Tesla model S?
3. How far can a Nissan Leaf travel on a full charge?
4. What is the maximum current (in amps) that can be provided by level 1 charging?
5. Some research for you: What is your cost per kWh for the following periods? (see your latest electricity bill if not sure)
(a) during the day?
(b) overnight?

Carrying power
The resurgence of cargo bikes

Can pedal power be used to replace a car? Adam Peck says yes, with his household replacing one car with two electric cargo bikes. He discusses the options.

CARGO bikes are becoming more and more popular these days. This article explains what they are and how to go about choosing one for your needs. It also highlights my family's journey from a two-car family with two garage-bound pushies to our new one-car status with two well-used electric cargo bikes.

Cargo bikes have become very popular in Holland and Denmark. They are often used as a family transport vehicle in these countries' bike-friendly cities—and also just for lugging bulky items around. Most of these are pedal-powered pushies due to the mainly flat roads and short distances.

The case for electric

In Australia, cargo bikes are becoming a more common sight around the roads, carrying kids and cargo. At least here in Perth, it seems that these are often electric cargo bikes. With our more hilly roads and longer distances, an electric cargo bike is more practical, making it more likely that it will be used frequently, and as a car replacement.

Cargo bikes are pretty heavy and the loads they carry can be even heavier, another reason why electric assistance is an attractive option. Most box-style cargo bikes (bakfiets, or box bikes) weigh 30+ kg, and can carry 80+ kg in the box, 40 kg on the back rack plus the weight of the rider—over 250 kg in total! With those sorts of loads, unless you have legs of steel, you might have to get off and push that bike uphill if it doesn't provide some assistance.

Cargo bike styles

There are a couple of different styles of cargo bikes. I nominally split them into three categories: bikes, trikes and utilities.

↑ The Bakfiets can take at least 80 kg in the front box.

Cargo bikes are two wheelers and have a big box in front of the rider. This may be made from wood or have a metal frame with a canvas cover. Most have a bench seat with space for two children and an optional extra bench for more. A rear rack and panniers can hold even more cargo. A stand under the box makes them stable when parked.

Cargo trikes are three wheelers, with two wheels either side of the box. They tend to be heavier than the two wheelers and can take bigger loads. Despite what you might think about the safety of three wheels versus two, three wheels are less stable when going around corners or over bumps.

Utility bikes look more like conventional bikes. They usually have a long wheelbase with sturdy rear racks. You can even convert an existing bike into a utility bike with an Xtracycle kit. The ultimate in this group in my view is the Workcycles Fr8, which can take a whopping 120 kg on the front rack!

Choosing a cargo bike

When choosing a bike, most importantly speak to dealers or owners of cargo bikes and ask for a test ride. Most dealers can put you in touch with people in your area who will let you test ride their bike. Some other things to consider are:

- **Usage.** What are you using the bike for? Is it for short or long distances (trike or bike), flat or hilly (pushie or electric), big loads or small (trike for big, bike for medium, utility

"When choosing a bike, most importantly speak to dealers or owners of cargo bikes and ask for a test ride."

for small). Standard cargo bikes will meet most family's needs, but there's a bike out there to suit everyone.

- **Quality**. Quality lasts, needs less maintenance, saves money in the long run and gives more pleasurable riding.
- **Budget**. Chinese-made bikes cost much less than their European counterparts, so if you're on a tight budget this may be your best option. Just remember that you get what you pay for. Cheaper bikes generally have cheaper components and can cost more in higher maintenance and lower resale value. If you're going to ride the bike a lot and have it for five years or more, you may even find that in the long run a European bike is cheaper. Also, keep an eye out for secondhand or test-ridden bargains.
- **Unisex**. If two or more people will ride the bike make sure you get a style that will suit them all (e.g. with a low step-in) and a quick-release saddle (standard on most bikes but not all).

Benefits

The benefits of cargo bikes over cars are many. You can gain health and fitness along with easier parking. They're also much cheaper to run (a full charge of our electric cargo bike costs just 15 cents!) and easier to load than a car. Of course, they also have lower carbon emissions and produce less pollution and congestion.

On top of all that, they provide a much more fun way to get around. ✱

Adam is an environmental research scientist based in Perth. You can find more details on Adam and his family's sustainability journey at sustainaburb.blogspot.com.au (lots of graphs!).

Journey to a lower transport footprint

Our family's sustainability journey is detailed in the blog Sustainaburbia. We track our footprint by monitoring our use of energy, water and transport kilometres. Despite significant gains on the energy and water fronts, the hardest nut to crack has always been transport.

For years our dependence on our two cars did not abate. We had two bikes which mostly gathered dust in the garage. Then one year we took the plunge and bought ourselves a Bakfiets electric cargo bike for Christmas. This became our main transport option for local trips to school, the shops and beach. We'd load up our son, a dog and other bits and bobs and hit the road.

We loved the Bakfiets, but it didn't quite solve our dependence on two cars. This was because on days when we both worked, we mostly drove. I rode the Bakfiets to work a few times but it felt a bit silly with nothing but a small bag in a huge box. Then I saw the solution: I fell for a beautiful bike by the name of Fr8.

The Workcycles Fr8 is a long-wheelbase utility bike which can be added to as needed with front or rear racks and kid seats. I decided that this would be perfect for my 40 km round trip commute to work, with the option of also transporting my son to and from school or taking work gear for field trips.

Working on past experience I knew that the key to this would be electric assist. I'm a big believer in e-bikes because they actually get ridden lots, unlike many pushies which gather dust in the shed. It removes so many barriers (mainly time and energy) and is the key to overcoming seemingly insurmountable humps, hills and head winds.

So, I retrofitted an eZee 36 V, 14 Ah conversion kit onto the Fr8 and haven't looked back since. I have gone from riding to work about once a month to two or three times a week. We ditched the unreliable, expensive-to-maintain old car. Sure, the bike cost a lot but how much does a car cost to run? The average family car costs $12,000 a year to run and I estimate we spent at least $5000 a year to run our old bomb. This means the bike paid for itself in under a year. The maintenance costs are about $100–200 a year and charging the bike costs about $15 a year doing 4000 km (see sustainaburb.blogspot.com.au for more info).

So, what's the result? Well we're on course to halve our car transport kilometres from 19,000 in 2009 to 9500 this year. This story could be yours: get on a cargo bike and you won't look back. Happy cargo bike riding!

↑ A Christiania trike with a wide load.

↑ The Workcycles Fr8 with eZee electrics in the bottom of the front box.

Cargo bike FAQ

Are they hard to ride? Cargo bikes are bigger than normal bikes but once you get used to them they ride like any other bike. This isn't true of trikes, which are harder to ride because you can't lean into a curve to keep upright. My partner Amy was never a big rider, but she has taken to the Bakfiets like a duck to water.

How much do they cost? Prices range from roughly $500 for an Xtracycle kit to $4500 for a European electric cargo bike.

What's the range of an electric cargo bike? This depends on many factors, but is normally in the range of 30 to 70 km.

Do you still get a workout on an electric cargo bike? Absolutely. Most electric bikes have the option of pedelec operation, where the motor only engages when you're pedalling. You can set the level of assist depending on how much effort you want to put in. Also, the fact that you'll probably do far more kilometres on an electric bike makes them a great way to increase your fitness.

Are they high maintenance? Absolutely not. On the contrary, good Dutch/Danish bikes are very low maintenance. This is due to such features as internal hub gears, chain guards, roller brakes and flat-resistant tyres. A once-a-year service should be all that's necessary.

Andrew Reddaway: another style of cargo bike

As a single-car household with a baby on the way, could we avoid a second car? Yes, by getting a freight bike instead. Our freight bike was custom-built by Greenspeed Cycles to a design similar to the '8 freight' available in the UK.

The steel frame is surprisingly light, but the weight does increase with a DIY polycarbonate box mounted inside. Handling is good, but you do have to take care on low-speed turns. Inside the strong plastic box, I mounted first a car baby capsule, then a child seat. In addition to a passenger there is room for groceries, a fruit tree or even a pet! The bike can be stored vertically in the corner of the garage.

The bike is used less frequently now that the kids have graduated to their own pedals, but at times it's still the only bike for the job.

Off-grid living
Ten years on solar

Rob Burlington and his wife Liz have been living off-grid for over ten years. He describes their self-sufficient solar and water setup, and the lessons learnt along the way.

MY wife Liz and I live on 100 acres in the Capertee Valley between Lithgow and Mudgee, west of Sydney. We bought the block 17 years ago and would visit on most weekends, escaping from the outskirts of Sydney while we waited for our two kids to finish their education and run away from home and/or get married.

Our first semi-permanent structure was a cabin we built from a donated garage. On this we installed two 30 watt solar panels charging a 12 volt, 300Ah battery through a 4amp regulator to successfully run our lights. We had no hot water but a gas Consul fridge (these are excellent), a small two-burner gas stove and slow-combustion wood heater. The cabin became our full-time residence for the initial 18 months while we built what is now our home.

↑ RAL homes are low-impact, energy efficient and fire-resistant—ideal for the Aussie bush. This is the eastern side of the home with the carport being a non-RAL addition.

A modular and self-sufficient home

Our 'new' (now 11-year-old) house is worthy of a comment or two. After looking at various alternatives we decided on a RAL modular home. It's a little different and creates some local discussion but is very practical and comfortable. The RAL factory is located in Ararat in Victoria and we cannot speak too highly of the quality of the workmanship or the support provided by owner-managers Reiny and Lorraine Loeliger and their staff. In fact, we still occasionally keep in touch even now.

We made the decision to go totally solar for two reasons. Firstly, we had always wanted to be as self-sufficient as practicable and secondly, even though at the time the cost of the panels was three times their current price, it was going to cost us at least $15,000 more to connect to the grid, by the time we paid for a transformer and three poles to connect to the high-voltage line that runs across one corner of our block.

Solar power ups and downs

We ended up with a 1.6 kilowatt system (20 x 80 watt Solarex panels) wired to a bank of 12 x 650 amp-hour, 2 volt Sun Gel batteries through an 1800 watt, 24 volt SEA Voyager inverter. This is controlled by a Plasmatronics PL40 regulator.

All in all we were fairly happy with the setup although in retrospect we should have opted for larger capacity batteries. Even though we weren't over-stressing the batteries, rarely taking out more than the top 20 to 25% of the charge, one of the batteries decided to turn up its toes after seven years.

At this point I decided to buy 12 five-year-old sealed lead-acid (SLA) batteries I saw advertised and make use of the remaining gel batteries on the cabin, which, over the years, we have updated for family and friends' accommodation with larger panels, hot water and a septic system.

The 1000 amp-hour SLAs turned out to be a mistake and within 18 months they had begun to "fall over". To shorten a long story we decided to cut our losses and invest in a new bank of Raylite flooded cell lead-acid batteries giving us a storage of 1660 amp-hours at 24 volts. The 1.6 kilowatt system is enough to have them on float by between 12 noon and 2pm with average usage on a

↑ Electricity comes from a solar array, with a generator for backup. Twenty 11-year-old 80 W Solarex panels are mounted on the shed. An underground line takes power to the house about 70 metres away.

↑ Water is gathered from the shed and house roofs, and stored in six 5000 gallon tanks. That's 30,000 gallons, or 136,500 litres! Batteries sit behind the shadecloth on the western wall of the shed; note the two external vents from the battery box at the back of shed.

reasonable day (we use about 150/160 amp-hours daily according to the regulator).

I've become a bit anal about how we treat our new batteries, and so start the generator whenever they get down to 90%. So far after 12 months I've had them at 88% and 89% on just six occasions altogether and used probably around $40 in fuel in the generator. My reasoning (and I'd be interested in comments) is that I reckon $40 or $50 in fuel per annum will probably pay for itself in the long term in length of battery life, by only cycling around the top 10% of capacity.

Things that have helped us

There are a couple of things worth noting which I've found of value.

Firstly, our solar panels are wired in two banks of 10 each (east and west) and each bank can be isolated separately. It's handy for eliminating half the panels to help find a fault. It also allows the system to operate on the remaining 10 panels while you're working on a fault on the other half. I'm not aware whether this is usual practice or not.

Secondly, I bought a 2500 watt sinewave inverter from China for around $350 as a backup. Our system suffered a lightning strike a few years ago and the SEA inverter had a seizure and had to be sent away for repair. Although we could run a generator as a replacement, I realised that inconvenience could be overcome at a reasonable cost by having a second inverter on hand. I would also question the use of a combined inverter/charger on the same basis—being unable to charge a battery bank while an inverter is being repaired seems illogical.

Possible improvements

Hindsight is always 20/20 but at this stage, having recently updated the batteries, my only further change would be to lift the capacity of the panels from 1.6 kW to 2.0 kW or more.

Liz and I do what we consider to be all the normal energy saving behaviours: an awareness of unnecessary lights on, appliances with standby facilities off at the power points when not in use, using heavy-drain appliances like irons when the sun is out etc. All of our lights are compact fluorescents (we are gradually changing to LEDs) but we still run a fridge/freezer plus a small chest freezer, TV, computer, breadmaker, vacuum cleaner, microwave—and Liz uses a sewing machine and I use my power tools in the shed fairly regularly. I must admit we have had the odd occasion when, say, we have the iron and breadmaker on and I turn on the 2000 watt table-saw for a few minutes, to then have the system kick out on overload—but that is rare. It's nice not to otherwise have blackouts.

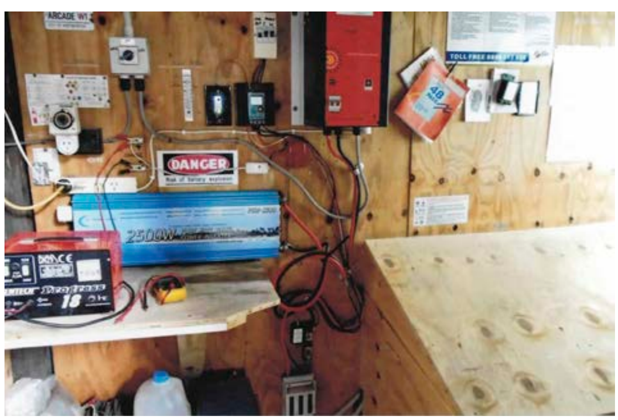
Our hot water is provided in summer by a solar collector (another hindsight thing—we should have two as one is not quite enough). It's fine in winter because the kitchen stove is wood-fired, heating and circulating the hot water from within the firebox. For summer cooking we run a normal four-burner gas stove and oven on LPG.

Water supply

Water we collect from the roof of the house and shed into a total of six 5000 gallon (22,750 litre) tanks. We have yet to use more than half our capacity even though we water our vegie garden from the supply as well as provide for the house. We also have another 5000 gallon tank that remains full, set aside for bushfires, and additional storage at the original cabin.

No such thing as a free lunch

We get quite a few comments from visitors and friends to the effect that it must be great to get our energy and water for nothing. I've

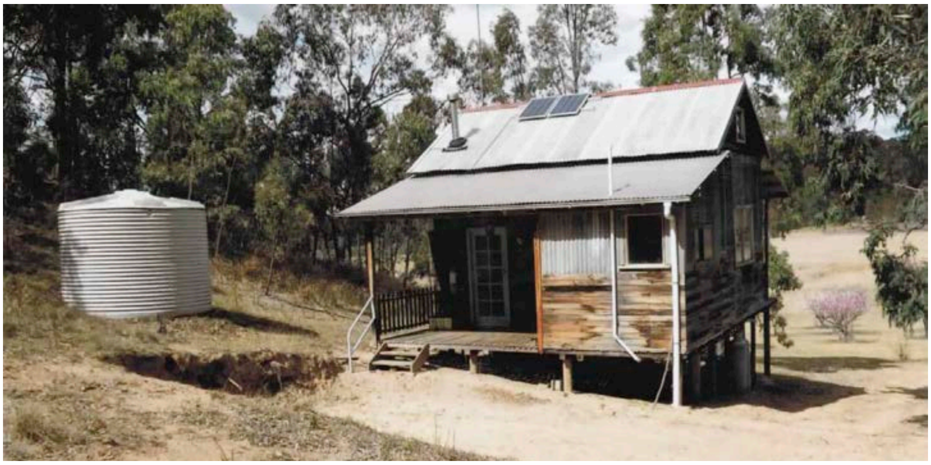


← The system has two inverters—the main SEA inverter (red box at the top of the photo) and the cheap backup (long blue box). Here you can also see the regulator, charger, switchgear and closed battery box on the right.

"We get quite a few comments from visitors and friends to the effect that it must be great to get our energy and water for nothing."

done the maths on our solar system and reckon that, allowing for battery replacement, generator use etc, we get our energy for approximately half the current grid rate on an ongoing basis. Our water supply is certainly free after buying the tanks. Ours cost us over $9000 at the time we built the house, so allowing $500 water costs a year, we've got about another seven years to break even. Of course in the meantime it's great to drink and wash in unpolluted rainwater. I am, however, also a great believer in the saying that there is no such thing as a free lunch.

I think the point is that it's a satisfying feeling to be able to approach a degree of self-sufficiency. Neither Liz nor I have a totally green philosophy but it is comforting to know that in an environment that is having ever greater demands placed upon it, we play a part in taking off some of the pressure.



↑ This cabin was their home prior to building the RAL house, and has its own water (including hot water), flush toilet and electricity supply from two 80 W panels and six 2 V gel batteries. It's now used by guests and family.

↑ Fruit trees coming into bloom in the mini orchard.

Incidentally both our kids did eventually get married and run away from home. After spending chunks of time with us on our block in the early years, they were both bitten by the country bug. They have also escaped from the city and we are blessed to have them settled not too far from us, along with our four grandchildren. (I told Liz that we shouldn't have given them our new address!) ✱

RAL homes still going strong

ReNew first looked at RAL homes back in issue 48, in 1994. RAL homes were designed to be a low-cost, energy-efficient alternative to the expense and long-term commitment of owner-building.

RAL homes are assembled from a few standard modules. By selecting the sections you desire, a home of almost any size can be built. You can start off small, with just one or two modules, and add on more as time and budget allows.

As RAL puts it: "The system involves prefabricated structural panels being bolted together to form a series of segmented and intersecting arches to make a house of varying and infinitely expandable size. The highly attractive internal appearance with intersecting arches is complemented by natural light from large windows."

The homes are prefinished with waterproof ply inside and the outer skin is pre-curved colorbond steel. This system provides an envelope with an insulation rating in excess of R4. Some timber options may not be the most sustainable, so make sure to choose a timber that isn't harvested from poorly managed forests.

The homes are delivered in kit form with instructions for assembly. Just two people with basic carpentry skills can assemble a RAL home—all you need is a plumber and an electrician. www.ralhomes.com.au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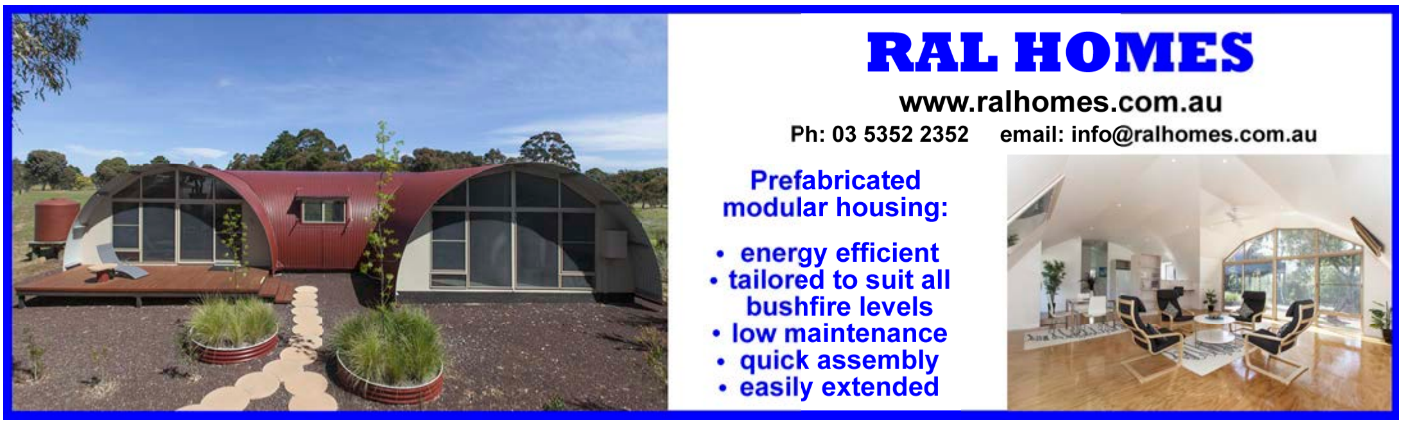
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Traveller tales
ReNew reader prize

We asked *ReNew* readers how they travel sustainably and we got back loads of great ideas and adventures. Whether travelling by road or river, or just finding places to relax, these readers have the ingenuity and technology to use less energy and to capture their own water and solar power. Thanks to all for writing in!

WINNER! Solar swagman

The dream was for a solar-powered houseboat. The affordable reality—an aluminium dinghy and a swag roll, with electric trolling motor and solar panels. I planned to travel in the solar boat up the Murray from Morgan to Echuca, powered only by the sun. Others have gone downstream, but as far as I know, no one has tried going upstream under solar power before. I reached Tooleybuc, but had to be towed by a power boat for about one kilometre on a stretch where the current was too strong. I completed the last leg of the journey by travelling downstream from Echuca, so the challenge remains: I'm working on it. **Trevor Toomer**

Congratulations to Trevor who wins a 120 W folding solar panel kit from Low Energy Developments.

Island getaway

French Island is my tip for a green holiday as it feels like a distance destination, but can be reached by public transport from Melbourne. The ferry trip helps to reinforce the psychological break from the 'mainland' and the everyday busyness of life.

Two-thirds of the island is national park, where you can connect with five distinct environments, including remnant forest, wetlands (Ramsar protected) and beaches. Accommodation and other facilities on French Island are mostly powered by solar and wind.

It's a great place to visit (200 bird species can't be wrong). You are also likely to spot koalas and echidnas. You can also enjoy walking and cycling (visitor cars are not allowed—I told you it's green). **Geoff Andrews**

Well organised

Our sustainable travel tactics:

- retiree outfit funded from 23 cattle
- fitted two deep-cycle batteries, all LED lighting, reducing energy use by 90%
- every six days we charge from 4WD or PV on a tracker
- frozen homemade dinners, made using our farm vegie patch and hens, kept in our Engel freezer, reheated in the camper oven
- laptop, camera and AA batteries recharged from the camper or a 240 V inverter while driving; 19-inch HD LED TV runs from 12 V
- email and internet on the laptop via a $10/month data pack on one mobile
- we cruise at a fuel-saving 85 kph.

Ian Hill

↓ Sunset in Karijini National Park, WA.

The staying-in-the-same-place kind of traveller

For several years we have been holidaying at our country retreat in Heathcote in central Victoria. The retreat came about as a project in sustainability, self-sufficiency and energy efficiency, starting with the salvaging and relocation of a 1920s weatherboard house from the suburbs of Melbourne. The house is fully off-grid and powered by an 840 watt hybrid wind/PV system charging a 550 Ah battery bank. Rainwater is collected in a 55,000 litre tank and most fruit and vegetables are grown on the property in a large enclosed garden. Internal heating is provided by a wood stove using fallen timber salvaged from the surrounding state forest. **Evan Pritchard**

Slow burning

Our dual-fuel stove is often used as the initial heat source, then the pots are placed into the insulated thermal cooker to continue to cook during transit. This uses the retained heat to cook the meal.

Although I initially bought our thermal cooker for camping use, it is regularly used at home as well—to the extent that I recently purchased a second unit! **Rebecca Hamby**

→ Rebecca's roadside stop just out of Dubbo, starting the cooking of a chorizo and red lentil stew in a thermal cooker to eat at the journey's end some hours later.

Disappointed

I purchased a '120 watt' solar panel from eBay to run a camp fridge and lights when camping. After testing the panel with a multimeter in optimal conditions, I determined that it was only producing a maximum of 4.2 amps and couldn't be more than 80 watts. When camping for extended periods, the panels failed to meet demand unless I remained at camp to track the sun. The dealer denied my claims and refused to assist. I've since learned to manage with the lower output, but I now strongly recommend only buying panels from reputable dealers! **Mark Price**

Keeping it simple

We have a simple rainwater collection system that we use to fill the freshwater tube that sits behind the spare tyres at the back of the van.

We use a 120 watt solar panel to charge two 100 amp-hour deep-cycle gel batteries, along with alternator charging when travelling. All our lights are now LEDs.

We shower using a garden-spray pump-up pressure tank—just add water heated to temp and a great shower follows. A sawdust compost loo creates no smell, no mess and is a magic way to recycle our waste. We use pedal-powered local transport for quick trips to shops and extensive local touring. **Kym Mogridge**

Staying away from civilisation

For us it costs very little to camp. We have two 6 V, 345 Ah batteries connected to a very old 42 watt solar panel which we bought nine years ago from a yachtsman at a garage sale.

It runs our 60-litre Engel fridge and allows us to stay away from civilisation for a longer period. I converted a water filtration urn, adding a copper pipe that we place in the campfire; in a short time we have hot water for cooking and showering. We also have two solar torches and four solar lamps. **Keith Graham**

↓ Paul Tyndale-Biscoe refueling the rig in north QLD.

Recycled panels

In 2010 we gave our 1985 Prattline low-tow caravan a mid-life upgrade by installing an Engel 12/24 volt DC fridge, a 12 volt FLA battery and a couple of 20-year-old 75 watt BP monocrystalline PV solar panels. The solar panels and an AERL MPPT controller used for the caravan solar charge system were recycled from our original 1992 house stand-alone RAPS system. Off-grid for 20+ years and continuing.

The solar caravan is very satisfying and enables us to camp (with fridge and lights) off the beaten track more confidently and not be so concerned about our LPG supply reserves. The benefits (economically and environmentally) are significant. The panels are mounted on a demountable static frame that consists of parts from our house RAPS system (BP solar static array frame and some 32 mm electrical conduit). The battery can also be charged in parallel with the tow vehicle's auxiliary battery or separately from the tow vehicle. **John Shaw**

2000 miles on the smell of an oily family

A few years ago my family and I decided to move from Melbourne to Darwin, and thought a slow drive up the coast camping would be a nice transition and holiday. I decided to try and get as far as possible on my homemade biodiesel, so stockpiled for months before the big trip.

In an old Hilux, pulling a homemade camper trailer, we set off with 380 litres of fuel, adding another 65 litres I had stockpiled at my parents farm near Canberra. In the end we made it to Maryborough in Queensland, some 2660 km from Melbourne, before having to buy fossil diesel. In north Queensland we found a place selling biodiesel so bought another 150 litres. The whole trip was around 6600 km and I reckon more than half of it was powered by the humble canola plant. **Paul Tyndale-Biscoe**

Travelling in style

After 18 months of research we imported a little-used secondhand high-end caravan from the UK and had it converted to Australian compliance standards. Our Fleetwood Heritage 640ES eight-metre caravan has double-insulated windows, insulated walls and roof, and a double-insulated floor.
Ben Somerville

Two wheels good

When travelling, whether locally or overseas, I always try to use my bicycle via the train network. If I need to use international air services (for logistic, time and money reasons) I always try to carbon offset my trip; and if I have to stay in hotels/hostels I opt for the green option of no new towel (definitely available in business hotels in Japan). The high-speed trains are much more energy efficient than aircraft.

This photograph was taken towards the end of winter at Lake Motosu, near Mt Fuji, after a snow dump the day before. I was cycling from the youth hostel in Fujinomiya to the youth hostel in Fujiyoshida. The next day I had to cycle the 100+ kilometres to Tokyo while it was snowing! I had intended to climb Fuji-san but the snow fall was too heavy.
Paul Anthony Judd

Travelling light

I have installed LEDs in every light of my motor home, including all the external safety lighting other than headlights. The system is powered by a 250 W panel that, together with the vehicle power when on the move, maintains two 120 amp-hour deep-cycle batteries. Even without sun or travel, we have four days in reserve.

A 1000 W inverter supplies our (little) need for 240 V appliances. Gas is used for refrigeration, heating and some cooking. Wood-fired devices are used when circumstances permit.

The outfit is totally self-sufficient and we never need grid power. **Jelle Burggraaff**

Compact

I converted a Renault Koleos (same as a Nissan X-Trail) into a long-range travel and camping vehicle for two people. It opens up rather than being internal. Aero roof boxes conceal tent and awning, spare wheel and recovery gear, with 128 W thin-film solar panels laminated to the top.

The kitchen at the back houses a 40 litre Engel fridge box and sufficient storage for two weeks food, plus we can keep food and reserve fuel in the now-empty spare-wheel well. In 40 °C ambient temperatures the solar panels run the fridge and keep the batteries 100% charged ad infinitum. Daily battery DoD is 10% maximum.

The back seats have been removed and a 100 Ah AGM battery is bolted to the floor in the centre, with a Redarc 1215 battery management system and 240 V inverter built in for charging cameras. Twin 50-litre bladder water tanks run each side in the footwell, with a 12 V pressure pump to the sink. These are all enclosed in boxes bolted down for safety, with the space above used for 'soft' storage of self-inflating mattresses. GVM (gross vehicle mass) is less than maximum rated, with no wind noise from messy roof racks as it is all Aeroed up top.

Best-ever fuel consumption is 5 litres/100 km; long-term average is 7.6 litres/100 km.

Camp is set up in 10 minutes and packed up in the same. We think nothing of moving every day, but recognise that a good trip is a slow trip. Our shortest hop on record is 45 seconds (Woodline Track, south of Kalgoorlie); longest 1.5 hours (Pacific Hwy). Nullabor—the average is 15 minutes!

I have done this stuff for 30 years, always trying to become lighter, smaller and more frugal. My next project is a Ford Ecosport—that's a Fiesta-sized campervan. Ultimately I want to achieve a totally solar-powered vehicle—that's the holy grail! Strangely, people in the RV industry think I'm mad. **Dick Clarke**

Camp out, green style
Sustainable camping and caravanning

Getting away from it all may be great for our stress levels, but what about stress on the environments we visit? Elizabeth Claire Alberts discusses some important considerations to minimise the impact.

IF YOU'RE a nature lover like me, you'll probably agree that one of the best things to do is set up your caravan or tent in a national park, boil a billy of tea and relax with a cuppa while listening to the magpies. Camping and caravanning can reinvigorate the soul, helping to dissolve the stresses of daily life. At the same time, these activities can place plenty of stress on nature itself. By becoming a more conscientious camper, you can enjoy a better—and more sustainable—relationship with the outdoors, and help protect the environment for future generations.

↑ Camping on a six-day rainforest walk through the Tasmanian Tarkine with bushwalking company Tarkine Trails.

Camp waste-free

Single-use plastics are responsible for choking our waterways, damaging our oceans and killing marine species. It may be convenient to buy a lot of plastic-packaged foods for a weekend camping trip, but a good sustainable camping starting point is to try to avoid as much plastic and other packaging as you can. Apply the 'carry in, carry out' rule to waste, taking it with you to be disposed of properly. And of course, ensure you use refillable water bottles—stainless steel or plastic.

Another way to minimise your waste is to invest in high-quality gear. Don't buy the cheapest tent you can find—the seams might rip after a short while and the tent might end up in the bin. Instead, buy a tent that will last for years, if not decades. If you can't afford decent equipment, rent your gear from a camping shop or borrow from a friend.

Protect wildlife

One of the best things about camping is the opportunity to observe native animals. If you're lucky, an animal may stay still long enough for you to snap a good photo. But chances are, it will scurry away as soon as it catches your scent. Don't follow the animal into the bush, even if it's tempting. Stalking an animal will cause it distress and straying from a trail can damage sensitive vegetation.

It's also important not to feed human food to native animals. It can be harmful to their health and may also encourage them to depend on human handouts.

Leave no trace

Many of the sustainable practices discussed so far (eliminating waste, staying on the trail, not feeding animals) fall under the minimal impact code, which was developed in Tasmania in the 1980s and which every Australian state has now adopted. In addition to the aforementioned practices, the minimal impact code specifies that campers should not clear any plants to set up tents or to construct fireplaces. Campers are also discouraged from digging drainage ditches or using vegetation to build shelters. And once again, when bushwalking, you should stay on the trail, even when it's muddy.

Need to use the toilet? The minimal impact code recommends that all toilet business occurs at least 50 to 100 metres away from streams or lakes. Dishes should be washed using small amounts of biodegradable soap and the dishwater should also be dumped 50 to 100 metres away from waterways. If possible, avoid using sunscreens or insect repellents, which can contaminate waterways if you decide to take a dip.

↑ Camping in northern New South Wales in North Coast Holiday Parks. These holiday parks use renewable energy and responsibly manage water and waste.

Think twice before you light

When I asked Rob Fairlie, the co-founder of the sustainable bushwalking company Tarkine Trails, what he thought most people didn't think about—or didn't think enough about—when trying to camp sustainably, he mentioned fires. "On those high fire-danger days, don't light fires," he advised. "It's just not worth the risk."

A fire could be particularly detrimental to sensitive regions like the Tarkine in Tasmania, which is the second largest temperate rainforest in the world. If a fire got out of control, Rob reckons it could burn three quarters of the Tarkine, and the area would never recover. "I don't think Australians have enough fear of fire," Rob said. "And every year, there are bushfires lit by people." As the Australian landscape gets drier with climate change, this becomes even more important.

Green your ride

Hauling a caravan on the back of a four-wheel-drive isn't exactly carbon neutral, but you can reduce your carbon footprint with some forward thinking. If you're in the market for a caravan, consider buying one with an aerodynamic shape. These caravans allow air to flow smoothly above and below them, lessening drag and reducing fuel consumption. It's also useful to get a caravan that's approximately the same width and height as your vehicle, which can improve the caravan's aerodynamic capacities.

If you already have a caravan, you can make it more fuel-efficient by getting rid of unnecessary weight, ensuring the tyres are properly inflated and switching off the air conditioner in the car. You can also improve your caravan's aerodynamic profile by getting rid of bike holders, kayak racks and other protrusions. And take your time driving to your destination. Accelerating slowly and maintaining a steady speed will save you a surprising amount of fuel.

Go somewhere green

Sustainable camping and caravanning can be practised anywhere in Australia, but if you're looking to stay at a campground or caravan park, consider going somewhere with high environmental standards. For instance, all of the North Coast Holiday Parks in NSW operate via renewable energy and responsibly manage water and waste. When you're at the campground or park, do your part by taking short showers, turning off lights, placing your waste and recycling in appropriate bins and reporting any faulty toilets or dripping taps.

And if you're looking to go camping with a tour company, look at their sustainability standards. One such group is Tarkine Trails in Tasmania, which has top-notch sustainability standards, and also takes you into one of the most breathtaking wilderness regions in the world. ✱

Elizabeth Claire Alberts is an environmental journalist based in Sydney. Her eco-memoir recently appeared in the book *Stories of the Great Turning*. www.elizabethclairealberts.com

Minimal impact code

Bushwalking groups and national parks services around the country have a minimal impact code for bushwalkers and campers. Although there is no one strict standard code, most include the following guidelines for minimal impact camping:

- Use an existing campsite rather than make a new one in the same area.
- If there's a toilet, use it. If not, bury human waste in holes at least 15–20 cm deep. Take a trowel and dig a small hole well away, at least 50 metres, from any open water.
- Wash well away from streams and ensure that soap, detergents and food waste do not enter watercourses. When cleaning utensils use gritty sand rather than soap.
- Apply the 'carry in, carry out' rubbish rule. This applies to orange peel, fruit cores, sanitary items, seeds and egg shells.
- Native flora and fauna should be left undisturbed.
- Don't touch historical or cultural structures and artefacts.
- Plan to reduce rubbish. Avoid packing too many bottles, cans and wrappings.

Sustainable caravanning guide

NSW-based Kimberley Karavans has a guide to the design issues to consider for sustainable caravans and caravanning (specific to their vans) including energy, water and resource efficiency. It's free, but you'll need to provide your email. www.kimberleykaravans.com/green-mobile-home

Low-carbon cooking
Cooking with the sun

Australia's abundant sunshine should inspire more solar cooking, writes Stephen Williams.

I SUSPECT cooking, unlike, say, water heating, is usually regarded as one of those energy uses that we can't do much about. But most of us cook something every day and we often do it at times of peak demand, so this aspect of our lives deserves more attention if we want to reduce our fossil-fuel dependence and greenhouse gas emissions. With more people moving to time-of-use electricity tariffs, it is also worth looking at our options from a financial point of view.

So what are the options? Gas is not the benign fuel many once considered it to be and who wants to shell out thousands for an efficient induction cooktop. And even an induction cooktop (assuming you have the required type of pots and pans) doesn't help when it comes to cooking in an oven. Could solar cookers come to the rescue?

↑ A good solar oven can reduce or even eliminate the need for a conventional oven. Here in action, Heather Stevens from Sun Cooking Australia cooks biscuits in a solar oven. From left to right, you can see the SunCook oven, the SunRocket (used to heat water) and the Global Sun Oven.

Cooking with solar radiation

With Australia's abundant sunshine, it seems we could easily use direct solar radiation more for cooking.

There are two main ways to cook using direct solar radiation. Parabolic mirrors concentrate heat to a focal point and are good for relatively quick cooking like frying or barbecuing. Solar ovens, on the other hand, are better for slower cooking and baking. This article focuses on solar ovens.

How they work

A solar oven is essentially a well-insulated box with a glass top (sometimes double-glazed) to let solar radiation in. Reflective panels direct the sun's rays into the box. You place the food to be cooked in a thin, dark-coloured metal container, and place that in the oven. You then angle the oven to take best advantage of the sun's position; you can move it during the day to track the sun, but this is not always necessary.

Good ovens can reach temperatures of around 180 °C and so can eliminate the need for a conventional oven for most uses. They can be used at any time of year, as long as there is sunshine; ambient temperature is not critical, but food will cook faster in warmer weather.

What can you cook in them?

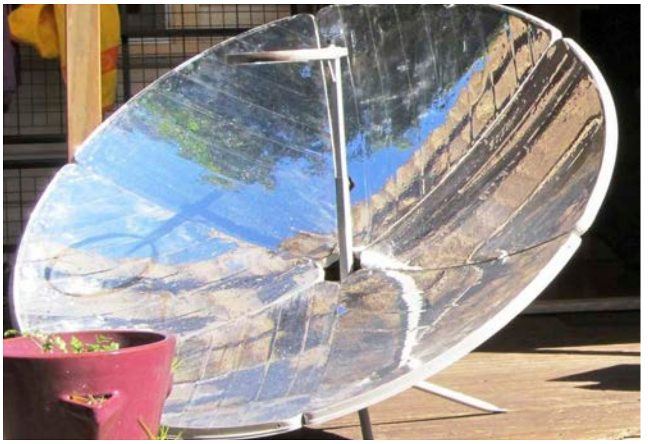
You can cook anything in a good solar oven that you can cook in a conventional oven or on a stovetop, except for cooking that requires frying or grilling. Baking bread, biscuits and cakes are obvious uses. Baked (or roasted) meats and vegetables are another mainstay. A solar oven will also do a slow-cooked stew or curry that you might otherwise cook on a conventional stovetop.

A solar oven will also boil water for cooking rice, pasta and so on, or do slow cooking of legumes such as chickpeas. Rather than have them simmering on the stove for hours, just leave them in the solar oven until done.

You can also use a solar oven as a food dehydrator by lifting the lid slightly to let the moisture out.

Fans of solar ovens say you cannot burn food in them as the heat is evenly distributed through the oven and baking dish, and the cooking is often long and slow. Nor does food tend to dry out as moisture is generally contained (depending on the oven's design).

"It's possible for your meal to cook during the day and for you to enjoy it when you get home after dark. "



↑ Parabolic dish cookers focus the sun's heat into a small area. They are ideal for frying and boiling.

Heather Stevens, an importer of the SunCook oven says, "I especially like solar cooking around Christmas time, when I can embrace the slow-cooked cakes and puddings of Europe but cook them using the summer sun, leaving my kitchen cool!"

Solar ovens available

Solar ovens range from light and cheap ovens, often homemade or designed for camping, to robust and expensive ovens, designed for regular long-term use. Like most things, you get what you pay for. A well-known top-end model is the Global Sun Oven. It has a gimballed seat for the cooking pot. This design has been copied by commercial manufacturers and backyarders.

Another deluxe solar oven is the Portuguese-made SunCook, developed in 2003 by SunOK. It is a bit heavier than the Global Sun Oven (13 kg versus 9.5 kg) but has a larger oven space. Comparisons of these two ovens can be found at www.solarcooker-at-cantinawest.com. Both ovens retail in Australia for about $500, depending on what specials are on offer. Another well-known solar oven is the SOS Sport, manufactured by the US-based Solar Oven Society.

Many solar ovens will come with a cooking pot and tray as part of the purchase price, and possibly a thermometer.

A couple of issues

Solar ovens have their drawbacks. Being reliant on the sun, if you get several days of rain you may be forced to enjoy salads. However, even without sun, some of the better solar ovens have insulation that allows for residual-heat cooking (often called 'haybox

Solar education

Megan Floris uses a solar oven in schools as part of her environmental education program, Foodweb Education (arecipeforresilience.wordpress.com). The oven provides a low-tech teaching tool that fits within the program's goals of demonstrating how the energy for most processes on Earth can be traced back to the sun. School kitchen gardens are used to give hands-on experience of this energy flow as students grow, cook, eat and compost food.

Megan says that the solar oven is great and easy to use, although you do need full sun. She adds that if not in a protected spot the wind can reduce its effectiveness and potentially blow the reflector panels over. It's also best to be available to adjust the positioning of the oven over time to capture the full sun or to cover it up to retain the heat once it has reached temperature.

She says it's incredibly satisfying and exciting cooking with the solar oven and that she'll give anything a go. Megan has cooked cakes, breads, lasagnas (including the bechamel sauce), stews and curries, with the accompanying rice or couscous stacked on top and cooked at the same time.

In a recent lesson, students mixed greens from their kitchen garden with eggs from the school chooks plus cheese to create a delicious quiche that was cooked in the solar oven. It was a warm, cloudless 25 °C spring day, and the oven reached 160 °C in around 30 minutes and cooked the quiches in about an hour. While half the class cooked, the others collected salad greens and nasturtium flowers for a salad that Megan dropped off to their classroom with the warm, cooked quiche—delicious!

↑ Learning about using the sun's energy with the school's kitchen garden in the background.

→ Sunbaking a delicious quiche. You can see the reflectors and the glass panel covering the oven.

cooking'): cooking is begun on the stovetop, then the hot food is placed in the solar oven to finish cooking.

Another potential problem is partial cooking. Safe temperatures for pasteurisation are above 65 °C so food should not be left in a solar oven for long below this temperature. Fortunately, most good solar ovens keep food hot enough even after the sun goes down, so it's possible for your meal to cook during the day and for you to enjoy it when you get home after dark.

Another problem is the relatively high cost. There are also no Australian-made solar ovens. One way around the cost issue is to DIY (see resources at end).

Cost and payback time

As noted, a top-of-the-line solar oven will cost about $500, so they are not for the faint-hearted. Mind you, that might seem good value when a Thermomix costs about $2000, needs electricity and won't last as long.

If you do a lot of cooking in the solar oven, it may pay for itself eventually in reduced electricity or gas bills, as it could last for decades. However, estimating payback time is tricky because there are many types of fossil-fuel ovens in use and people have different cooking habits. Even estimating the electricity use/cost of an electric oven for comparison purposes can be difficult, as they tend to be hard-wired into the house supply so you can't use an energy meter. If you use gas for cooking, you probably use gas for other things as well, so you can't judge your cooking cost from your gas bill. You can try to estimate the cost of running your particular fossil-fuel stove by looking at your energy consumption increase over the cooking period or you could contact the manufacturer.

Having said that, an electric oven rated at 2000 watts and used for an hour would use 2 kWh of electricity if running at full capacity. But it might never run at full capacity: ovens use a lot of energy in the first 10 minutes to get to the desired temperature, then the thermostat controls the power draw. In practice, a 2000 watt oven might use 1 kWh of electricity if running for an hour. With a tariff of 20 cents a kWh, you would use $1 worth of electricity a week if you used your oven five times a week for an hour each time. So it would take you 500 weeks (or 10 years) to break even on a $500 solar-oven purchase, assuming electricity prices remain constant.

However, electricity and gas prices are rising. Also, 20 cents per kWh is probably an under-estimate, particularly as people move to time-of-use tariffs, where 50 cents a kWh during peak times (2 pm to 8 pm) may be closer to reality—and this is the period commonly used for cooking. In that case, a payback time of five years might be closer to the mark. Either way, with an oven life of, say, 20 years, it should pay for itself if used consistently.

There will be net greenhouse gas savings as well although I have not investigated embodied energy for solar ovens or looked at a life-cycle analysis. Less wear and tear on your fossil-fuel oven could also be a saving, with less cleaning required as an added bonus. ✻

Stephen Williams is a freelance writer from NSW, specialising in green living. He has a financial interest in the SunCook solar oven.

Resources on solar cooking

www.solarcooker-at-cantinawest.com: A US-based website selling both the Global Sun Oven and SunCook ovens, with information on both.

www.solarovens.org: The Solar Oven Society, based in the US, maker of the SOS Sport.

www.sunok.eu: SunOK, Portuguese manufacturer of the SunCook solar oven.

www.sunoven.com: Sun Ovens International, makers of the Global Sun Oven.

www.sunoven.com.au: Australian importer and retailer of the Global Sun Oven.

www.suncooking.com.au: Australian importer of the SunCook solar oven and other solar-cooking products, including parabolic dishes.

www.bit.ly/diysunoven: A step-by-step guide to building your own solar oven, similar to the Global Sun Oven.

www.sizzlingsolarsystems.com: A Queensland-based website specialising in DIY solar cookers (owners featured in *ReNew 117*).

www.bit.ly/bitsunoven: A comprehensive site on DIY solar, including food dehydrators.

www.solarcookers.org: Solar Cookers International.

↑ Fresh out of a solar oven.

Sustainable stays
Tread lightly when you travel

You can have your carbon-neutral breakfast and eat it too, writes Olivia Wykes.

↑ Eco doesn't need to be expensive. The Grampians Eco YHA in Victoria was specifically designed with the aim to use 50% less energy and water than conventional hostels. It includes solar PV tiles incorporated in the roof.

EVERYONE knows we need to get away from it all more, from the stress at the office, in the queue or the traffic jam, or from reading some more bad news about the state of our climate. What if you could put the world on hold and rediscover some inner peace, while relaxing in the knowledge your accommodation is part of the solution?

Some savvy hosts have taken a sustainable step forward and created accommodation options which work with their surroundings, and even enhance them. From passive solar design to revegetation, from PV to wildlife conservation, from water reuse to food miles, these venues have it covered, before your head even hits the organic cotton pillow slip.

Once you've decided on a location and paid your carbon offsets, let's look at some options.

Accommodation types

CAMPING

If you're looking to commune with nature there are many ways to do it: from no-frills camping to luxury eco tent 'glamping', there are many options that can get you out under the stars. Parks Victoria manages Wilderness Retreats, which are reasonably priced options in Buchan Caves Reserve, Wilsons Promontory and Cape Conran Coastal Park. There are quite a few high-end 'glamping' outfits available, from Nightfall Wilderness Camp near Lamington National Park, opening early 2014, to Bamurru Plains near Kakadu National Park.

ECO HOSTELS

For those on a tight budget, the Eco YHA hostels in Apollo Bay and Halls Gap in Victoria are good options. Grampians Eco YHA was designed and built in 2005 with the aim to use 50% less energy and water than conventional hostels.

B&B AND LODGES

There are some beautifully designed, sustainable properties available including self-contained lodges, apartments and B&Bs. In Victoria, The Chocolate Lily in Sedgwick was inspired by watching *Grand Designs*—and reading magazines like *ReNew* and *Sanctuary*, so we love them already! Halcyon Hideaway in Strathbogie was built with structural timbers milled from fallen trees on the farm. MillDuck StrawBale B&B in Harcourt North offers tours of their strawbale, passive solar house. Heron's Rest in Grenfell, NSW, is constructed of thermally efficient core-filled concrete blocks by Smartblock. Windrose B&B in Denmark, Western Australia, features internal rammed-earth walls and strives to be carbon neutral. Corinna Wilderness Experience in the Tarkine area of Tasmania offers 19 eco lodges.

LUXURY

If you are looking to treat yourself, there are many properties that can help you unwind in sustainable style. Tanonga Luxury Eco Lodge located on the Eyre Peninsula, SA, offers two architect-designed, self-contained lodges. Dreamers in Mt Beauty, Victoria, provides accommodation in eco apartments including a penthouse. There are quite a few secluded boutique-style apartments across Australia including The Trig on Mount Arthur near Launceston and 43 Degrees on Bruny Island,

↑ Bombah Point Eco Cottages in NSW (above); PV sunset at Hidden Valley cabins in Queensland (right).

Tasmania. In New South Wales, Billabong Retreat has treetop cabins and offers yoga, meditation, massage and organic food. Also in NSW, Bombah Point Eco Cottages offers six self-catering cottages.

Design philosophy

Building in a sustainable way is for many a sound business decision that makes best use of a site and reduces running costs.

Grampians Eco YHA is constructed from rammed earth, stone, timber and reverse-brick veneer with corrugated iron cladding. Floors are polished concrete and north-facing walls include windows to capture winter sun, with minimal windows on the southern side. Eaves, balconies, pergolas and deciduous plantings shelter the building in summer.

The owners of The Chocolate Lily wanted to build a home that was easy to maintain, sustainable and aesthetically pleasing. Virginia and Peter Weaving designed the home with guidance from a draftsperson and built it in collaboration with Justin Gee Construction. The B&B is rated at approximately 7.5 Stars and has won awards including the MBA's 'Most energy-efficient home in NW Vic' in 2013.

The building is constructed of timbercrete blocks with rammed-earth internal walls and solid timber doors. Double-glazed north-facing windows allow solar gain on the polished concrete floors that feature a sprinkling of green wine bottles for colour. There are two layers of earthwool insulation throughout, and when cooler goldfield nights require, two slow-combustion fires add comfort. Using reversible ceiling fans and heat transfer ducting means warm air is directed where it's needed most.

Bombah Point Eco Cottages in NSW was a dream project by retiring builder Peter Madden, the aim being to build a retreat that could show "you do not need to compromise on luxury in order to be green." Much inspiration came from Michael Mobbs and his book *Sustainable House*. The building design combines the classic 'Queenslander' style with open-plan living. The expanse of laminated glass in the cottages immerses guests in the treed surroundings while being an integral part of the passive solar design.

Technology and self-sufficiency

The Grampians Eco YHA features a 2.5 kW PV system, which includes 171 solar tiles put together with UV-resistant frames and incorporated into the roof. Half of the hostel's lighting is LED.

The hostel also has seven solar hot water units: five triple-collector systems supply 443 L each, and a further two double-collector units provide 302 L each. There are two Nobo electric radiator panels and two slow-combustion wood heaters, with a water heating jacket in one of the slow-combustion heaters. During winter fans are used to force heat from the stoves towards the living area. Five 23,000 L tanks supply water for the hostel, as well as providing reserves for fire fighting. A reed system filters greywater for use in the hostel's toilets.

The Chocolate Lily's electricity bills are mostly in credit, thanks to a 3.32 kW PV system which consists of a 3 kW inverter and 14 PV panels, installed in 2011 by BSG and Goldfields Solarhub. All lighting in the property is LED or CFL. Four 22,500 L tanks supply all their water needs and a dam feeds the orchard, vegie patch and garden in the warmer months. Hot water is supplied by a Rheem heat pump. A worm-based toilet system also takes kitchen scraps and enables the B&B to utilise both greywater and blackwater as fertiliser for the berry patch.

Bombah Point Eco Cottages has a grid-interactive array of 48 x 80 watt PV panels set on four trackers. The owners installed the system early on in the building process and by the time the cottages were complete they found out they were $300 in credit with their electricity supplier. The PV system currently provides 60% of the cottages' power needs, and the owners are in the process of upgrading the efficiency and size of the array.

There are a total of 12 buildings on site, including a communal building and sheds, which together collect more than 100,000 L of rainwater a year. The water is filtered via a washable filter and twin cartridge system. They also store 120,000 L of bore-water to supply toilets, bathrooms, fire hoses, rooftop sprinklers and garden, and top up the swimming pool. Should the need for fire-fighting arise, there is 55,000 L in the pool and a further 300,000 L in a dam.

Toilets use a wet composting system with sewerage treated in a bio-reactor which incorporates 80 m² reed beds, filled with lime-rich oyster shells from local oyster farms. The treated water is pumped 30 cm under the soil to water fruit trees in the permaculture garden.

↑ The pumpkin patch at The Chocolate Lily. Much of the produce they provide for guests is grown on site.

Environment and enhancements/ revegetation/wildlife conservation

The Chocolate Lily participated in a tree-planting project in 2005 to provide koala habitat around the perimeter of their land. As part of the Trust for Nature nesting-box project, they erected four boxes on their property to encourage local birdlife.

Bombah Point Eco Cottages is built on a site that was cleared for cattle grazing until about 40 years ago. Since then regeneration has reestablished the site to the point where it is over 90% wooded. In 2006 the property became a wildlife refuge in association with NSW National Parks and Wildlife Service.

Pathdorf B&B in Alice Springs, NT, has undertaken quite a few projects to improve the sustainability of the site including an extensive buffel grass elimination project taking nearly a year to complete. Since then native grasses and wildflowers have returned along with native fauna.

Nightfall Wilderness Camp in Lamington, Queensland, has set its tents into the tree-line in small forest clearings. Thick vegetation provides privacy for guests and planned replantings of fire-resistant natives will ensure the character of the rainforest location remains intact.

Organic food and food miles

Some establishments such as Corinna Wilderness Experience in the Tarkine area of Tasmania are restricted in what they can grow due to their pristine location, but they do source their food locally. Billabong Retreat in Maraylya, NSW, provides 100% organic produce grown either on site or on a farm just a kilometre away.

Halcyon Hideaway in Strathbogie, Victoria, has recently commenced an extensive native revegetation project, an orchard and a vegetable garden. The owners hope to return the property as much as possible to its original state, whilst aiming for self-sufficiency on the farm.

Finishes, furnishings and cleaning products

When it comes to paints, varnishes and cleaning products, there could be a temptation to cut corners, but many proprietors care enough to use low-VOC paints, natural oil finishes and chemical-free cleaning products.

Heron's Rest in Grenfell, NSW, is cement rendered and painted with Ecolour paints. Organic and Fairtrade linen is supplied by Blessed Earth in Maleny, Queensland, and they use chemical-free cleaning products.

MillDuck Strawbale B&B is rendered externally so there's no need to paint, but inside they have used Porter's lime-wash paints. Bombah Point Eco Cottages made their inbuilt seating, tables and bathroom vanities from logs found on site.

Nightfall Wilderness Camp has used carved sections of tree trunks, rocks and driftwood in furnishings. Cleaning products are white vinegar, bicarb of soda and oils of lemon-myrtle, eucalyptus, tea tree and clove.

Get out there!

Go on, get out there! Whether you need a short break or some inspiration for your dream home, why not book yourself some R&R in one of the venues mentioned? You'll be able to lie back in comfort, knowing your hosts are doing their best to look after this lovely place we all call home. ✱

Olivia Wykes is desperate for a holiday after doing all this research!

Useful sites:
www.greengetawaysaustralia.com.au
EcoTourism Australia: www.ecotourism.org.au

What we've included

Passive solar design and green technology were key factors in selecting properties, but they all have varying levels of both. Some properties are wildlife refuges or have taken large regeneration projects on board and others have not. Before you decide to stay at a venue it is worth asking some questions. A lot will depend on where you want to go and your budget.

We found the properties both by referrals and searching online. We contacted them to request more information on their design philosophies and the sustainable technologies they use; not all properties responded and in that case, we sourced information from their websites. We haven't visited the properties (unfortunately!) and a listing isn't intended as endorsement of any particular venue over another.

Ecotourism certification

While it was not a key factor in the research, some venues listed in the article and/or table have applied for Ecotourism or Climate Action Certification with Ecotourism Australia, a not-for-profit body set up in 1996 to educate and inform consumers. Ecotourism members include a variety of accommodation and tour operators.
www.ecotourism.org.au

Sustainable stays listings

New South Wales

Bombah Point Eco Cottages
Bombah Point NSW
Cost per night $275–325
www.bombah.com.au

Bondi Beach Eco Garden
Sydney NSW
Cost per night $89–429
www.bondiecogarden.com

Billabong Retreat
Maraylya NSW
Cost per night $200–230
www.billabongretreat.com.au

Heron's Rest
Grenfell NSW
Cost per night $140 double
www.heronsrest.com.au

Jemby Rinjah Eco Lodge
Blackheath NSW
Cost per night $185–200
www.jemby.com.au

Stone Stream Eco Cottage B&B
Brooklana NSW
Cost per night $175
www.stonestream.com.au

Sun Worship Eco Villas
Crescent Head NSW
Cost per night $190–400
www.sunworship.com.au

Woolshed Cabins
Blackheath NSW
Cost per night $390–490
www.woolshedcabins.com.au

Northern Territory

B&B Pathdorf
Alice Springs NT
Cost per night $115–199
www.pathdorf.com

Bamurru Plains
Mary River Flood Plains NT
Cost per night from $520
www.bamurruplains.com

Banubanu
Bremer Island NT
Cost per night $360–530
www.banubanu.com

Moonshadow Villas
The Gardens NT
www.moonshadowvillas.com

Queensland

Hidden Valley Cabins
Hidden Valley QLD
Cost per night $89–229
www.hiddenvalleycabins.com.au

Lyola: Pavillions in the Forest
Maleny QLD
Cost per night $285 per couple
www.lyola.com.au

Nightfall Wilderness Camp
Lamington QLD
Cost per night $360–$575
www.nightfall.com.au

Svendsens Beach
Great Keppel Island QLD
Cost per night $52.50–100
www.svendsensbeach.com

Whitsunday Organic B&B
Airlie Beach Whitsundays QLD
Cost per night $185–210
www.whitsundaybb.com.au

South Australia

Antechamber Bay Eco Cabins
Kangaroo Island SA
Cost per night $130 per couple
www.kiecocabins.com

Ridgetop Retreats
Delamere SA
Cost per night $225 per couple
southernoceanretreats.com.au

Tanonga Luxury Eco Lodges
Charlton Gully SA
Cost per night $250–370
www.tanonga.com.au

Tasmania

43 Degrees Eco Apartments
Bruny Island TAS
Cost per night $190–240
www.43degrees.com.au

Corinna Wilderness Experience
Corinna TAS
Cost per night $160–250
www.corinna.com.au

Freycinet Eco Retreat
Coles Bay TAS
Cost per night $180–380 double
www.freycinet.com

The Trig on Mt Arthur
Lilydale TAS
Cost per night $250
www.thetrig.com.au

Victoria

26 Acacia
Sandy Point VIC
Cost per night from $205
www.promcoastholidays.com.au/accommodation/37

Aquila Eco Lodges
Dunkeld VIC
Cost per night $230–300
www.ecolodges.com.au

Bothfeet Walking Lodge
Johanna VIC
Cost from $500 per night (inc walking package)
www.bothfeet.com.au

The Chocolate Lily
Sedgwick VIC
Cost per night $160–190
www.thechocolatelily.com.au

Dreamers Eco Resort
Mount Beauty VIC
Cost per night $270–590 off peak
www.dreamersmtbeauty.com.au

Eco YHAs
Apollo Bay VIC
Grampians, Halls Gap VIC
Cost per night $26–119
www.yha.com.au

Great Ocean Ecolodge
Cape Otway VIC
Cost per night $370–400 double
www.greatoceanecolodge.com

Halcyon Hideaway
Strathbogie VIC
Cost per night $150–$390
www.halcyonhideaway.com.au

Hummingbird Eco Retreat & Conference Centre
Red Hill VIC
Cost per night $165–350
www.hummingbirdeco.com.au

Koorameet Luxury Retreat
Barwon Heads VIC
Cost per night $360–500
www.koorameet.com

MillDuck StrawBale B&B
Harcourt North VIC
Cost per night $160–220
www.millduck.com.au

Riversdale Retreat
Chewton VIC
Cost per night $220–265
www.riversdaleretreat.com.au

Sawmill Mountain Retreat
Sawmill Settlement VIC
Cost per night $260–550
www.stayz.com.au/accommodation/vic/wine-high-country/mount-buller/61275

Venus Bay Eco Retreat
Venus Bay VIC
Cost per night $265 per couple
www.venusbay-ecoretreat.com.au

Wilderness Retreats
Wilsons Promontory, Cape Conran & Buchan Caves Reserve
www.wildernessretreats.com.au

Western Australia

Maitraya Private Retreat
Albany WA
Cost per night $60–250
www.maitraya.com

Sal Salis Ningaloo Reef
Cape Range National Park WA
Cost per night $375–750
www.salsalis.com.au

Windrose B&B
Denmark WA
Cost per night $140–160 inc breakfast
www.windrose.com.au

Yelverton Brook Eco Chalets
Margaret River WA
Cost per night $190–275
www.holidaywithwildlife.com

More info

We've collected a bit more info on these properties, including the renewable and building technologies they use. See: renew.org.au/stays

Solar on the move
Providing power to mobile abodes

Collyn Rivers has a long history of self-sufficient caravanning. He explains some of the traps when designing solar systems for caravans.

THE number of caravans, motor homes and camper trailers currently registered in Australia is estimated at about 450,000. Many such recreational vehicles (RVs) are bought with solar panels factory-fitted while some have solar retrofitted or added as an expansion to an existing system.

However, feedback (from readers of my books, TAFE lecturers and auto-electricians I deal with in my business) suggests that many of these mobile solar systems fail to meet user expectations.

The problems are in many cases particular to mobile systems. Both exaggeration of what's feasible and overly optimistic user expectations have a role to play in user disappointment, but there are also easily fixable issues that often are not addressed in the design and setup of such systems.

A major problem is that many RV solar systems assume that users will have overnight access to a 230-volt supply for recharging of batteries and overnight electricity usage. Most RVs include solar/battery systems sized for daytime use only, with only occasional (single) nights away from mains power (or without alternator charging via driving).

However, a substantial proportion of RV owners 'free camp', without access to mains power, often for many days on end. One estimate suggests that half of all regular RV travellers avoid staying in caravan parks whenever feasible. This type of usage is rarely allowed for in standard production RVs.

Installing mobile solar systems is also very different from domestic practice. Domestic installers rarely understand the complexities of RV electrical systems, in particular of

Photo: copyright 2011: Caravan & Motorhome Books, Church Point NSW 2105.

↑ Camping in the Kakadu—made easier with the right electrical system.

interfacing solar with alternator charging, and the need to keep voltage drop (see box at right) under 0.02 volt.

Prior to around 2000, most alternators generated 14.2 to 14.7 volts (the latter being adequate for efficient auxiliary battery charging) but many are now only 13.8 volts and post-2014 may be as low 12.7 volts. To cope with this, dc-dc alternator chargers accept whatever the alternator produces and, by juggling volts and amps, optimise the output to best suit the charging regime of the auxiliary battery used.

Auto electricians have been hindered by RV electrics and solar not being included in their training (although I understand this is now being considered by several TAFEs).

This article explores the issues with mobile solar and offers some solutions. Despite the above-mentioned issues, adding solar to RVs (and boats) can work well, provided the installer understands what's required. Most top-grade systems are by owners who have really done their homework or by a few specialists who do excellent work in this area.

System sizing—how much energy?

To correctly size the panels and battery for a mobile system, you need to first take into account the available solar energy.

Sizing for domestic systems usually proceeds in the other direction, based on the

Photo: Middle Lagoon (Kimberley) 2009, courtesy Brian Fox.

↑ Extra energy input can be gained by the use of additional folding solar panels—unfortunately, these are common targets for thieves in campgrounds and caravan parks.

energy usage. However, the limitations on size of solar panels/battery and location of a mobile system mean that it is usually best to match energy usage to the available energy rather than the other way around.

The available energy depends on the output rating of the solar panels, the number of solar panels, the available solar input in sun-hours per day and losses due to factors such as temperature and battery charging.

SOLAR PANEL RATINGS

Because every last watt-hour is important given the small size of mobile systems, it's even more important for buyers of mobile solar systems to understand exactly what they are getting when they buy a solar panel.

Most panels are sold quoting wattage according to Standard Operating Conditions (SOC), a laboratory method which produces a higher wattage than under real conditions. (I think of this as the maximum briefly producible power, produced at a higher voltage than is mostly usable, around midday on top of a chilly equatorial mountain in mid-summer!)

The actual operational wattage rating is the important figure for buyers and is about 30% less than this. This information is usually available on the panel's data sheet expressed as wattage at Nominal Operating Cell Temperature (NOCT). Using this, buyers can make a realistic estimate of the amount of energy their solar panels will produce.

For example, a panel rated at 120 watts under SOC will typically have realistic output of 87 watts under NOCT. So be aware of this; the SOC can catch out non-industry buyers.

AVAILABLE SOLAR INPUT

Of course, the rating of the panel and number of panels are just part of the equation, with the actual energy produced also dependent on the available solar input.

It is important for RV buyers to understand that a solar module produces most of its output during the two to three hours before and after midday. Solar input is measured using peak sun hours. A peak sun hour is a solar irradiation of 1000 watts per square metre over one hour. This is a concept similar to measuring rainfall; the solar equivalent of a rain gauge can be visualised as a standard-sized light bucket. When the bucket is 'full', that represents one peak sun hour. The bucket may fill six or seven times daily during a Hobart summer, but only twice or so daily in that city's winter.

Daily peak sun hours for any given locality are available from the Bureau of Meteorology, but as many RV owners travel widely and at different times of the year, it is easier to use a rule-of-thumb. For RV users, at least a separate winter/rest of year rule is needed, as a yearly average doesn't mean much if you're travelling in winter!

In Australia a good rule-of-thumb divides the country into two. South of a line from Geraldton to Townsville, you can assume 2 to 2.5 peak sun hours per day during winter, and 4 to 5 peak sun hours per day the rest of the year. North of that line, assume about 5 peak sun hours per day in winter and 6 to 6.5 peak sun hours for the rest of the year. This includes some margin for overcast days.

The solar input to the panel is affected by mounting angle and orientation. With RVs, the mounting often needs to be horizontal. This incurs negligible loss in summer, but can impact on input in winter. However, most RVers head north in winter!

One way to overcome the issue of non-optimal angle and orientation is to use folding panels. You take them out when you set up, plug them in to the dedicated socket on the van, unfold them and aim them at the sun directly, so you get maximum output. Many RVers seem to be using them nowadays.

TEMPERATURE-RELATED OUTPUT LOSS

Output loss due to temperature also needs to be taken into account. Most solar modules

What is voltage drop?

Every cable will resist the flow of electricity through it to some extent. This produces heating in the cable and a drop in voltage. Two ways to combat this is to lower the resistance by using a bigger cable or raise the voltage. This is why a 230 V appliance can have a much thinner cable than a similar 12 V one. The power available to a device will be a product of the electrical voltage and current (Power = Voltage x Current). So for a particular power consumption, the lower the voltage, the higher the current flow. Cable is sized by the electrical current that it will carry. Hence, thicker cable is needed for a lower voltage system (like in RVs). This thicker cable has less resistance to the flow of electric current (it's a 'bigger pipe'). Less resistance means lower voltage drop and less heat generated.

Resources:
Free app to help calculate voltage drop 'MagniGauge': itunes.apple.com/app/magnigauge/id697974788?mt=8
Or check out a great online calculator at www.kilowatts.com.au/calculator-voltage-drop.php

lose output when hot (around 4% to 5% loss per 10 °C increase in cell temperature above 25 °C). Amorphous modules lose far less, but being less efficient than crystalline panels, they produce far less energy per unit area—a major drawback for RV usage, where roof space is limited.

Heat loss is often taken into account only when the ambient temperature is above 25 °C. But at that ambient temperature, the dark-coloured solar cells are typically at 46 to 49 °C. They have already lost 10% or so output on a temperate sunny day; up north the loss is more like 15% to 20% much of the time.

Decide on solar/battery capacity

Keeping all the factors of realistic solar panel rating, peak sun hours and temperature losses in mind, you can then approximately determine how much energy your RV solar panels will produce under a range of conditions. But that's not the end of the story: the interplay between battery and solar sizing is an important factor.

A major constraint with almost all production RVs is limited allowance within permitted on-road weight for heavy additions. Despite this, most RV systems have too little solar capacity (typically 10 kg/120 watts) for the installed battery capacity (typically 30 kg/1200 Wh for a lead-acid battery).

As with limited daily income, solar happiness requires (on average) more to be earned than spent, with some reserved for times of less income. Many RV owners routinely running short of energy add more battery capacity. If you don't have sufficient solar input to charge the increased capacity, this no more helps than a second credit card assists with inadequate income.

So how do you get the balance right between solar input and battery size? If you are going to 'free camp', lead-acid battery capacity should be sized to be fully chargeable by around noon from solar alone, assuming typical overnight draw. This will provide sufficient energy to free-camp almost indefinitely during times of average sun.

Let's look at an example. An 18 foot caravan's roof usually has space for a module capacity of 600 watts SOC—or a realistic 420 watts NOCT. Daily output at a pessimistic 2.5 peak sun hours results in just over 1000 watt hours a day. An RV at rest still requires daytime power for the fridge, water pump(s) etc. Any energy left over is available for battery charging. This typically limits battery capacity to about 200 amp hours. The maximum battery capacity for caravan use is usually limited by weight anyway—but it is best to keep battery capacity to that which can be realistically charged from 60% state of charge to 100% state of charge in a day or so, assuming 2.5 peak sun hours. This is still tough on a lead-acid battery and many RV batteries last only three years as a result. Lithium batteries promise an improvement in this regard (see 'Using lithium batteries on the road' on page 56).

Battery charging/discharging losses are usually calculated in amp-hours, despite the process being one of energy transfer and an amp-hour is not a unit of energy. To charge, batteries require at least 10% higher voltage than they deliver, so the calculation must be in watts and watt-hours (i.e. units of energy). Factor that it in and the loss is closer to 20% than the usually quoted 10% to 12.5%. This affects only the input stored and reused, but is still substantial.

The overall loss from solar captured to available energy (direct and stored), allowing for voltage drop loss, is close to 50% in a typical RV.

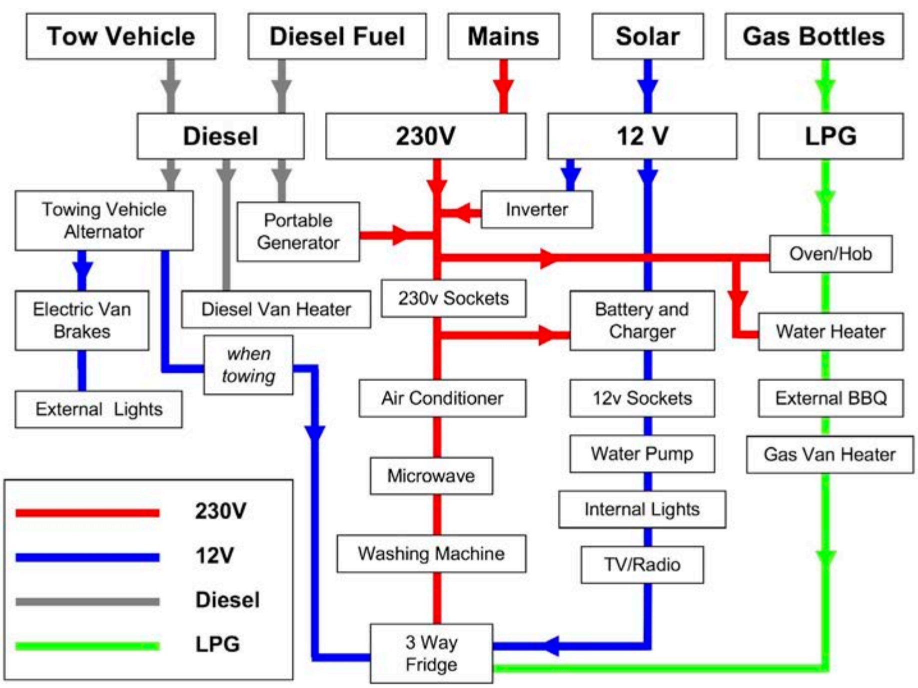


Chart courtesy of *Caravan Buyers Guide* (to be published February 2014).

↑ Here we have a logical diagram of a typical RV electrical system showing which appliances run from each power source. Note that this is not a wiring schematic, so not shown are the vital safety devices such as break-before-make isolation of inverter/generator and mains power, circuit breakers, residual current devices (earth leakage circuit breakers) etc. The appliances are all still electrically connected in parallel, not series.

What devices are feasible?

Having established the energy available from your solar/battery system, you can then work out the devices you can run in a typical caravan or small- to medium-sized motor home. (Large RVs usually have inbuilt generators, often powering air conditioners and many electrical goodies; although some token solar is often installed, it can only marginally assist.)

There are some general guidelines. I recommend that the RV owner should avoid any device or appliance intended to produce heat over extended time, including electric heaters, ovens and halogen globes. One exception is electric blankets, if used briefly: 12 volt versions draw 35 to 50 watts each.

COOKING

Microwave oven ratings, as for pumps and big electric motors, are of work performed, not energy consumed. In this universe at least, the latter is always more. A typical microwave oven badged as 800 watts will draw 1250 watts—you can find this rating on the back. An inverter powering such an oven may draw 1350 to 1400—this is a current draw of up to 115 amps, often from a 12 volt lead-acid battery usually intended to provide no more than 45 amps—and often via grossly undersized cable. Those familiar with Peukert's Law will realise that a battery cannot provide this current for very long.

If that microwave oven is deemed essential, use it only on mains power. Otherwise you could end up spending $2000 for a 1600 watt inverter and the solar and battery capacity required to drive a $199 oven about an hour a week. I would suggest that freeze-drying is cheaper and healthier.

FRIDGES

For all but huge RVs, electric fridges are responsible for around 70% to 80% of the total electricity consumption. At 0.75–1.0 watt per litre, the power draw is roughly proportional to capacity, up to fridges of 100 litres or so (above this it becomes proportionately less). Chest fridges use marginally less than door opening fridges of similar capacity, and energy use of the latter rockets if their door seals leak.

Fridges also draw 5% more energy for every 1 °C increase in ambient temperature. This is an issue with daytime temperatures up north consistently 27 °C to 40 °C or more; it stays hot all night too.

Eutectic fridges are an energy-efficient option. These use a phase-change material inside the fridge to store 'cold'; the compressor can be turned off and the cold reserve keeps the fridge cold. These fridges can be used in either of two modes. If used as a normal fridge, by simply setting the thermostat to the desired temperature, they use much the same amount of energy as conventional fridges of that volume. They also have a so-called 'pump-down mode'. This requires them to be initially run at their coldest setting for 10 to 12 hours, but thereafter run only an hour or two each morning and night, or about twice that in very hot areas. In that mode they use about 40% less energy thereafter. Such fridges cost 10% to 20% more, but the cost is offset by less solar and battery capacity being required. You can even DIY using the excellent US SeaFrost eutectic kits.

Another important consideration is fridge siting. Many RV builders appear not to realise that fridges pump heat from where it is not wanted (inside the fridge cabinet) to where it does not matter (the room, or outside). Thus, the fridge needs a well-ventilated space around it to pump all that heat into. One $375,000+ motor home I saw had two fridges; one inside a totally sealed wooden enclosure, the other a huge chest opening unit which slid out on runners from an airtight locker little larger than the unfortunate fridge. Both ran continuously 24/7, yet barely cooled at all.

To further exacerbate fridge performance issues, most have cabling that is far too thin. Their performance can be almost transformed for the price of a few metres of twin-core 6 mm² cable, as the thicker cable lets the

→ Solar panels are easily built in to even the smallest of mobile abodes.

Supplementing solar

Wind turbines are not usually useful for RVs. The underlying constraint is that their output (almost regardless of rotor design) is proportional to the square of the rotor diameter and the cube of the steady wind speed. If there is enough steady wind to produce useful energy, it is far too windy to camp there.

However, there will always be times when you are away from mains power and the solar panels won't provide enough energy input—such as when camping during the wet season. To provide additional energy and prevent over-discharge of the battery, extra charging can be had using a small petrol generator (genset) or fuel cell generator.

Small petrol generators are very cheap, but they can make noise and pollution that may upset the RVing experience. In this case, a fuel cell might be a better option as they produce little of either.

For reliable appliance operation, an 'inverter' genset should be used. These have an internal inverter that takes unregulated power from the genset's alternator and converts it to mains-quality power with a regulated voltage and frequency.

Truma's long-promised 12 volt, 20 amp LPG-powered fuel cell charger is available in Europe—but not in Australia or NZ—as installation is not covered by existing gas appliance regulations. EFOY has an ethanol fuel cell range but their costly fuel must be bought in sealed canisters from the importer, or the warranty is rendered invalid.

Unless using a three-way fridge running on LPG, it is advisable to carry a 1 kW or 2 kW inverter generator as a backup, using its 230-volt output to power a 25 to 30 amp multi-stage charger. Do not attempt to charge via its 12 volt output—it is most likely a non-regulated 13.6 volts at 8 amps. Even if labelled 'Battery Charger' its output voltage is far too low for effective charging.

compressor see the full battery voltage and hence operate more effectively.

For those travelling in the far north the (EU) 'T' rated Dometic units are good units that reliably cool up there. Correctly installed, they maintain their rated performance up to 43°C.

TVS AND COMPUTERS

Power draws of small (for example 44cm) TVs are closely related to price. Many are ultra cheap but draw 50 to 75 watts. Spend about $300 and buy an LED backlit unit, some of which draw under 20 watts. Be aware that TV (and computer screen) power draw is a function of the square of their screen size.

Laptops draw 25 to 50 watts, depending on processing power and usage; these can be an issue for compulsive users! ✱

Collyn worked as a technical editor for many years, including founding *Electronics Today International*. He has published several books on solar power and caravanning. See www.caravanandmotorhomebooks.com

Cabling issues

A major issue with RVs is what I call the cable rating trap. Automotive cable sizes are often specified by their diameter in mm as opposed to the cross-sectional area in mm². So a 4mm (diameter) automotive cable has only 1.8mm² of conductor due to the thickness of the plastic insulation, and 2mm may have a mere 0.5mm². As the copper/plastic content varies from brand to brand, conversion to mm² is not possible for the smaller sizes of auto cable, but the 6mm size is usually about 4.6mm² and 8mm is usually about 7mm².

Mistaking auto cable rating for mm² could result in large voltage drops. The smaller cable not only has a higher resistance, it may not be capable of handling the current drawn through it. In the worst case this can result in cable overheating.

Most production RVs also have a 230-to-12 volt converter that runs the lights, pumps, fridge etc when the RV is connected to mains power, typically producing an unregulated 13.65 volts. However, this will be too low to be useful for battery charging, especially with the voltage drop from typically thin RV wiring. Owners usually attempt to overcome this by adding a multi-stage battery charger with appropriately sized wiring.

However, if the existing wiring is under-sized (as it usually is), leading to significant voltage drop, voltage-sensitive devices such as fridges may not work properly. Much heavier cabling is also needed for high-draw devices such as inverters, loo macerators and water pumps which may stall and burn out at too low a voltage.

Replacing existing wiring is usually not practical as it is between the inner and outer wall cladding, but it should be possible to run cable at floor level within existing cupboards etc, or in protective ducting or conduit underneath the floor.

More details are available under 'Articles' on Collyn's website at www.caravanandmotorhomebooks.com

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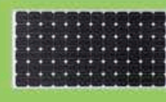

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Early adopters
Using lithium batteries on the road

Rodney Dilkes of EV Power Australia explains how he got into using lithium batteries for better caravan energy systems.

↑ Jim Jones in the outback with his lithium-battery-powered Kimberley Karavan.

IN 2005, as an enthusiast, I wrote an article for *ReNew* about my electric Mighty Boy car conversion. At the time I used lead-acid batteries to power the car, but in the article I mentioned the coming-of-age of lithium batteries large enough to power cars. A year or so after that, I imported some lithium iron phosphate ($LiFePO_4$) cells for the same car and used my rudimentary electronics knowledge to build a battery management system to balance and monitor them. As far as I know, that car, now sold, is still running on those same lithium batteries.

From those beginnings, grew a small business, EV Power Australia, importing cells and manufacturing lithium iron phosphate battery packs for other enthusiasts and businesses. Initially, the main use was for electric vehicle conversions, but these lithium batteries also became popular as storage for renewable energy systems of many kinds—including mobile systems.

It was 2010 when Jim Jones contacted me inquiring about lithium batteries for his caravan. I think at the time he talked his mate into buying and testing them first! After the mate had quality checked them, Jim bought a set for himself and installed them in his van. He was one of the first of our customers to apply $LiFePO_4$ batteries to caravans.

Since that time, EV Power has supplied quite a number of batteries for caravans, in particular for Kimberley Karavans. Their caravans are factory fitted with sealed lead-acid (SLA) batteries: nine 30 Ah batteries, weighing 11 kg each, for a total of 270 Ah and 99 kg. We developed a replacement $LiFePO_4$ battery of 260 Ah capacity weighing just 36 kg—which, in fact, results in considerably more usable capacity than the SLA batteries.

The main benefits of $LiFePO_4$ batteries for caravans (and other storage uses) are:

- high energy density, so more amp-hours in a smaller, lighter package than SLA (half the weight of equivalent capacity SLA batteries)—important for caravans given the need to minimise towing weight and space used
- higher voltage under load (12.8 V nominal) with minimal voltage sag at deep discharge rates
- a high cycle life of 2000+ discharge cycles to 80% depth of discharge
- more usable amp-hours than SLA; 80% depth of discharge on a regular basis is no problem compared to a maximum of 50% for SLA
- capable of a high discharge rate; e.g. discharging in one hour can still deliver the full battery capacity
- safe chemistry with non-toxic, non-corrosive recyclable components.

As a supplier of batteries, safety is an important concern. Lithium iron phosphate batteries are good in the safety department, especially when compared with other lithium chemistries, but they are not infallible. Neither, for that matter, are lead-acid batteries. So, we generally supply batteries prefabricated with a cell balancing/monitoring management system that can switch off the battery if there is a problem.

We have been early adopters of lithium technology and have done a lot of work to overcome some teething troubles. At this time the major international manufacturers are showing serious interest and will eventually dominate the market. Hopefully there will still be a niche market for small Aussie businesses like us. ✷

Jim Jones: a set-and-forget system

Using and replacing battery-stored energy in our caravanning world was always in question. A shortage of available amp-hours and the inability to replace these amp-hours in an efficient, effective way required better planning than the 4.5-year-old battery system could deliver, with its charging efficiency issues, time-consuming supply source connections and tolling weight.

With my AGM battery replacement imminent, I contacted EV Power in 2010. Rod's advice was that with lithium iron phosphate batteries we'd only need around 50% of the capacity of our AGM battery system; that is, around 180 Ah rather than 350 Ah. He also noted that the technology could handle any amount of current likely to be found in a normal caravan/vehicle system, whether discharging or charging.

Three years on and I have nothing but praise for this battery technology for this sort of use. I'm now looking at adding an auxiliary battery in our tow vehicle for backup and portable power.

One issue is that battery charger technology for $LiFePO_4$ has been slow to catch up, with the required step-up DC-to-DC power supplies also difficult to procure. I have two RanOx units that have performed the required DC-to-DC step-up function for alternator charging. They're no longer available, but I'm sure there are or soon will be other systems that can be sourced.

$LiFePO_4$ batteries are approximately 25% more costly than AGMs but I have found that this cost is recouped in reduced weight, enhanced recharge rate and cyclic longevity and the minimal storage space required.

They are brilliant batteries for an 'almost' set-and-forget system.

Adrian: another happy camper with lithium batteries

I have three lithium iron phosphate batteries from EV Power in Perth: two 180 Ah batteries and one 40 Ah battery.

The 40 Ah one is the starter motor battery in my 100-series Landcruiser. It never fails me! Even after the car had been parked next to the flooded Murrumbidgee River for a week I just had to turn the battery management system off and on to start the car without any difficulty at all—even though, as I discovered later, an appliance had been a slow power drain on the battery.

The first of the other batteries is in the caravan and runs the fridge/freezer, lights, winch, water pumps, radio/DVD player, TV, fan and toilet and starts the diesel cooktop and water heater. I don't bother with the solar panel unless it is a lengthy stay as the battery lasts for five days without charging and will be fully charged within the travel time to the next destination.

The second of the 180 Ah batteries is the auxiliary battery in the Landcruiser; it powers a 110-litre fridge/freezer, the winch and the compressor. I never have to worry about this one as it is wired into the car charging system in a manner that charges it rapidly. After a weekend away without charge, I arrive home with it fully charged. A typical drive home is about three hours. I believe that such rapid charging can kill other battery types!

I have a battery management system for each battery and highly recommend this practice.

Know your renewables
Electrical terms (part 1)

There are many technical terms associated with electrical systems, but what do they mean? Lance Turner explains the most common terms you are likely to come across.

YOU don't need to have a working knowledge of electrical systems to own a renewable energy system, but knowing the basic terms can help you understand your system—as well as enable you to explain problems to installers in a more cogent manner.

Electricity and electron flow

Electricity in a circuit is the movement of electrons (a subatomic particle with a negative electrical charge) through a conductor. A conductor is any material, often a metal, that allows electrons and hence electricity to flow easily through it.

Electricity in conductors (electrons) flows from negative to positive (called electron flow), but most people talk about current flowing from positive to negative (called conventional current). Electricity may also be a flow of positive ions (an ion is a charged atom; a positive ion is an atom with one or more electrons missing), usually inside batteries, where ions flow through the electrolyte. For most purposes, especially when talking about electrical circuits with appliances attached to power supplies by cables, we are talking about a movement of electrons.

Another two terms often used (and confused) when talking about electricity use and generation are power and energy.

Power

Power is the rate at which energy is generated or used to do work, and is measured in joules per second (see box *Joules and coulombs)*. Power has been assigned its own unit, the watt (W), but it's important to remember that it is a rate, a bit like measuring your travelling speed in km/h. It's an instantaneous measurement, at a particular point in time.

Energy

Energy measures the total amount of work done by a particular level of power over a period of time. The work may be producing heat or illuminating a light bulb or turning a motor. Energy is calculated as power multiplied by the duration of use, a bit like calculating distance as speed multiplied by time.

The usual units used to describe electrical energy are the watt-hour, equal to one watt of power used for one hour, and the kilowatt-hour, equal to one kilowatt (or 1000 watts) of power used for one hour.

Your electricity bill is measured in kilowatt-hours, although some energy companies just call them 'units'. If you use 500 watts of power for four hours, you'll have used 2000 watt-hours, or two kilowatt-hours, of energy—or 7,200,000 joules (500 joules used for 4 hours = 500 * 3600 * 4). Larger energy quantities are measured in megawatt-hours (1,000,000 watt-hours) or gigawatt-hours (1,000,000,000 watt-hours).

To sum up, power is the *rate* at which energy is generated or used, and energy gives the *amount* generated or used over a period of time.

Appliance power ratings, instantaneous power and average power

There are a number of different power ratings that apply to appliances and devices. Often, an appliance will have a **rated power** and this is usually the maximum power the device will draw in normal operation. For example, a heater with two settings might have a rating of 2000 watts. If used on low it might draw just 1000 watts, and might only draw 2000 watts if used on high. No appliance should ever draw more than its maximum rated power for any length of time.

However, many appliances do draw considerably more than their rated power for very brief instances when first turned on. This is due to a number of factors, including the high level of power required to get a motor moving from rest, or because heating elements have a lower resistance when cold than when at operating temperature. This is called the **surge rating**, and should only occur for a second or two at most.

When you measure the power of an appliance with a meter you are measuring the **instantaneous power**. This can vary, depending on the type of appliance. Simple things like heaters may draw the same power continuously, but more complex devices such as computers and other electronic devices may draw different power levels at different times, depending on what they are doing at the time. Indeed, this is how energy meters work. They measure the power being used by the device many times (sometimes as often as many times each second) and average it out over the measurement time period to calculate the energy used.

This leads us to **average power**. For example, if a device draws 1000 watts for half an hour and then reduces to 500 watts for another half hour, its maximum power would be 1000 watts, but the average would be 750 watts. The average power is simply calculated by measuring the energy the device used and dividing this by the time it was run for.

Voltage and current

So where do volts and amps come in, both terms that you'll hear a lot about when dealing with renewable energy systems?

Voltage is often described as the electrical 'pressure' of electricity. Technically, it measures the amount of energy (joules) in each unit of charge (measured in coulombs), and is measured in joules/coulomb and assigned the unit volts (V).

The higher the voltage, the greater the electrical pressure and the more dangerous it can be. Mains voltage is typically around 230 volts and is very dangerous, whereas a car battery is only 12 volts and is considered safe to touch.

It is the voltage that 'pushes' the current through a circuit. Generally, for a given circuit, as voltage increases, so does current.

Current is the rate of flow of electricity in a circuit. It measures the amount of charge (in coulombs) that passes a point each second. This is measured in coulombs/second and is assigned the unit amperes, or amps (abbreviated to A and called I in mathematical formulae).

Thus, Power = Voltage x Current
= joules/coulomb x coulombs/second
= joules/second or watts.

Resistance

Resistance is one of the basic fundamental electrical concepts, and is a measure of a material's ability to restrict the flow of electrical current through itself. Resistance is measured in ohms (Ω). A resistance of one ohm will allow one amp of current to pass through it at a voltage drop of one volt.

Together, voltage, current and resistance are used to form the most basic fundamental law of electricity—**Ohm's law**: a simple mathematical formula that allows either voltage, current or resistance to be calculated when the other two values are known. The formula is: V = I x R, where V is the voltage, I is the current, and R is the resistance.

This brings us back briefly to appliances and why they have a particular voltage rating. All devices are designed for a specific voltage so that they draw their rated current and hence power—i.e. Ohm's law in use. If you use them with too much voltage, too much current flows, damaging the device and possibly causing a fire.

Given these definitions of voltage and current, we can take another look at electrical energy in a battery-powered circuit. A watt is equal to a current of one amp through a resistance of one ohm; the voltage drop across that resistance is equal to one volt. Add all voltage drops in a battery circuit and they will equal the battery voltage.

As you can see, all of the definitions rely on each other. This is one of the reasons understanding electrical theory can be so difficult—you need to understand all of the terms together for it to really make sense.

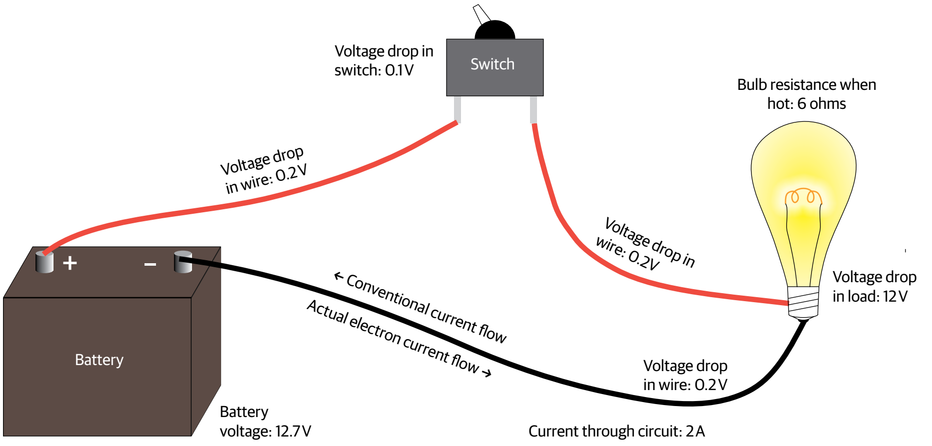
AC/DC

Current can be of two types: alternating or direct.

Alternating current (AC) is the type of electrical current supplied from the mains grid. It is called alternating current because the direction of current flow continually reverses direction. This happens because it is produced by an alternator in a power station. In simple terms, these consist of many windings that pass over many magnets. As the winding approaches the magnet, current is forced in one direction. As it recedes from the magnet it flows in the other direction. The frequency at which it reverses is measured in cycles-per-second, or **Hertz** (Hz).

Direct current (DC) is the type of current that flows in one direction only, although it may vary in magnitude. Batteries produce DC electricity, as do most small power supplies for devices such as phones, laptop computers and the like. ✱

Next issue: metering in electrical systems.



↑ Current flows from the battery positive, through the switch and to the bulb, and then back to the battery negative. The voltage drops across each section of the circuit are shown, with the total equalling the battery voltage. Note that the resistance of the bulb is known: as we know its voltage drop and the circuit current, resistance can be calculated using Ohm's law (R=E/I). The power used by the bulb is 24W and the wires and switch waste 1.4W, or 5.5%.

Voltage levels

There are a number of ranges that voltages fall into. The lowest is **extra-low voltage** (ELV) and this includes DC voltages up to 120 volts and AC voltages up to 50 volts. This is often erroneously referred to as "Low Voltage" by many people, including those in electrical and renewable energy industries.

Low voltage (LV) actually covers DC voltages from 120 to 1500 volts and AC voltages from 50 to 1000 volts. So 240 volt mains power is actually technically low voltage.

High voltage includes voltages above 1000 volts AC and 1500 volts DC. It is not normally found in domestic electrical systems.

Joules and coulombs

A joule is equal to one watt of power used for one second, or a watt-second. To convert from joules to watt-hours, divide by 3600 (based on 60 seconds in a minute, 60 minutes in an hour).

To get an idea of how much energy a joule actually is, it helps to look at some everyday examples. A joule is the amount of energy needed to raise the temperature of 1 gram of cool, dry air by 1.0 °C. An average person sitting quietly produces 60 J of heat every second. The amount of energy required to lift a small apple (around 100 g) 1 metre against Earth's gravity is roughly equivalent to 1 J.

A coulomb is a measure of the amount of charge in 1 amp of current flowing for one second. Electricity is a flow of electrons, but each electron has a very tiny charge, so a coulomb represents a very large number of electrons—it is the equivalent of $6.24150975 \times 10^{18}$, or 6,241,509,750,000,000,000 electrons!

Ditching the inverter
A DC appliances buyers guide

You don't need an inverter to run appliances off a battery-based renewable energy system—many AC appliances have DC-powered counterparts. Lance Turner looks at what's available and why you might want to use them over AC versions.

Most homes have quite a few appliances, most of which run from 230 V AC mains power. However, if you live off-grid and use a battery bank and inverter for your electricity supply, then AC appliances running from the inverter are not always the best option. Even on-grid homes that have a battery backup power supply (which is becoming more common as users seek to shift loads to cheaper off-peak rates) can run DC appliances if desired.

While the thought of having no AC appliances might seem impossible for a modern home, for small homes, weekenders, caravans and those wishing to eliminate mains voltages, it is possible to have an all-DC home, albeit with some limits to the type and size of appliance that can be operated.

Many appliances actually run on DC, usually via an external or internal power supply. To do this, you are converting battery DC power into AC via your inverter, then back to DC via the device's power supply—a double-level conversion that can waste quite a lot of energy. Further, just one small device will mean a large inverter needs to keep running, making that energy conversion process even more inefficient. It's not uncommon for a two watt load to keep an inverter pulling 20 watts or more from the batteries.

Even if you have a large home with all the mod-cons, it is worth considering running some devices directly on DC, allowing you to eliminate some of the power supplies and plugpacks that litter the average home. This is especially the case if you are building or renovating, as it is the ideal time to run extra-low-voltage (ELV) cables without much added cost.

← The Wave Box microwave oven is available in DC only and AC/DC versions. Rated input power is 660 W and cooking volume is 7 litres, making it quite a bit smaller than conventional ovens, but for many users it may be all that's required.

Why DC?

The main reason for using DC appliances is the independence of not relying on an inverter. Although modern inverters, especially the Australian and European-made ones, can be very reliable, all inverters inevitably fail, and they often do so at the worst times, such as during a heatwave when refrigeration is critical, or just before a long weekend, when replacements are unavailable.

There can be other advantages too, such as eliminating the various power supplies on some appliances. For example, an LCD monitor might have an AC to 12 V DC power supply. If you have a 12 V battery you may well be able to power the monitor off it directly, eliminating both the electrical noise of the monitor's switchmode power supply and the energy losses in both levels of conversion—in the inverter and the power supply. This may mean a reduction in energy use for that device of up to 30% or 40%.

However, despite the advantages for some appliances, there is one big disadvantage of using DC directly—although it is not insurmountable—which is related to an appliance's power rating. Power is equal to the supply voltage multiplied by the current used by the appliance. So, for a set power rating, if the voltage is reduced, then the current must increase proportionally. For example, a 480 watt appliance running from 240 volts requires 2 amps of current (480/240 = 2). For a much lower voltage, say 12 volts, the current would be 480/12 or a huge 40 amps.

Why is this a problem? Well, cable has some resistance in it, which means that for a fixed current, there is some power loss in the cable itself. At low current levels and common cable sizes, this loss is negligible, but if the current is suddenly multiplied by 20 then the losses are much greater. Indeed, the loss is calculated by multiplying the square of the current by the resistance (called the I^2R law).

Photo: Peter Halasz

↑ The old and the new. On the left is a Clipsal 402/32 plug, while on the right is a PowerHunt DC socket that can handle up to 70 A.

So if the current increases 20-fold, the loss actually goes up 400-fold for the same cable. Thus, when running appliances at lower voltages, cables with a much lower resistance are required, and this means that they must be proportionally thicker.

As a result, extra-low voltage (ELV, see en.wikipedia.org/wiki/Extra_low_voltage) DC cabling is usually much thicker than for mains voltages. While the standard cable cross-sectional area (CSA) for mains voltages running to power points in a home is 2.5 mm², for DC cabling it can be much higher—6 mm² to 16 mm² cable sizes are not uncommon—even heavier for large loads, or where long cable runs are unavoidable.

Cabling, plugs, sockets and switches

There are a number of standard plug-and-socket systems designed for the higher currents of DC systems. The common cigarette lighter plug is well known, but it isn't a reliable system and should be avoided. A similar-looking but much more reliable system is the ISO 4165 connector, known as Merit or Hella plugs here in Australia. These are common in RVs (recreational vehicles, such as caravans and motorhomes) and are rated to 12 A continuous current.

The Clipsal 402/32 T-configuration system is found on older DC systems. The connectors are rated at up to 15 A and 32 V DC. Note that although the top of the T is usually the positive terminal, polarity varies and should always be checked if buying appliances with this plug fitted.

Anderson plugs are a high-current, high-voltage plug-and-socket system that have become quite popular for their robustness and reliability. There are two types. The SB Multipole series is a two- or three-pole, one-piece hermaphroditic plug. These are available in a range of sizes and current ratings, up to 700 amps or more.

The other type, the Powerpole, consists of a range of single-pole connector housings that link together to form different combinations. They can have different-sized terminals inserted into them, depending on the current rating required. See www.andersonpower.com.

There are a number of other high-current DC plug-and-socket systems. An interesting one is from PNP Systems (Power Hunt brand, see www.power-hunt.com), suppliers of a number of high-power DC appliances such as microwave ovens, sandwich makers and the like. Their plugs have two terminals—one is flat, like a minus sign, and the other is cross-shaped, like a plus sign. These shapes indicate the polarity of the connectors, so it is easy to wire them correctly. The PowerHunt range includes one- and two-socket power ports and heavy duty matching plugs rated at up to 70 A continuous, and has been developed specifically to reduce losses in DC appliance systems.

The switches used in DC systems are different to AC switches in home power points. DC has a tendency to arc, thereby burning switch contacts, so DC switches must be designed to cope with this. Good-quality DC switches are readily available as they are used in high-end automotive applications, but you can also take a different tack when switching DC currents.

Solid-state relays (SSRs) can be used to control large DC currents; they can even do this remotely, thus reducing run lengths of heavy DC cables. For example, instead of running heavy cable from the power source to the switch and then to the appliance, you can run it directly to the appliance and connect a solid-state relay in the cable anywhere between the power supply and appliance. The relay is controlled by a much thinner cable and lightweight general duty switch, as it only requires a few milliamps to control it.

Cable used for DC systems is usually more flexible than that used for mains power, and a lot heavier and more expensive. The best sources are DC appliance suppliers and solar equipment suppliers, but one often overlooked source is welding cable, which is tough, flexible and often rated to 600 V. It is usually cheaper than other types too.

Which voltage?

This leads us to another question—what system voltage should you use? Although 12 volt appliances are very common as they are made for the automotive and RV markets, 24 volts is a more suitable voltage for a whole-of-house battery bank as the higher voltage means lower currents and therefore lower cable losses and lower cable size requirements—meaning cheaper cables.

Just as 24 volts is better than 12 volts, 48 volts is an even better voltage, for the same reasons mentioned above, and is probably the most common voltage for larger domestic off-grid renewable energy systems. Cables in

Safety first!

As DC electricity tends to arc (and sustain an arc) more readily than AC, some people believe it is inherently more dangerous. This is only true if the correct safety precautions are not taken when installing DC systems.

All DC circuits must be protected by suitable fuses or circuit breakers. You should only use DC-rated switches and circuit breakers and all connections should be double-checked during installation.

Never solder the ends of wires before inserting them into screw connections. The solder flows under the pressure of the screw clamp and the wire may loosen over time, causing failure of the connection and possibly a fire.

All DC cabling should be protected from damage and must be suitably sized to handle the loads required of it.

If you have large loads such as DC fridges or cooking appliances, they should have their own dedicated circuit. This allows you to size circuit breakers accordingly, without the issue of needing to protect lower-powered devices on that circuit as well. Although this approach adds to cabling costs, it does produce a more efficient, more reliable and safer system.

48 volt systems can be much smaller for the same power ratings than the lower voltages, so running this higher battery voltage can save a lot in cabling costs.

However, 48 volt appliances are not common, so DC to DC converters are required to run most DC appliances on a 48 volt system. These are readily available and range in ratings from tiny units capable of providing a few watts up to much more powerful devices that can supply even the most power hungry of DC appliances. Good-quality units will have high efficiency, so even though you are doing one level of power conversion, you will still use less energy than running an AC appliance from an inverter.

Limitations of DC appliances

As you might expect, the higher currents involved with ELV DC appliances mean that there is an upper limit to the rated power of DC appliances. There are almost no DC appliances rated at more than 800 watts. High-powered appliances such as vacuum cleaners will still need to be 230 volt AC models (unless you have all hard floors and can get by with just a broom or a robot vacuum!). Appliances that contain high-powered heating elements, such as dishwashers and washing machines, are generally not available as DC versions.

Some DC appliances are made more for occasional use and so may have a shorter lifespan than their mains-powered counterparts. This is not true of all DC appliances though, so look at product reviews by others who've bought the item you're considering.

Appliances available

In recent years there has been an increase in the range of DC appliances for the RV and caravanning market. Although many of these appliances may be little versions of their AC cousins, for many people, especially smaller households, they may be all that is required.

COOKING

Although off-grid cooking is often done with an alternative fuel such as wood or LPG, there are quite a few 12 V and 24 V options. They include microwave ovens, electric frying pans and grills, sandwich makers, tea and coffee makers, mini ovens/food warmers and quite a few others. And you don't have to go without modern ideas such as rangehoods—even they are available in DC models, although they are normally used over gas cooktops as DC-powered ovens and cooktops are unavailable as they would draw too much power.

REFRIGERATION

Most people need a fridge, but an AC fridge can have some drawbacks. The first is that it places a high startup load on your inverter, so you need a suitably sized inverter to run it. If you have no other large electrical devices, you may be buying a larger inverter than you need, just to start the fridge.

Also, as most fridges are electronic, even when they are not running they still need electricity available, so the inverter never gets to go into standby—it runs in idle all the time, wasting energy.

Probably more importantly an AC fridge will not run should you have an inverter failure. This is not that common an occurrence, but when it does happen you have two options—find a replacement inverter within a few hours or lose potentially hundreds of dollars of stored food. A DC-powered fridge, while more expensive than an AC fridge, eliminates these problems.

There are some very inefficient DC fridges which use thermoelectric devices called Peltier-effect devices. These are much cheaper than compressor-based fridges but use vastly more energy and should not be used on DC renewable energy systems.

PUMPS

Like fridges, AC pumps can place a large startup strain on an inverter and may mean you need to buy a much larger inverter than needed for your other loads. DC pumps can eliminate this problem, while ensuring that you still have water if you have an inverter failure. *ReNew* regularly publishes a DC pumping buyers guide (the most recent one is in *ReNew 108*).

HEATING AND COOLING

Fans, both ceiling and pedestal, are available in DC versions, and are usually much more efficient than their AC equivalents. Even small fan heaters are available, but being designed for the RV and automotive market, where the RV's battery is regularly recharged from the alternator or mains power, they are not really a good idea as they will use a lot of energy and waste a lot of valuable PV-generated energy.

If staying warm is an issue, then a DC-powered electric blanket (or a simple throw) may be the best option. Also in the heating category are hair dryers. These are generally small travel-type devices rated up to 200 watts or so; they're nowhere near as powerful as a mains-powered dryer, but can still be useful.

LIGHTING

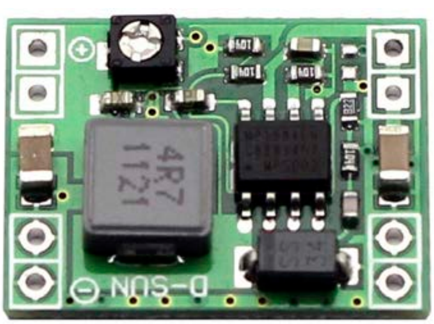
With most lighting now progressing towards being LED-based, there has been an explosion of DC lighting options, from replacements for regular light bulbs and fittings to rigid and flexible LED strips, panel and puck lights (small, flat disc-like surface-mounting lights which look like a hockey puck) and a myriad other types and designs. Most of these come with a power supply or LED driver that converts mains power to ELV DC for the LEDs, so it is often an easy task to replace the power supply with one designed for DC power. Some types of LED lighting, such as strip lights, have current control in the form of resistors or similar on the strip and simply require a DC power supply of suitable voltage.

ENTERTAINMENT

There's a wide range of entertainment devices such as TVs, radios, stereo systems and the like made to be portable or for the mobile-home market that are ideal for the DC-powered home. Further, many mainstream appliances come with external power supplies that provide DC—often at 12 volts—to the appliance anyway. It's a simple matter of replacing these with an appropriate DC–DC converter. For some appliances with less critical input voltage ranges, simply connecting them to the DC supply without any need for modification may be all that's required.

DIY conversions

It is possible to convert mains-powered appliances to use 12 or 24 volt DC power directly. Small devices that run from DC power supplies simply need voltage conversion (either up or down) and there's a huge range of DC–DC converters available that can do this. Some are so small, such as the one pictured, that they can be fitted inside the appliance or device, converting it to a 12 volt appliance.



↑ Tiny DC–DC converters let you use DC-powered appliances directly from 12 V power supplies, replacing their original mains-powered power supplies. Measuring 22 x 17 x 4 mm, this one can be fitted inside many electronic devices.

For the experienced DIYer, more advanced projects are possible, such as converting non-functioning AC appliances to DC by replacing motors and controllers. With the huge range of low-cost microcontroller boards now available, as well as readily available DC motors, solenoids and other parts, these sorts of conversions are more possible than ever. ✱

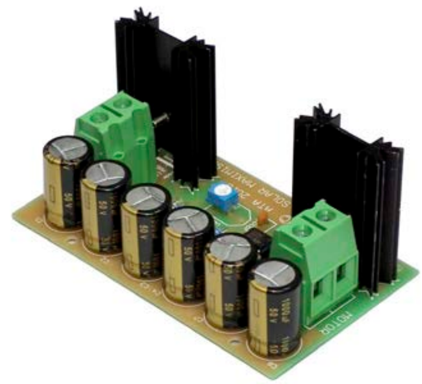
The table below lists the suppliers that we were able to find and the general range of appliances they stock, as well as any applicable accessories. The list is by no means exhaustive, but it provides a good indication of the types of appliances available. You will need to look around for your local suppliers or, in many cases, you can purchase them online.

Table 1: DC suppliers and appliances.

Manufacturer/supplier	Model/type	Rated power	Voltages available	Price	Comments and features
12 Volt Shop 4/12 Kewdale Rd Welshpool WA 6106 Ph: (08) 9458 1212 www.12volt.com.au	Samsung DE7711 microwave oven	750 W consumption, 450 W cooking power	12 V DC	POA	20 litre oven capacity, dimensions 490 x 282 x 351, weight 17.5 kg.
	Blender	-	12 V DC	POA	4.5 metre cigarette lighter cord, two-speed motor, large capacity, impact-resistant plastic carafe, weighted base.
	Hair dryer	200 W	12 V DC	POA	Folding handle.
	Water pumps	Assorted sizes	12, 24 V DC	POA	Circulation, transfer and pressure pumps.
	Engel fridges	Varies	12, 24 V DC	POA	Sizes range from 15 to 80 litres.
	Waeco fridges	Varies	12, 24 V DC	POA	Sizes from 50 to 220 litres in chest and upright styles.
	Fans, vents and rangehoods	Varies	12, 24 V DC	POA	Wide assortment of models.
	Assorted accessories	-	ELV DC	POA	Switches, fuses, switch panels, connectors.
	Lighting	Varies	12, 24 V DC	POA	Large range of ELV fluoro fittings, halogen fittings and accessories.
Rainbow Power 1 Alternative Way Nimbin NSW 2480 Ph: (02) 6689 1430 www.rpc.com.au	Hair dryer APL-025	200 W	12 V	$27.00	
	Digital timer	-	12, 24 V DC	$55.00	Controls up to 10 A.
	Waeco fridges	Varies	12, 24 V DC	POA	Models from 23 to 212 litres in chest and upright styles.
	Water pumps	Assorted sizes	12, 24 V DC	POA	Circulation, transfer and pressure pumps.
	Assorted accessories	-	ELV DC	POA	Switches, fuses, switch panels, connectors.
	Fans and vents	Varies	12, 24 V DC	POA	Oscillating fan and muffin fan.
	Lighting	Varies	12, 24 V DC	POA	Range of ELV fluoro and LED fittings and bulbs.
Jaycar Ph: 1800 022 888 techstore@jaycar.com.au www.jaycar.com.au	Mini-oven YS2808	NA	12 V DC	$49.95	Cooks, warms or reheats at up to 125 °C. ABS plastic case. Measures 265 x 180 x 155 mm.
	Car kettle GH1380	NA	12 V DC	$17.95	Boils up to 550 ml.
	Digital timer AA0361	-	12 V DC	$49.95	
	Powertech fridges – GH1600, 1602 and 1604	200 watt-hours per day	12, 24 V DC	$695 $749 $825	30, 40 and 50 litre respectively.
	Fans, lights etc	Varies	12, 24 V DC	POA	Assorted fans, lighting and accessories.
	Plugs, sockets, cabling, switch/power panels	-	ELV DC	POA	
Dometic/Waeco PO Box 2495 Burleigh BC QLD 4220 Ph: 1800 21 21 21 www.waeco.com.au	Waeco fridges	Varies	12, 24 V DC	POA	Models from 23 to 212 litres in chest, drawer and upright styles.
	PerfectKitchen MCK-750 kettle		12 V DC	$49.95	Heats up to 750 ml. Cordless kettle with base. Automatic cut-off when boiled.
	CK150/155 rangehoods	30 W	12 V DC	$219/$339	Measure 400 x 165 x 75 mm and 405 x 280 x 69 mm respectively.
PowerHunt itsupport@pacific-smart.com www.power-huntstore-au.com www.power-hunt.com	12 V griddle	600 W	12 V DC	$129.95	Requires PNP power port.
	12 V grill	550 W	12 V DC	$119.90	
	12 V sandwich maker	550 W	12 V DC	$119.90	
	Wave Box microwave DC only	660 W	12, 24 V DC	$340.95	7 litre cooking volume. Requires PNP power port.
	Wave Box microwave dual power	660 W	12, 24 V DC or 120, 240 V AC	$394.23	
	Personal coffee maker	350 W	12 V DC	$89.95	Requires PNP power port.
	10 cup coffee maker	600 W	12 V DC	$109.95	
	Hair dryer	425 W max	12 V DC	$79.95	
	Fan heater	700 W max	12 V DC	$93.45	
	Hellfire quartz heater	500 W	12 V DC	$185.95	
	Power Port with 2.4 m cable	-	12, 24 V DC	$49.95	Up to 70 amps max.
	Dual Power Strip	-	12, 24 V DC	$69.95	Up to 70 amps max per socket, 100 amp max total.
	3.6 m power cable for use with Power Strip	-	12, 24 V DC	$43.93	
Energy Matters PO Box 5265 South Melbourne VIC 3205 Ph: (03) 8608 5051 www.energymatters.com.au	Sundanzer, Fisher & Paykel, Autofridge and Westinghouse DC fridges/freezers	Varies	12, 24 V DC	POA	Large range of DC fridges up to 330 litres capacity.
Camec Ph: 1300 422 632 www.camec.com	Rangehood	-	12 V DC	$179.00	2-speed rangehood with twin LED downlights. Dimensions 586 x 305 x 60 mm.
	Vitrifrigo fridges and freezers up to 230 litres	Varies	12, 24 V DC	POA	
	19 and 24 inch LED high definition TVs	-	12, 24 V DC	$319/$469	USB PVR and media player, inbuilt DVD player.
Oze Fridge Ph: (03) 5826 5458 ozefridge@ozemail.com.au www.ozefridge.com.au	DIY 12/24 V fridge kits for converting existing cabinets	Varies	12, 24 V DC	POA	
Off Grid Living Ph: (02) 6581 5226 www.offgridaustralia.com	Remote-control ceiling fan	12W max at 240 rpm	12 V DC	$249.00	1320mm diameter fan with six speeds. Forward and reverse remote controller included.
	Remote-control ceiling fan with LED light kit	28W max @ 200 rpm	12 V DC	$299.00	1320mm diameter fan with six-speed brushless motor. Forward and reverse remote controller and 12 W LED light kit included.
	DC lighting	Varies	12, 24 V DC	POA	Range of 12 and 24 volt DC lighting options including bulbs, fittings and accessories.

Maximiser makeover

John Knox describes the new versions of these popular kits.



↑ The mini maximiser on the left can handle up to 6 amps, while the midi/maxi on the right can drive motors at up to 20 amps, depending on configuration.

THE ATA's solar maximiser kit has had a long and distinguished career helping hundreds of people around Australia (and the world) make the most of their investment in solar panels. By using the maximiser, based on an original design by Alan Hutchinson of Plasmatronics, people can greatly improve the performance of pumps and motors that run directly from solar panels without batteries.

For example, it allows you to get the maximum output from water pumps, with pumps starting earlier in the morning and running later in the afternoon, increasing the amount of water pumped each day.

Previously the maximiser came in three flavours: mini (6 A), midi (12 A) and maxi (20 A). Due to lack of interest, the maxi was dropped from the lineup in 2008. However, recently there has been growing demand for the maxi-maximiser, so we have taken the opportunity to give the range a makeover, now available from the ATA webshop at shop.ata.org.au.

Mini, midi and maxi revamps

Firstly, we redesigned the mini board, removing the need for the wire link, reducing the board size significantly and improving the component layout.

We also redesigned the midi board, incorporating those same design improvements as well as making it a dual-purpose board: by simply adding two extra capacitors, you can change the midi maximiser into the maxi maximiser, allowing for the use of higher-rated pumps and motors.

Apart from the neater circuit layout and smaller size, the redesign of the midi/maxi maximiser also includes some other useful improvements:

- the solar and motor connectors are now at opposite ends of the board
- the heatsinks are electrically isolated from the FET and diode, making it possible to attach the heatsinks to a metal case to improve heat dissipation
- the copper on the board has been increased from 1 oz to 2 oz, reducing losses and improving current carrying capacity.

People running high-power motors and pumps from solar panels will surely find a good use for these "new/old kids on the block". ✱

PV power
A solar panel buyers guide

We've contacted photovoltaics manufacturers for details on warranties, cell types, size and price to help you decide which solar panels are best for you. Our listing of panels starts on page 72, plus find out the features to look for in the following article.

SOLAR photovoltaic (PV) panels have a range of uses from powerful grid-interactive or off-grid rooftop installations to small DIY applications such as for camping or pumping water.

Over the last few years, grid-interactive rooftop installations have emerged as the most popular use of PV in Australia. Well over a million homes are now enjoying reductions in their electricity bills. Worldwide, demand from rooftop systems and solar farms has produced economies of scale leading to significant reductions in panel prices, especially for the larger panels used in such applications.

A solar installation consists of several components, depending on the application. This guide focuses on panels. For information on other components, system sizing and economic returns, see 'More info' at the end of the article.

Photo: DOE/NREL 15679/groSolar

↑ Even tiny homes can have solar!

How solar cells work

Solar cells produce DC electricity, similar to that from a battery. The amount of current produced by a panel of cells is proportional to the amount of light hitting the panel.

The basic mechanism of operation for a solar cell is as follows.

A solar cell is made of a thin slice of a material such as silicon. The silicon is modified by a process called doping with elements like boron and phosphorus to form what's called a semiconductor P-N (positive-negative) junction inside the cell.

As photons in light strike the solar cell, they cause electrons (electrically negative sub-atomic particles) to cross the P-N junction, causing a voltage across the junction.

By connecting a load from one side of the cell to the other, the electrons will flow through the load, allowing the electrons to be harvested as an electric current.

The different technologies

A typical solar cell only produces around half a volt, which is too low to be of much use. Photovoltaic panels are made of a group of solar cells, usually with the cells connected in series to produce a much higher, usable voltage. There are three common types of solar cells: monocrystalline, polycrystalline and thin film.

Both mono- and polycrystalline cells are made from slices, or wafers, cut from blocks of silicon. Monocrystalline cells start life as a single large crystal known as a boule, which is 'grown' in a slow and energy-intensive process. Polycrystalline cells are cut from large blocks of silicon rather than single large crystals.

Thin-film technology uses a different technique that involves the deposition of layers of different semiconducting and conducting materials directly onto metal, glass or even plastic. The most common thin-film panels use amorphous (non-crystalline) silicon and are found everywhere from watches and calculators right through to large grid-connected PV arrays.

Other types of thin-film materials include CIGS (copper indium gallium di-selenide) and CdTe (cadmium telluride). These tend to have

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

Crystalline panels are made from many individual cells that are cut from blocks of silicon and have electrical contacts printed on each side. A single monocrystalline cell can be seen here. The thin horizontal lines are the current collectors and the vertical lines are the busbars that are connected to the next cell in the string via thin soldered-on foil strips.

higher efficiencies than amorphous silicon cells, with CIGS cells rivalling crystalline cells for efficiency.

Each cell type has some advantages and disadvantages over others, but all in all, modern solar panels all do pretty much what they are designed to do. There are no moving parts to wear out, just solid state cells that have very long lifespans.

Crystalline cells are a very mature technology and have a long history of reliability, at least with most brands, so a good quality mono- or polycrystalline PV panel will very likely perform to specifications for its rated lifespan, which is normally 20 years or more for most panels. Crystalline panels are usually cheaper than thin-film types, with the cheapest being polycrystalline panels.

Thin film panels usually perform better than an equivalent-rated crystalline panel under cloudy or partially shaded conditions, and they tend to suffer less output reduction at higher panel temperatures (see later for a more detailed discussion of these issues). The main disadvantage with thin-film panels is their lower conversion efficiency compared to crystalline panels, which means a panel of a specified wattage is larger than an equivalent crystalline panel. This can be a deciding factor in which technology you choose, especially if roof space is limited.

Panel construction

In its most common form, a solar panel consists of a number of solar cells (usually 36 or 72) connected together via thin, foil-like conductors (called busbars) soldered to each side of the cells. The cells are usually coated in a plastic such as ethylene vinyl acetate (EVA) and sandwiched between layers of glass and/or plastic, or sometimes plastic and metal. The collection of cells is usually surrounded by a metal or plastic frame for strength and to allow easy mounting of the panel. A junction box is often mounted on the back of the panel for easy electrical connection, although many panels now have flying leads with standardised connections called MC4 connectors (made by the manufacturer Multi-Contact, these include a 4 mm^2 contact assembly pin, rated at 20 A and 600 V maximum, depending on the conductor size used).

Where glass is used as a covering for solar panels, it is usually low-iron glass to allow as much light transmission as possible, thus maximising energy output.

Many panels have glass on the front and a plastic, such as Tedlar, on the back to seal the panel. There are also panels designed to replace windows and other glass panels in architectural uses, and they may have glass on both sides of the cells, depending on their intended use. This means the home owner can offset some of the cost of the solar panels, as the panels themselves double as building materials. There are even flexible panels that are simply stuck to a roof or other flat surface, no framing required.

Flexible panels are a spin-off of thin-film technology. These are manufactured on a plastic or thin-metal substrate and can be rolled up or attached to curved surfaces, and are often used for camping and boating. They are generally more expensive on a dollar-per-watt basis, although larger ones designed for mounting on buildings are competitive with conventional rigid panels.

Most solar panels are designed to be mounted on external frames, themselves mounted to a building's roof or ground-mounted frame, such as a solar tracker. The main requirement is that the panels are held strongly enough that they won't twist or be blown off in bad weather.

"A typical solar cell only produces around half a volt, which is too low to be of much use. Photovoltaic panels are made of a group of solar cells, usually with the cells connected in series to produce a much higher, usable voltage."

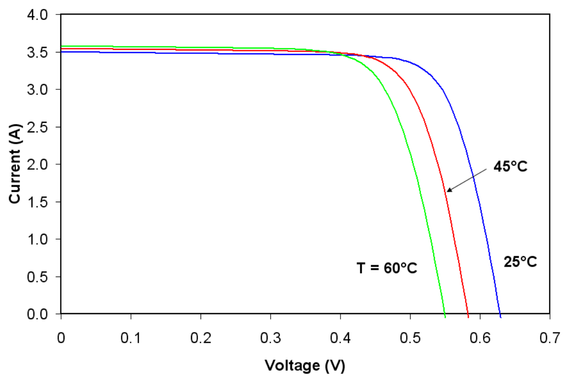
There has been a tendency in recent years to manufacture larger wattage panels, up to 300 watts or so, particularly for grid-interactive systems. This has allowed a reduction in the number of panels to be installed as well as the number of connections between panels, making for faster installations. However, panels of any size can be used for any type of system, whether it be grid-interactive, stand-alone or hybrid. Indeed, for odd-shaped roofs a greater number of smaller panels may allow the installation of more generating capacity than fewer larger panels.

The size of the panels used tends to be up to the installer, but certain sizes, especially in the 200–300 W range, can often be considerably cheaper than other panels of the same quality as they are made for the larger grid-interactive systems market.

Panel ratings

There are a number of different ratings on solar panels, so let's have a look at what they are and what they mean.

→ IV curves are graphs of output current versus voltage for different levels of insolation and temperature. They can tell you a lot about a panel's ability to cope with temperature increases, as well as performance on overcast days. Here we see a typical IV curve from a single crystalline silicon solar cell. Notice how the voltage, and hence available power, decreases as temperature increases.



"The most important ratings when doing calculations for a power system are the voltage, current and power at maximum power under NOCT conditions."

Firstly, there are two sets of figures that you may find. The first set are Standard Operating Conditions (SOC) figures, produced when the panel is tested under factory conditions. These figures, which are taken at an insolation level (strength of light falling on the panel) of 1000 W/m² and a cell temperature of 25 °C, do not represent what you are likely to get from the panel under real world conditions. However, let's look at them now.

Rated (peak) power: This is the maximum sustained power output of the panel, assuming SOC. In general, the solar panel's rating is the rated peak power.

Nominal voltage (Vn): The system voltage that the panel is designed to be used in. A 12 volt panel is designed for a 12 volt system, but will produce voltages well above 12 volts. Some panels can be rewired to suit 6 or 24 volt systems. Other panels are designed for grid-interactive systems and have nominal outputs of 48 volts or even higher.

Voltage at maximum power (Vmp): This is the voltage measured across the panel when the panel is producing peak power under SOC.

Current at maximum power (Imp): The maximum current available from the panel at peak power, also at SOC.

Open circuit voltage (Voc): The maximum voltage available from the panel with no load attached. This is usually around 21 volts for a 36 cell, 12 volt unit.

Short circuit current (Isc): The current obtained when the output of the panel is short circuited under SOC.

Temperature at rated power: This is the temperature that the solar panel manufacturer rates their panels at. Most panels are rated to put out their maximum power at 25 °C, i.e. SOC.

Because SOC figures are rather unrealistic given that the panel temperature under typical Australian conditions can be up to 70°C, a second set of more realistic ratings is often provided, and these are stated to be at the nominal operating cell temperature, or NOCT. These are the ratings of the panel when the cells are running at solar irradiance (insolation) of 800 W/m², an air temperature of 20 °C and a wind velocity of 1 m/s (3.6 km/h), for panels mounted with their backs open to the breeze. Under these more realistic conditions, cell temperatures can exceed 50 °C and panel output can be considerably less than the SOC ratings.

A related rating that many panel suppliers provide in datasheets is the **temperature coefficient:** This tells you at what rate a panel's output decreases with rising temperature. For instance, a panel with a temperature coefficient (of power) of -0.5%/°C means that for every degree of panel temperature above 25 °C, the output decreases by 0.5%. This doesn't sound like much of a decrease until you realise that the panel might be running at 70 °C in extreme conditions. In this case, the decrease is 45 (the increase above 25 °C) multiplied by 0.5, which equals 22.5%, a significant amount.

If you live in a hot climate then you should look for panels with as low a temperature coefficient as possible. Temperature coefficients can be specified as a change in output voltage, output current or maximum power. Sometimes only the power figure is given, sometimes all are provided (and sometimes none are!).

Current-voltage (IV) curves

While all these figures can be a bit daunting, there is a simple visual representation of them known as an IV curve. Many solar panel datasheets include IV curves and it's worth asking the supplier for them if not provided.

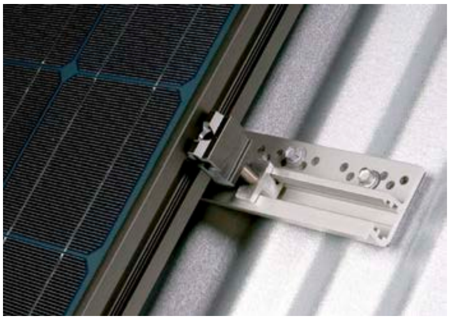
The most important ratings when doing calculations for a power system are the voltage, current and power at maximum power under NOCT conditions. Which numbers you use for system design depends on the rest of the system. For instance, a battery-based system using a conventional charge controller might be designed using the current rating of the panels, whereas systems using MPPT (maximum power point tracking) devices—which match the solar array output to the load and maximise generation, and are found in many battery charge controllers and all grid-interactive inverters—can be sized using panel wattage ratings.

The open circuit voltage and short circuit current ratings are important from a safety point of view, especially the voltage rating. An array of six 12 V panels in series, while having a nominal 72 volt rating, can put out over 120 volts DC—more than enough to be dangerous.

Heat and shading

As mentioned earlier, panel performance is affected by temperature. This is more of a problem with crystalline panels than with thin-film units, which suffer far less output loss with increasing temperature. In many cases, a thin-film panel will perform as well or better than a crystalline panel which is rated at up to 10% higher wattage. For example, a thin-film 65 watt panel will often perform as well as a 70 watt crystalline unit on an 'overall energy produced per year' basis. An exception to this is the Panasonic HIT panel, which combines aspects of both thin-film and crystalline panels. It is considered to be one of the best-performing panels available, but this comes at a price.

Shading affects different panels in different



↑ The Zep Solar mounting system makes for faster installation than the traditional bolted on method.

ways. The reduction in performance of the crystalline panel types, even when a single cell from a panel is shaded, is quite considerable.

Thin-film panels often perform somewhat better, especially panels which have bypass diodes built into each cell. Also, because thin-film panels usually have cells that are long and thin, they are less likely to have individual cells fully shaded by debris build-up.

However, shade falling on the panels should be eliminated if at all possible. There is not much point investing large amounts of money in power-generating equipment if you don't allow it to do its job!

Material use and embodied energy

As far as material use is concerned, crystalline panels use a great deal more semiconductor material than an equivalent-output thin-film panel. This occurs for two reasons. The first is that a lot of material is lost in the process of cutting the silicon boule or billet into wafers. The cutting is done with a diamond saw or wire, which may well be thicker than the resulting wafers, so more than half of the silicon may be lost in this process. Manufacturers have been working on reducing this wastage, but it is still a considerable proportion of the total material.

The other reason for greater material use with crystalline cells is that, because they are handled as individual cells, they must be robust enough to withstand mechanical handling—so a good proportion of the cell is actually there just to provide support to the active junction. This is also an issue that manufacturers are working to improve upon. Cells have gradually become thinner in recent years, but not by a great deal.

Thin-film panels don't have these problems and so use a lot less semiconductor material, in many cases less than 1% of that used by a crystalline panel. Some thin-film modules have an active material thickness of less than half a micrometre (μm—one thousandth of a millimetre). Compared to a typical crystalline cell thickness of 100 to 200 μm, this uses as little as 1/600th of the silicon—and that doesn't even take into account the silicon wasted by the cutting process for crystalline cells.

There are two reasons why silicon use can be an issue. The first is the embodied energy of the silicon—it takes a lot of energy to make the highly purified silicon used in solar

Special panels: microinverters and PV-thermal

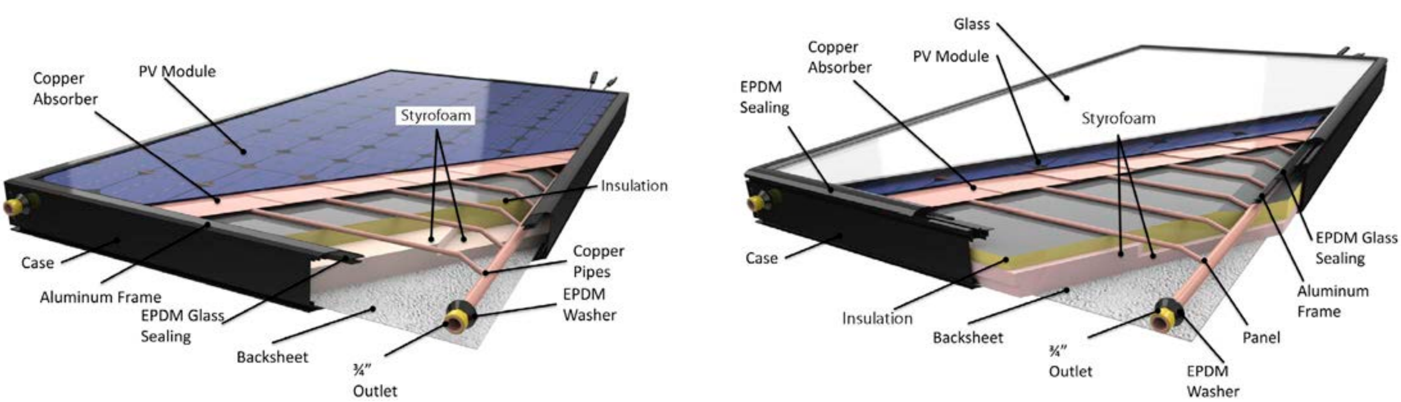
Not all solar panels produce a DC output. Some panels are designed specifically for grid-interactive systems and come with a tiny grid-interactive inverter, a microinverter, attached to the back of the panel. In these systems, there is no DC wiring in the system at all and standard AC cables are simply run to each panel for connection, simplifying the installation considerably. Tindo Solar panels are an example.

One advantage with this system is that, because each panel operates independently, shading or failure of one panel has no effect on the rest of the array.

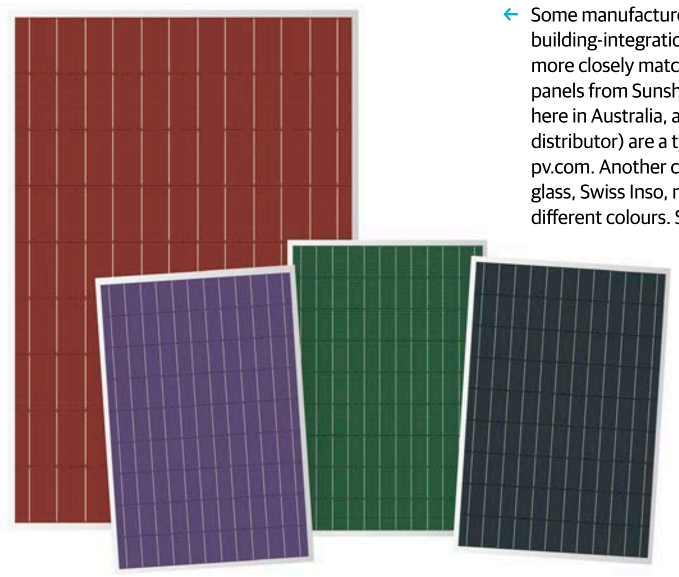
Another new type of solar panel is the combined PV and solar thermal (water heating) panel from Solimpeks. Known as the PV-T-Hybrid, there are two versions, the PowerVolt, which is optimised for maximum electrical output and less hot water output, and the PowerTherm, which is optimised for more hot water and less electricity. (Because combined PV/thermal panels are not readily comparable to just PV-only panels, Solimpeks preferred not to be listed in the table.)

There are advantages to be gained from combining solar PV and solar thermal in one unit. For example, if the solar thermal side is used for pool heating, the PV part of the panel will run much cooler than a standard PV panel under the same conditions, as pool water temperatures are relatively cool. They also have the advantage of allowing both electricity and solar hot water to be collected from the same roof area—ideal for residences with limited solar-suitable roof area.

Because they are not just a PV panel, both the Tindo and the Solimpeks panels cannot readily be compared on a dollar per watt basis with regular PV panels, and it is important to factor this in when comparing different technologies.



↑ The hybrid panels from Solimpeks combine both a PV panel and hot water collector panel—useful where roof space is limited.



← Some manufacturers are making their panels more building-integration friendly by colouring them to more closely match common roof colours. These panels from Sunshine PV in Taiwan (not yet available here in Australia, although they are looking for a distributor) are a typical example; see www.sunshine-pv.com. Another company that specialises in coloured glass, Swiss Inso, now also have thin-film panels in six different colours. See www.swissinso.com

panels. The second is that high-grade silicon suitable for this sort of use can be in short supply due to the demand for it in both solar cells and integrated circuits.

Embodied energy is the amount of energy required to produce the panel and includes all energy used to make every part of the panel, including cells, frame, cable or junction box and assembly. Some panels, especially the thin-film units, will repay their energy 'debt' within a year or less, while others, especially monocrystalline panels, take longer. However, all panels on the market will produce much more energy than they use over their lifetime, if installed and used correctly.

Mounting systems

Most solar panels are surrounded by an aluminium frame. This gives them rigidity and makes for easy mounting of the panels to racking (the rails that hold panels to the roof). Until recently, most panels simply had mounting holes in their frames to allow them to be bolted to the mounting frames. There are now several mounting systems that speed up installation. These usually consist of slots in the frames that mounts or bolts can be slid into, or systems that clamp the panel in place against the mounting frame. A popular system of this type is from Zep Solar (zepsolar.com.au), with over a dozen PV manufacturers making panels with compatible frames.

Which mounting system your installer uses may not mean much to you, but it can affect installation time and therefore the final cost of an installation.

PVs in architecture

One way to reduce installation costs of PVs is

Maximising output: MPPT and maximisers

Maximum power point tracking (MPPT) is a method of power conversion that allows the solar array to run at its maximum power point, i.e. at the voltage where the greatest amount of power is generated. MPPT controllers also allow the array voltage to be completely different to the battery or grid voltage—the MPPT controller steps the voltage from the array up or down to match the battery or grid voltage.

The design of charge controllers for battery-based systems has steadily moved towards maximum power point tracking. The MPPT charge controller down-converts the power from the panels to match the battery voltage. This allows greater input from the solar array than would be available from a series type regulator. But the other big advantage is that lower cost-per-watt panels designed for grid-interactive systems can be used effectively in battery-based systems, reducing array costs.

Maximum power point tracking is the system used on all grid-interactive inverters, including microinverters found on AC panels, as mentioned earlier. However, there are also devices called panel maximisers which shift the MPPT to the panel itself, rather than at the inverter. These devices are often sold separately but may be installed by some solar system installers by default and may even be included on some panels.

The manufacturers of these devices claim that by performing maximum power point tracking at the panel, systems that use a larger central inverter will perform more efficiently. In a regular installation where panels are connected in strings and wired to a central inverter, any panel that is underperforming due to damage, dirt build-up or shading will drag down the whole string. Maximisers eliminate this problem by interacting with each other while allowing each panel to operate independently at the maximum possible output, even when the panels are still connected in series.

Like microinverters, maximisers also give better system control and safety. For example, they monitor the panel performance and will disconnect a panel should a short circuit or overload be present. Further, like microinverters, they are usually networked and can be controlled from a central point. Monitoring data is also usually available from each unit, so faulty panels and underperformance issues are easily detected.

But are maximisers worth it? According to a study by Photon Labs in 2010, Tigo maximisers, one of the leading brands, increase yield by around 1% to 3% when modules are soiled and from 2% to 36% when partially shaded, as compared to modules without maximisers.

"Not all solar panels produce a DC output. Some panels are designed specifically for grid-interactive systems and come with a tiny grid-interactive inverter, a microinverter, attached to the back of the panel."

to use them as a building material. There are a number of ways to do this, from using standard panels as sunshades and pergolas, through to buying panels specifically made for building-integrated PV systems. These will often be designed to replace roofing tiles or materials, and can vary in looks. Coloured panels are a recent development, as in the image at left.

Rest of system costs

There are lots of small costs in a solar energy system that may not be apparent when first looking at solar panels. While these don't really affect the panels that you buy, they should be considered as they affect the system economics, if such things concern you. These costs include cabling, safety disconnects, junction boxes, solar array frames and the like. There are also of course additional costs in the inverter, battery and regulator, where required, but a discussion of those costs is beyond the scope of this article.

What to look for

It's important to buy a panel that has the correct ratings for your use, with consideration given to their performance as determined by their IV curve. You also need to look for a few other things when buying, such as construction quality, frame type and panel shape and weight. Some panels may be more suited to your roof shape than others, especially when used on small buildings such as sheds or outdoor toilets.

Panel quality is very important. In years gone by, many of the cheaper Chinese panels have been of variable quality; however, the overall quality of Chinese panels has improved enormously in the last few years due to intense competition, to the point where most of the recognised brands are as good as the panels from other companies.

Any solar panel worth buying will come with a long warranty. If the manufacturer doesn't have enough faith in their product to offer a good warranty, then why would you buy it? Most panels come with a warranty of at least five years and some warranties are up to 25 years. We have not included any panel with less than a two-year warranty in this guide.

Of course, a warranty is only as good as the company that provides it. If the company disappears in a few years, you might be left with no ability to make a warranty claim should a panel or panels fail. Unfortunately it's not possible to know the future of any solar panel manufacturer or installer as some of the biggest players over the years have simply disappeared.

Warranties come in different forms. Some are just a power output warranty but don't cover things like construction quality, while others are a bit more comprehensive. Ask questions before you hand over any money.

There are a few odd solar panels on the market. For instance, some have just 24 cells and are touted as 12 volt panels, but they simply won't generate enough voltage to fully charge a 12 volt battery. You can use them in other systems, such as three in series for a 24 volt battery system, or a string of many in series for a grid-interactive system, but this will mean more interconnects between panels and hence possibly greater installation costs and more connections that may fail. ✱

About the table

The table lists a range of solar panels suitable for solar power systems for which suppliers provided information. It includes the important information such as maximum power, voltage and current (usually rated at 25 °C), cell type, panel construction and dimensions, including weight, and the rated lifespan. Also included (where provided) are recommended retail prices including GST. However, prices should be taken with a grain of salt. Price usually depends on the number of panels purchased at the time and many dealers will offer panels at lower cost, so don't settle for the first price you are given—ring around!

More information:

Solar Electricity Booklet (ATA, 2013). A thorough yet concise overview of what you need to know before choosing and installing a solar energy system: shop.ata.org.au/shop/solar-electricity

Alternative Technology Association: www.ata.org.au

Your Home Technical Manual: www.yourhome.gov.au

Living Greener: www.livinggreener.gov.au

Clean Energy Regulator: www.cleanenergyregulator.gov.au

Clean Energy Council: www.cleanenergycouncil.org.au

'Selecting PV panels in a buyers market': *ReNew 122*

Articles on PV testing results by Colin Dedman in *ReNew 118*, *119* and *124*

ReNew Inverter, Regulator and Battery Buyers Guides: www.renew.org.au/buyers-guide

ATA solar payback calculations page: www.ata.org.au/news/latest-solar-payback-times

Is PID an issue?

A term that has cropped up in recent years in regards to PV panels is PID, or potential induced degradation. This can be a problem with (usually) crystalline silicon panels where the lowest (most negative) panel in a series string has a negative potential (voltage) relative to ground. The problem can result in a temporary or permanent reduction in panel output and is exacerbated by heat and humidity.

PID can cause a reduction in panel output in two ways. The first is polarisation, where an electric field exists between the cells and the other panel components, such as the frame (which is always grounded for safety). This is reversible by discharging the potential between the components at night.

The second way causes permanent degradation and occurs when ions from the cells migrate towards other parts of the panel, degrading the cells and reducing output. This problem normally occurs on grid-interactive systems, as the inverter requires that some of the string is positive in respect to ground, some negative.

The simple solution is to ground the negative-most panel in the string, if the inverter allows for this. Transformerless inverters don't, but PID can automatically be reversed at night by using an offset box, such as the one developed by inverter manufacturer SMA. Some panels have been designed to minimise or eliminate PID.

While this is not something most people will experience on their system, it is one method of panel degradation that is often overlooked in grid-interactive systems. More info: www.bit.ly/AE-PID and www.bit.ly/SOLON-PID

Brand (made in)	Model	Power (watts)	Vmp	Imp	Cell type	Test cell temp °C	Construction	Size in mm (L x W x T)	Weight (kg)	Warranty (years)	RRP inc GST ($)	Lifespan (years)	Comments
AIDE SOLAR www.aidesolar.com for factory website and www.aidesolar.com.au for Australian customer local website	AD190M5-Ba	190	37.15	5.10	Monocrystalline	48	EVA, TPT, tempered glass, aluminium frame	1580 x 808 x 50	16.05	25, 12, 5	POA	25+	Wind and snow loads guaranteed up to 5400 Pascal. All modules are tested for output before and after lamination. Designed to prevent deforming and fracturing due to freezing or other forces.
	AD195M5-Aa	195	36.94	5.28				1580 x 808 x 35	15.00				
	AD245M6-Bb	245	30.43	8.05				1636 x 992 x 50	19.30				
	AD245M6-Ab	245	30.59	8.01									
	AD290M6-Aa	290	36.40	7.97				1956 x 992 x 50	23.00				
	AD240P6-Ab	240	30.15	7.96	Polycrystalline			1636 x 992 x 50	19.30				
	AD235P6-Bb	235	29.55	7.95									
	AD290P6-Aa	290	36.19	8.01				1956 x 992 x 50	23.00				
	AD245Q6-Ab	245	30.40	8.06	Quasi-monocrystalline			1636 x 992 x 50	19.30				
	AD295Q6-Ab	295	36.46	8.09				1956 x 992 x 50	23.00				
Axitec (Asia) Krannich Solar ph: (03) 9339 5100 info@krannich-solar.com.au www.krannich-solar.com.au	AXIblackpremium	250	29.65	8.47	Monocrystalline	25	Black anodised aluminium frame, composite film, hard-ened, low-reflection white glass	1640 x 992 x 40	19.5	12 years manufac-turer, 90% after 15 years, 80% after 25 years	POA	25+	Guaranteed positive power tolerance from 0-5 Wp by in-dividual measurement. High stability due to AXITEC-Soft-Grip-Seam aluminium frame construction.
	AXIpremium						Silver anodised aluminium frame, composite film, hard-ened, low-reflection white glass						
	AXIpower	250	30.7	8.18	Polycrystalline	25							
BENQ (Malaysia) Apollo Energy ph: 1300 855 484 www.apolloenergy.com.au	PM318B01	327	54.7	5.98	Monocrystalline	25	High-transmission tempered anti-reflection glass, back contact cells, composite film, anodised aluminium frame	1559 x 1046 x 46	18.6	25	599.50	25+	20.1% efficiency modules, -0.38%/K peak power tem-perature coefficient.
BenQ Solar (Asia) Krannich Solar ph: (03) 9339 5100 info@krannich-solar.com.au www.krannich-solar.com.au	SunForte PM096B00	325	54.7	5.86	Monocrystalline	20	Anodised aluminium frame, composite film, high-transmission tempered glass AR-Tech	1559 x 1046 x 46	18.6	25	POA	25+	Module conversion ef-ficiency over 20%, Back contact cell design.
Bosch Solar Energy (Germany) ph: (03) 9541 7048 sales.se@au.bosch.com www.bosch-solarenergy.com.au	M60S EU42117/42123	250	30.31	8.25	Monocrystalline	25	Glass/foil laminate with black aluminium frame, black backsheet	1660 x 990 x 50	21	10 year product warranty, 90% after 10 years and 80% after 25 years per-formance	POA	25	-
	M60 EU44117/44123	265	30.55	8.68			AR/glass/foil laminate with silver aluminium frame, white backsheet		19.5				
	P60 EU30123	240	30.03	8.11	Polycrystalline		Glass/foil laminate with silver aluminium frame, white backsheet		21				
	M48S EU40123	195	23.8	8.3	Monocrystalline			1343 x 988 x 40	16				
Bosch (Germany) Solar Inception ph: (07) 3166 9598 info@solarinception.com.au www.solarinception.com.au	C-SI M60 EU44117	265	30.55	8.68	Monocrystalline	25	Glass/foil laminate with silver aluminium frame, white backsheet	1660 x 990 x 50	21	25	Contact distribu-tor	25	Contact Solar Inception for latest price and information. Contact installer for installation information
Canadian Solar (Canada & China) ph: (02) 9889 4395 inquire.au@canadiansolar.com www.canadiansolar.com	CS6P-P	245-260	30.4	8.56	Polycrystalline	STC25/ NOCT45	4 busbars, tempered glass, anodised aluminium alloy frame	1638 x 982 x 40	18.5	25 year power output warranty, 10 years product	POA	See war-ranty	New 4 busbar cell technol-ogy, Tier 1 manufacturer, local support in Australia via Australia-wide distributors, non-cancellable warranty insurance.
	CS6X-P	295-310	36.4	8.52	Polycrystalline			1954 x 982 x 40	22				
	CS6P-M	245-260	30.7	8.48	Monocrystalline			1638 x 982 x 40	18.5				
	CS6P-MM	260-265	31.1	8.67	ELPS			1638 x 982 x 40	18.5				
CNPV (China) MPower ph: 1300 733 004 info@mpower.com.au www.mpower.com.au	CNPV5M	5	18	0.28	Monocrystalline	25	EVA embedded cells, Anti-reflective tempered glass, aluminium frame, 3% positive power tolerance	215 x 303 x 35	1.2	5 year product warranty, 20 year output guarantee	30.20		-
	CNPV10M	10	18	0.56				357 x 303 x 35	1.5		35.50		
	CNPV20M	20	18	1.14				357 x 540 x 35	2.5		70.45		
	CNPV30M	30	18	1.69				450 x 540 x 35	3.5		105.50		
	CNPV40M	40	18	2.22				637 x 540 x 35	4.5		140.50		
	CNPV60M	60	18	3.33				917 x 540 x 35	7		210.80		
	CNPV80M	80	19	4.2				917 x 540 x 35	7		280.40		
	CNPV105M	105	19.1	5.5				1200 x 540 x 35	7.5		363.40		
	CNPV150P	150	18.8	8	Polycrystalline			1492 x 674 x 35	13		515.00		
	CNPV205M	205	38.1	5.38	Monocrystalline			1581 x 809 x 35	15	10 year product, 25 year lin-ear power output guarantee	POA		
	CNPV250P	250	31.2	8	Polycrystalline			1650 x 992 x 35	18				
	CNPV260M	260	31.5	8.25	Monocrystalline			1650 x 992 x 35	18				
	CNPV310M	310	37.9	8.18	Monocrystalline			1965 x 992 x 35	22				
Daqo (China) Apollo Energy ph: 1300 855 484 www.apolloenergy.com.au	DQ250PSC-BLK	250	37.2	8.2	Polycrystalline	25	3.2mm high-transmission low-iron tempered glass	1640 x 992 x 45	19	10	312.50	25+	MC4 connector
DuPont Apollo (Hong Kong) DPA Solar Pty Ltd ph: (03) 9696 1119 sales@dpasolar.com.au www.dpasolar.com.au	DA100-A1	100	75	1.34	Amorphous	25	Glass, EVA, Tedlar	1410 x 1110 x 35	20	25	227.20	25+	-
	DA142-C1	142	121	1.17	Amorphous/ micro-crystalline						335.25		
EcoTech (China) Soanar Pty Ltd ph: (02) 8832 3000 info@soanar.com www.soanar.com.au	ZM9093ECO	10	17.0	0.59	Monocrystalline	25	Tempered glass/EVA weatherproof back film, aluminium alloy frame, with industry standard plugs or flying leads	396 x 289 x 23	1.4	25	POA	25+	High efficiency monocrystal-line solar cells. Certified to ISO9001 and ISO14001 TUV,UL,IEC &VDE AS/NZS compliant BCSE approved 175W and above IEC6173 and IEC61215
	ZM9094ECO	20	17.2	1.17				639 x 294 x 23	2.4				
	ZM9501ECO	40	17.6	2.28				645x 545 x 23	5.2				
	ZM9500ECO	50	17.6	2.86				835 x 540 x 28	5.5				
	ZM9096ECO	65	17.2	3.78				1210 x 540 x 28	8.2				
	ZM9097ECO	80	17.6	4.55				1210 x 540 x 28	8.2				
	ZM9098ECO	120	17.5	4.85				1250 x 808 x 35	11.8				
	SSPM180ECO	180	36.8	4.90				1580 x 808 x 35	15.5				
	SSPM185ECO	185	37.0	5.00				1580 x 808 x 35	15.5				
	SSPM190ECO-S	190	37.3	5.08				1580 x 808 x 35	15.5				
	SSPM250ECO	250	47.8	5.23				1601 x 1061 x 46	21.0				
ET Solar (China) PS Electrical Wholesale ph: 1300 067 787 michael@psew.com.au www.psew.com.au	ET-M53620WW	20	17.8	1.14	Monocrystalline	25	3.2 mm low-iron solar glass, 50mm anodised aluminium frame for strength, IP65 junc-tion box with three bypass diodes and 1000mm leads.	662 x 299 x 35	2.5	25 year output—no more than 0.65% lower than previous year. 10 year materials & workman-ship	POA	25+	Contact PS Electrical Wholesale for all pricing and specification enquiries.
	ET-M53640WW	40	17.8	2.27				645 x 542 x 35	4.3				
	ET-M53655WW	55	18.4	2.99				980 x 445 x 35	6.0				
	ET-M53690WW	90	18.3	4.93				1205 x 545 x 35	8.4				
	ET-P636135WW	135	17.8	7.59	Polycrystalline			1482 x 676 x 50	13.2				
	ET-M572200WW	200	37.0	5.41	Monocrystalline			1580 x 808 x 50	15.0				
	ET-M660250WW	250	30.4	8.22				1640 x 992 x 50	18.8				
	ET-P660250WW	250	30.3	8.24	Polycrystalline			1641 x 992 x 50	19.8				

Brand (made in)	Model	Power (watts)	Vmp	Imp	Cell type	Test cell temp °C	Construction	Size in mm (L x W x T)	Weight (kg)	Warranty (years)	RRP inc GST ($)	Lifespan (years)	Comments
Hanwha SolarOne (China) Hanwha Solar Australia Pty Ltd ph: (02) 9455 0017 hinhyung.Ma@hanwha-solarone.com www.hanwha-solarone.com	HSL60P6	250	30.4	8.23	Polycrystalline	25	Tempered glass/EVA/cell/ back sheet, anodised aluminium alloy frame, with J-box	1636x988x40	19±0.5	25			Certified to ISO 9001 quality, ISO 14001 environmental and OHSAS 18001 OH&S, IEC 61215 & IEC 61730 Application Class A certifications. Anti-reflective coating for high sunlight absorption, withstand up to 4000 Pa wind load and up to 7000 Pa snow load. Modules are qualified to withstand PID.
	HSL72P6	300	36.1	8.32				1956x988x45	27±0.5	25			
	SF-160	190	35.8	5.33	Monocrystalline	25		1580 x 808 x 40	14	25	POA	25	
Hareon Solar Company (www.hareonsolar.com) PIVOTAL Solar Solutions (official Australia distributor for Hareon) ph: 1300 935 145 www.pivotalsolarsolutions.com.au	HR240P-18/Bb-1	240	29.67	8.09	Polycrystalline	60	EVA, TPT, tempered glass, aluminium frame	1662 x 1000 x 40/45	19.7	25 year linear warranty 10 year product warranty	POA	25+	All new design incorporating 4 busbars and 3 junction boxes to ensure lower resistance, therefore lower losses and lower temperature, leading to higher efficiency. Modules are also positive sorted and current grouped.
	HR245P-18/Bb-1	245	29.88	8.20									
	HR250P-18/Bb-1	250	29.98	8.34									
	HR255P-18/Bb-1	255	30.25	8.43									
	HR290P-24/Ba-1	290	35.86	8.09	Polycrystalline	72		1982 x 1000 x 40/50	21.0				
	HR295P-24/Ba-1	295	35.98	8.20									
	HR300P-24/Ba-1	300	36.30	8.26									
	HR305P-24/Ba-1	305	36.61	8.33									
	HR310P-24/Ba-1	310	36.82	8.42									
	HR250 TrueAC	238Wp AC	230V AC	1.035 A AC	Polycrystalline	60	EVA, TPT, tempered glass, aluminium frame. Incorporating Pantheon Gen 2 integrated microinverter by Solarbridge	1636x992x40	21.60	25 year linear, 10 year product, 25 year micro inverter	POA		Integrated microinverter so each panel has its own inverter. Ideal for all site locations but also suitable for non optimal locations. They deliver greater yield if modules are soiled, unavoidable shading or non optimal roof design or orientation.
Hyundai (Korea) Hyundai Heavy Industries Co. Ltd ph: (07) 3166 9598 info@solarinception.com.au www.solarinception.com.au	His-S220MF	230	28.1V	8.2A	Monocrystalline	-	High-transmission low-iron tempered glass. Weatherproof film on back	1476 x 983 x 35	17	25	POA	25	Contact Solar Inception for latest price and information. Contact installer for installation information.
	His-S260MG	260	31.0V	8.4A				1645 x 983 x 35	19				
JINKO Solar (China) JINKO Australia www.jinkosolar.com	JKM250P-60-A	250	30.4	8.23	Polycrystalline	25	Hign-transmission, low-iron tempered, coated glass	1650x 992 x 40	18.3	10 year product, 25 year linear power	POA	25	The first tier one company passing PID test.
Kyocera Solar (Japan/USA) Kyocera Solar Australia Pty Ltd ph: 1800 242 118 info@kyocerasolar.com.au www.kyocerasolar.com.au	KD325GH-4FB	325	40.3	8.07	Polycrystalline	25	Cells encapsulated between tempered glass cover, EVA, PET back sheet and anodised aluminium frame	1662 x 1320 x 46	27.5	10 year limited product, 25 year limited power output	POA	25+	Grid tie module with SMK connectors. First module manufacturer to pass TUV Long Term Sequential Test.
	KD250GH-4FB2	250	29.8	8.39				1662 x 990 x 46	20				
	KD215GH-4FBS	215	26.6	8.09				1500 x 990 x 46	18				
	KD140SX-1FBS	140	17.7	7.91				1500 x 668 x 46	12.9				Accessible J Box connection.
LG Electronics (South Korea) 2 wonderland Drive Eastern Creek NSW 2766 ph 02 88054038 www.lgenergy.com.au	LG255S1K	255	31	8.24	Monocrystalline	25	EVA embedded cells, tempered glass with anti-reflective surface treatment, aluminium frame with piano black finish	1640 x 1000 x 35	17.3	10 year product, 25 year linear performance guarantee	POA	25+	For panel purchase contact our distributors Solar Juice (02) 9725 1111 and Supply Partners (07) 3122 7584.
	LG260S1C	260	30.2	8.61									
	LG290N1C	290	31.8	9.41									
	LG300N1C	300	31.9	9.46									
Lightway Solar (China) Krannich Solar ph: (03) 9339 5100 info@krannich-solar.com.au www.krannich-solar.com.au	P 1650×990 Series	250	29.95	8.36	Polycrystalline	25	-	1650 × 990 × 50	21	10-year materials and workmanship; 25-year >80% power output	POA	25+	Positive tolerance up to 5W; Three busbars ensure high power output. Excellent weak light performance. 3% degradation rate the first year, 0.68% yearly linear degradation.
Lightway Green New Energy Co Ltd (China) Lightway Australia Pty Ltd info@lightwayaustralia.com.au www.lightwayaustralia.com.au	LW240(29)	240	29.65	8.11	Polycrystalline	25	EVA, 3.2mm low-iron tempered glass, anodised aluminium alloy, >IP65 rated, 3/6 diodes, MC4	1640 x 990 x 40 or 1640 x 990 x 50	18.5 or 19.5	10 year product, 25 year linear degradation	POA	Refer warranty	New models expected in late 2013/early 2014: Smart DC module and Black Poly module.
	LW245(29)	245	29.8	8.24									
	LW250(29)	250	29.95	8.36									
	LW255(29)	255	30.1	8.48									
	LW260(29)	260	30.25	8.61									
Low Energy Developments ph: 0405 809 015 gareth@lowenergydevelopments.com.au www.lowenergydevelopments.com.au	TN-72-5M190	190	37.1	5.11	Monocrystalline	25	Glass, EVA, polyester	1580 x 808 x 35	15	25, 10, 5	289	-	-
	TN-60-6M 250	250	30.7	8.15				1640 x 992 x 35	19.5		234		
	SL5CE-18M	5	16.6	0.3				334 x 175 x 18 or 294 x 254 x 25	0.8		14		
	SL10CE-18M	10	17.64	0.56				385 x 290 x 25	1.5		23.5		
	SL20CE-18M	20	17.64	1.13				645 x 295 x 25	2.6		37.5		
	SL40CE-18M	40	17.5	2.29				600 x 535 x 25	4.3		59		
	SL40CE-18P	40	17.4	2.3	Polycrystalline			670 x 500 x 25	4		41		
	SL50CE-18M	50	18.25	2.74	Monocrystalline			720 x 550 x 35	5		69		
	SL65CE-18M	65	18	3.6				840 x 550 x 35	5.9		99		
	SL75CE-18M	75	18	4.17				1490 x 350 x 35	7.5		125		
	SY-80M	80	17.5	4.57				1185 x 545 x 35	7.5		94		
	SL80CE-18P	80	17.4	4.6	Polycrystalline			1185 x 545 x 35	7.5		79		
	SL100CE-18M	100	18	5.56	Monocrystalline			1197 x 535 x 35	7.5		139		
	SL110CE-18M	110	18	6.12				963 x 805 x 35	7.5		149		
	SL120CE-18M	120	18.5	6.49				1040 x 810 x 35	11.5		138		
	SL130CE-18M	130	18	7.23				1210 x 810 x 35	12		144		
	SL140CE-18P	140	18	7.78	Polycrystalline			1480 x 670 x 35	12		159		
	SL150CE-18M	150	17.5	8.57	Monocrystalline			1485 x 668 x 35	12		198		
	SY-200M	200	18	11.12				1580 x 808 x 35	15.5		219		
	SY-300P 12V	300	-	-	Polycrystalline			1956 x 992 x 50	25		309		
	JMM72-200	200	36.5	5.47	Monocrystalline			1580 x 808 x 35	15.5		198		
	TN-60-6P230	230	29.8	7.99	Polycrystalline			1650 x 992 x 45	23		163		
	SM672-300M	300	36.3	8.26	Monocrystalline			1960 x 1000 x 50	24		349		
	SM672-300M	300	36.7	8.17	Polycrystalline			1960 x 1000 x 50	24		309		

Brand (made in)	Model	Power (watts)	Vmp	Imp	Cell type	Test cell temp °C	Construction	Size in mm (L x W x T)	Weight (kg)	Warranty (years)	RRP inc GST ($)	Lifespan (years)	Comments
Luxor Solar (Asia) Krannich Solar ph: (03) 9339 5100 info@krannich-solar.com.au www.krannich-solar.com.au	Eco Line 72	200	37.39	5.39	Monocrystalline	25	Stable, anodised aluminium frame in a hollow-section design, hardened solar glass with low iron content	1580 x 808 x 35	15	10 year product guarantee, 12 year guarantee for 90% rated power, 25 year guarantee for 80% rated power	POA	25+	The homogenous black surface portrays a positive image through its optimal low-light behaviour, and is perfect for dark roofs.
	Eco Line 60	250	30.79	8.17				1640 x 992 x 45	21				The 60-cell module is the large-size all-rounder among the Luxor modules. Eco in this case means especially economical: The high wattage makes the module the ideal solution for industrial scale equipment.
	Eco Line Full Black 60	250	31.13	8.08									The monocrystalline Luxor module with black surface is the best guarantee for highest efficiency from the range.
	Eco Line 60	250	30.83	8.16	Polycrystalline	25							This is the largest all-rounder among the Luxor panels. Its high wattage and the relatively low voltages make it possible to install more modules in series, so that the inverter can be designed more economically.
Powertech (China) Jaycar Electronics ph:1800 022 888 techstore@jaycar.com.au www.jaycar.com.au	ZM-9093	10	17	0.59	Monocrystalline	25	Tempered glass, EVA, Tedlar, aluminium frame	396 x 289 x 23	1.4	25	39.95	25+	ZM-9088 is Clean Energy Council approved as Talesun Solar model TP572M-200. Powertech brand is used for marketing purposes.
	ZM-9094	20	17.2	1.17				639 x 294 x 23	2.4		79.95		
	ZM-9095	40	17.2	2.32				645 x 545 x 23	4		149.00		
	ZM-9097	80	17.6	4.55				1200 x 540 x 28	8.2		249.00		
	ZM-9086	90	18	5				1200 x 540 x 28	8.2		279.00		
	ZM-9085	120	17.2	6.68				1190 x 660 x 35	11.5		329.00		
	ZM-9087	145	18	8.06				1250 x 808 x 35	12		369.00		
	ZM-9088	200	37.8	5.31				1580 x 808 x 35	14.5		599.00		
	ZM-9132	40	17	2.35			Portable folding type typically used for camping, 4WD, caravan/RV use. Charge controller included in all but 180W model	840 x 420 x 36	5.5	25 for solar output, 12 months for construction and electronics	249.00		These portable folding panels are used in recreational and outdoor applications, designed to charge a 12V battery on a campsite etc.
	ZM-9130	80	17.3	4.64				1090 x 623 x 36	10.5		379.00		
	ZM-9134	120	18	6.67				1090 x 835 x 36	13		499.00		
	ZM-9136	180	18	10				1074 x 1195 x 38	19		599.00		
Q CELLS www.q-cells.com.au Available through Hanwha Q CELLS Australia Pty Ltd, Sydney, NSW ph: 1800 QCELLS	Q.PRO-G3	250-270	30.8	8.85	Polycrystalline	25	3.2 mm thermally pre-stressed glass with anti-reflection technology; anodised aluminum frame	1670 x 1000 x 35	19	12 year product warranty; 25 year linear performance warranty	POA	25+	Cyclone tested at James Cook University, suitable for all cyclone regions across Australia.
	Q.PEAK-G3	265-280	31.58	8.95	Monocrystalline								
REC (Singapore) Apollo Energy ph: 1300 855 484 www.apolloenergy.com.au	REC250PE-BLK	250	30.2	8.3	Polycrystalline	25	High-transparency solar glass with anti-reflection surface treatment/double layer polyester back sheet/ aluminium frame	1665 x 991 x 38	18	25	375.00	25+	The lowest embodied energy panel on the market.
	REC260PE-SLV (MC4)	260	30.7	8.5							366.60		
ReneSola Australia Pty Ltd ph: 1300 700 788 www.renesola.com australia@renesola.com Available direct in Melbourne, Sydney, Brisbane, Perth and Adelaide	JC250S-24/Bb	250	30.1	8.32	Monocrystalline (Pmax -0.43%/°C)	25	High-transmission, low-iron, tempered and (non-)AR coating glass. EVA/ fluorinated backsheet. Black or silver anodised aluminium alloy frame. Junction box with IP65 or IP67 protection	1640 x 992 x 40	18.5	25	POA	25+	PID-free, low LID, outstanding performance at low light conditions and exceptional temperature coefficient of Pmax, saltmist and ammonia certified, dust and wind certified, Aus standards fire certified and Tier 1 on Bloomberg New Energy Finance. IEC EN 61215, IEC EN 61730, CE conformity. Austrialia CEC listed and member.
	JC250S-24/Bb-b	250	30.1	8.32	Monocrystalline - Full Black (Pmax -0.43%/°C)								
	JC250M-24/Bbv	250	30.2	8.29	Virtus I - Quasi-Mono/ SCMo (Pmax -0.39%/°C)								
	JC250M-24/Bb	250	30.1	8.31	Virtus II - Multi-crystalline / SCMi (Pmax -0.40%/°C)								
SCHOTT Solar (Germany) PIVOTAL Solar Solutions (official Australia distributor for Hareon) ph: 1300 935 145 www.pivotalsolarsolutions.com.au	SCHOTT POWER POLY 250	250	30.80	8.12	Polycrystalline	60	3.2mm low-iron solar glass, Tedlar backsheet, black anodised aluminium frame, IP65 junction box with three bypass diodes, thermo-plastic cell embedding	1652 X 992 X 35	20	25 year linear warranty 10 year product warranty	POA	25+	SCHOTT Power and Perform modules are now made under licence by Hareon Solar. The modules achieved over 90% yield after 26 years in the Fraunhofer Independent Study 1984–2010.
	SCHOTT PERFORM POLY 250	250	30.80	8.12									
Solar Frontier (Japan) Apollo Energy ph: 1300 855 484 sales@apolloenergy.com.au www.apolloenergy.com.au	SF150-L	150	79.0	1.90	CIS (copper-indium-selenium thin film), no toxic elements such as lead or cadmium	25	Tempered glass/EVA/ weatherproof back film, anodised aluminium alloy frame, with output cables	1257 x 977 x 35	20	20	419.10	25+	Low embedded energy in manufacturing and higher overall energy output of CIS in real operating conditions, particularly at high ambient temperatures or in partial shading.
SolarWorld (Germany) Solarmatrix ph: (08) 9457 4341 info@solarmatrix.com.au www.solarmatrix.com.au	Sunmodule plus SW 250	250	30.8	8.12	Polycrystalline	25	Aluminium frame, glass, Tedlar	1675 x 1001 x 31	21.2	25 years linear performance, 10 year product	517.00	30+	SolarWorld pioneered manufacturing and recycling processes of solar modules and has an active recycling program in place.
	Sunmodule plus SW 260 black	260	31.6	8.24	Monocrystalline						572.00		
	Sunmodule plus SW 270	270	32.1	8.42	Monocrystalline						582.12		
SunPower SunPower Corporation Australia ph: 1800 786 769 www.sunpowercorp.com.au	E20-327	327	54.7	5.98	Monocrystalline	25	Maxeon Gen II monocrystalline cells, Class 1 black anodised aluminium frame, anti-reflective tempered glass	1559 x 1046 x 46	18.6	Combined 25 year product and power warranty	POA	40+	SunPower products are backed by a full 25 year combined product and power warranty.

Brand (made in)	Model	Power (watts)	Vmp	Imp	Cell type	Test cell temp °C	Construction	Size in mm (L x W x T)	Weight (kg)	Warranty (years)	RRP inc GST ($)	Lifespan (years)	Comments
Suntech (China) Krannich Solar ph: (03) 9339 5100 info@krannich-solar.com.au www.krannich-solar.com.au	STP260S - 20/Wd	260	30.9	8.42	Monocrystalline	25	Anodised aluminium alloy, tempered glass	1640 x 992 x 35	18.2	10 year material & workmanship; Nominal power: 97% in the first year, 0.7% max decrease per year for years 2 through 25, with 80.2% in 25th year.	POA	25+	Module efficiency up to 16.0% achieved through advanced cell technology and manufacturing capabilities; System output maximised by reducing mismatch losses up to 2% with modules sorted and packaged by amperage
	STP250 - 20/Wd	250	30.7	8.15	Polycrystalline								Module efficiency up to 15.4% achieved through advanced cell technology and manufacturing capabilities; System output maximised by reducing mismatch losses up to 2% with modules sorted and packaged by amperage.
Tindo Solar (Australia) ph: 1300 846 367 www.tindosolar.com	Karra-240 DC	240 DC	29.6	8.11	Polycrystalline	25	All black modules with 100% electroluminesence testing using low-iron, anti-reflective, texturised, tempered glass, two layers of EVA, Tedlar backsheet, FPE aluminium junction box and SolarBridge inverter.	1695 x 1027 x 55	20	25	479	>25	Tindo Solar panels are manufactured in Australia and Tindo Solar is a 100% owned Australian company. Tindo panels are manufactured on a highly automated production line with extensive steps to ensure quality and reliability. Tindo specialises in AC solar panels that have a 240VAC output ready to be connected into the grid. Each solar panel is able to be individually monitored from anywhere in the world. You can expand your system as little as one panel at a time.
	Karra-240 AC	240 AC	29.6	8.11					22		679		
	Karra-245 DC	245 DC	29.8	8.22					20		489		
	Karra-245 AC	245 AC	29.8	8.22					22		689		
	Karra-250 DC	250 DC	30.0	8.33					20		499		
	Karra-250 AC	250 AC	30.0	8.33					22		699		
	Karra-255 DC	255 DC	30.2	8.44					20		509		
	Karra-255 AC	255 AC	30.2	8.44					22		709		
	Karra-260 DC	260 DC	30.4	8.55					20		519		
	Karra-260 AC	260 AC	30.4	8.55					22		719		
TBEA Sunoasis (China) AVIC INTL Renewable Energy ph: 02 8065 9155 office@avic-intl.com.au	TBEA4190	190	36.6	5.2	Monocrystalline	STC 25/ NOCT 49	Glass/Tedlar, aluminium alloy frame, anti-reflective coating	1577 x 790 x 40	14.5	25, 12, 5	POA	25+	-
	SPSM-190D	190	37.85	5.02				1580 x 808 x 35	17	25, 10, 5			
Trina Solar (China) Phone: 13000 TRINA www.trinasolar.com.au	TSM-DC05A	260-270	30.2-30.8	8.61-8.77	Monocrystalline Honey M	25	High-transparency glass, anodised aluminium alloy frame, MC4 connectors, selected models with Honey cell technology	1650 x 992 x 35	18.6	10 year product, 25 year linear power	POA	See warranty	New models in 2013 include Trinasmart DC, Honey M (mono) and Double Glass modules with improved specs and features.
	TSM-PC05A	250-260	30.3-30.6	8.27-8.5	Polycrystalline, Honey			1651 x 992 x 35	18.6				
	TSM-PC05	230-245	29.2-30.2	8.03-8.13	Polycrystalline	25		1650 x 992 x 35	18.6				
	TSM-PC014	300-310	36.2-36.7	8.04-8.38	Polycrystalline, Honey	25		1956 x 992 x 40	27.6				
	Trinasmart DC (e.g. TSM-PC05A.28)				Polycrystalline with smart junction box–various model combinations possible								
	TSM-PDG5	240-255	29.9-30.4	8.04-8.39	Polycrystalline, frameless/double glass	25	Frameless, double glass design	1688 x 1000 x 32	24	10 year product, 30 year linear power			
Yingli Green Energy (China) The 12 Volt Shop ph: 1300 128 658 sales@12volt.com.au www.12volt.com.au	YL20	20	17.5	1.14	Polycrystalline	25	Low-iron 3.2mm tempered glass. EVA encapsulant material. Frame composed of anodised aluminium tested to withstand wind loads of 2.4kPa.	525 x 350 x 25	2.3	25	Check web site.	See warranty	Yingli is one of the largest vertically integrated solar module manufacturers in the world. This ensures that quality is monitored thorugh the entire manufacturing process. Power tolerance of +/- 3% is maintained minimising PV system mismatch losses. Yingli was the first Chinese company to become a member of PV Cycle.
	YL30	30		1.71				535 x 510 x25	3.3				
	YL40	40		2.29				660 x 490 x 25	5.4				
	YL50	50		2.9				660 x 540 x 25	6.3				
	YL60	60		3.43				660 x 630 x 25	7.3				
	YL80	80		4.57				900 x 660 x 25	7.9				
	YL90	90		5.14				900 x 660 x 25	7.9				
	YL110	110		6.3				1172 x 660 x 25	8.3				
	YL135	135		7.67				1470 x 680 x 25	11.8				
Yingli Solar (China) Australian Sales and Technical office ph: 1300 309 489 australia@yinglisolar.com www.yinglisolar.com/au	YGE 250	250	30.4	8.24	Polycrystalline	25	Glass/EVA/backsheet	1650 x 990 x 40	19.1	10 year product, 25 year power	POA	25+	Yingli Solar is the largest solar manufacturer in the world based on deliveries of over 30 million panels (7GW) to more than 40 countries. Our panels are rated in the top 5 for energy yield by both TUV Rheinland (2011) and Photon Laboratories (2102) year-long field tests.
	PANDA 270	270	31.1	8.68	Monocrystalline								

Warm sun, cool house
Solar-powered evaporative cooling

Martin Chape describes how he put an old evaporative cooler to good use, automating the system in the process.

LAST year I promised myself that I was going to try and use the excess heat that my solar hot water system generates to cool my home. It was my intention to do this by extracting the heat from the hot water tank, either directly or with a heat exchanger replacing the redundant electric heating element, and use either an absorption or adsorption cooling process.

However, after one or two unsuccessful experiments, I put this idea aside for a while and instead decided on a much easier build: an evaporative cooler using solar PV to power it directly.

My plan was to source a discarded evaporative cooler rooftop box and replace the AC-powered fan and pump with 24 volt DC versions to be powered by a solar PV/battery system. I would also add a control system for monitoring and controlling the system remotely. Evaporative coolers are simple devices that draw air through wet absorbent pads. This cools the air through evaporation, and has the advantage of using a lot less energy than a refrigerated air conditioner. The main issue with using a second-hand unit is the cost of replacement pads, as they degrade over time and may become mouldy if unused for a while.

↑ The converted evaporative cooler is powered by two of the solar panels.

Step 1: sourcing the cooler rooftop box

I figured there ought to be plenty of those evaporative cooler rooftop boxes discarded after they wear out, break down or folks switch to other forms of air conditioning. I put the word out and within days my nephews had dropped off the parts for a Bonaire Brivis they'd found on the side of the road!

However, I ended up deciding to use a Bonaire Celair instead, which I bought for $50, as the Celair has thicker pads than the Brivis and the cost of pad replacement is lower.

Step 2: replacing the fan

I decided to source a fan used in the automotive industry, an 18 inch (457mm) 24 volt DC fan, commonly used to cool the radiators of the big haul pack mining trucks.

The Celair's removable fan mount made modifying it easy. However, the original fan was larger (19 inches), so I got a plastics company to make me a spacer to close the gap at the outer edge of the blades.

Step 3: replacing the pump

I first considered using a bilge pump but found these are not warrantied to run continuously for the number of hours the system would need. Pond pumps were the next obvious contender as these can run 24/7 as long they're kept cool underwater. After mistakenly buying an AC (rather than DC) pump from a pond shop, I ended up sourcing a submersible 24 volt DC pump from China that would manage 20 litres per minute (the flow rate that Bonaire advised for the original pump, and that many of these pumps run at).

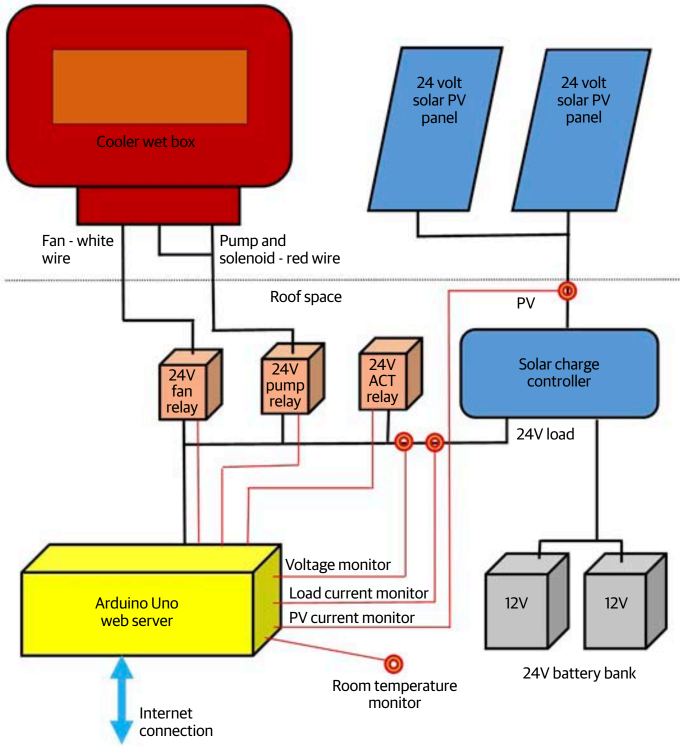
When it arrived I was particularly pleased as it included a speed controller which meant I could vary the flow rate, which would allow me to tweak the system for best performance. I wired it through a float switch so it cannot run unless the water chamber is full, to prevent any damage to the pump.

Step 4: solar/battery system design

The cooler load is 12.5 amps, so I chose two 250 watt 24 volt PV panels, each of which can deliver around 8 amps (their rated load current); wired in parallel, they can deliver a maximum of 16 amps when the sun is out.

The solar cooler uses an MPPT (maximum power point tracking) charge controller which can direct PV current to the batteries, the cooler or split between both. If you turn the cooler on while the PV panels are charging the batteries, the MPPT controller directs 12.5 amps to the cooler and the balance of 3.5 amps to continue to charge the batteries. If the cooler is off, then it sends all current down to the batteries. When there is no sun, the MPPT controller isolates the PV and sends all current to flow to the load terminals from the batteries.

I factored in enough battery capacity (55 amp-hours) to be able to run the cooler in the evening as the PV current drops off and even after dark for an hour or so. The batteries are protected by the MPPT controller; it shuts down the load terminals if a pre-determined battery voltage is reached indicating the batteries are running down.



→ The complete system schematic.

Step 5: sourcing solar panels

I have to thank Reg at wholesaler YHI Power in WA for supporting me by providing a pair of 24 volt, 250 watt PV panels at an excellent price. The cost of solar PV has dropped dramatically in recent years and the efficiency has also improved, which makes projects such as this much more feasible. For example, two years ago I paid $490 for a 24 volt, 200 watt PV panel capable of delivering a short-circuit current of just over 5 amps. Today, these 250 watt PV panels cost just $200 each and they are able to supply a short-circuit current of greater than 8 amps.

Each panel is wired back to a single-pole isolation switch inside the roofspace using solar MC4 connectors and 4 mm² cabling. Even the MC4 connectors are cheap these days, but for that some quality has been sacrificed. I had difficulty snapping some sockets and plugs together and ended up having to file them and replace the rubber O-rings.

Step 6: sourcing batteries

The 12 volt, 55 amp-hour batteries I chose came from the same local importer as the solar PV. I was again given a good price of $100 each as they were end-of-line stock. The batteries are low-maintenance sealed lead-acid deep-cycle units. I connected the two batteries in series to give 24 volts, and mounted them in plastic battery boxes from Boating Fishing Camping.

Step 7: sourcing the charge controller

Any solar setup that includes batteries needs some way of controlling the charge into the batteries so that they are not overcharged, which will damage them and shorten their lifespan, especially with sealed units. Charge controllers are also often called regulators.

As previously noted, I used a 30 amp MPPT controller, sourced from China through eBay. Including shipping, the price was under $50.

Step 8: the cooler control system

For the cooler monitor and control system I decided to use an Arduino Duemilanove microcomputer that I had in my junk box.

You can purchase Arduino micros from $12 to $45 in Australia depending where you shop, and for $5 in bulk from China. You don't need to use the Duemilanove; there are other Arduino boards, such as the Uno and its big brother the Mega [you can also buy an Arduino with on-board ethernet called the EtherTen from www.freetronics.com—Ed].

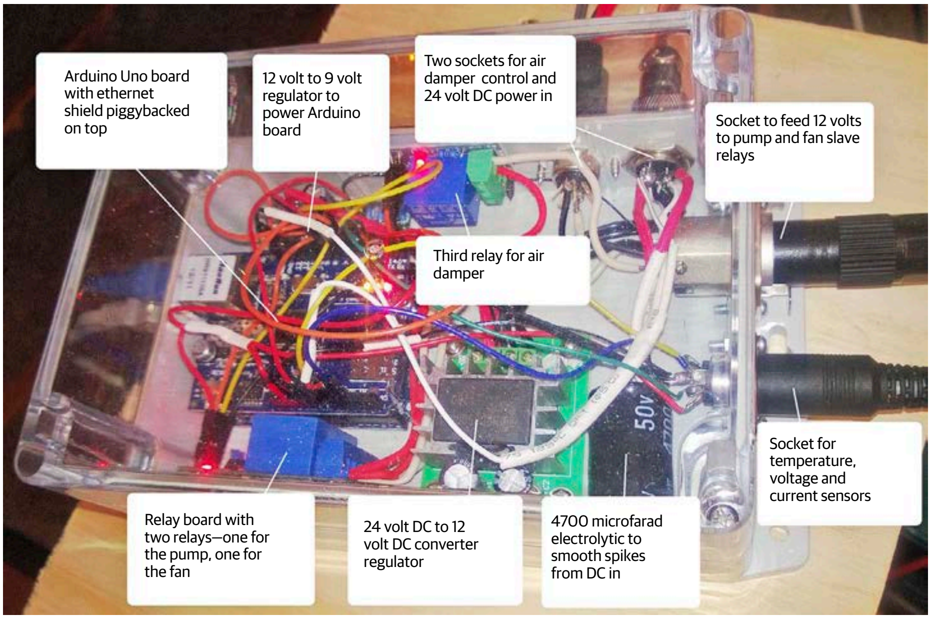
I had played with the Arduino before but all I'd made it do was flash an LED on and off. For this project, I wanted it to be able to monitor the temperature in the room(s) being cooled, provide that information across the internet and be able to turn the system on/off as well.

This part of the project entailed a steep learning curve. But, buoyed by the fact that I'd done some C++ programming early in my engineering career and that I was pretty fluent in HTML, I charged ahead. I should also thank Bill at www.artifactory.org.au who provided advice and encouragement.

I piggybacked an Ethernet board (around $8) on the Arduino board to enable internet connectivity so that I could use a smartphone to monitor the temperature in the house from anywhere, and switch the cooler on before I got home if needed. I set up the Arduino as a web server that serves a single web page to control the system. I used a web page rather than an app, as an app would have required different versions for Android, iOS and Windows.

It took me three tries but I eventually successfully created a web page with three buttons to control the system. 'Cool' turns on fan plus pump, 'Fan' turns on only the fan, and 'Off' turns everything off. The display shows the room temperature in the house, battery bank voltage and PV charge current. The web page works on my Windows 8 Nokia Lumia 920 handset but it may require tweaking for other OS phones, and will likely morph as the project runs on.

Arduino is open source. To get started go



↑ The Arduino controller box showing the various components.

Installation

Although my roof is getting quite crowded, I managed to find a couple of spots for the two solar panels close to the cooler wet box where they would not be shaded during the day. I built brackets to hold the ends of the panels up over the hip line of the roof.

I mounted the Celair wet box on a Polyaire plastic Drop-X box that goes through the corrugated iron roof. The Drop-X box comes complete with its own mount and flashing.

I fed the PV cables through the corrugated iron roof using cheap and simple plumbers' pipe collars.

Inside the roof

As yet, I haven't worked out how I will keep the electronics in the roof cool or even what needs to be kept cool. Most likely the Arduino box will need a fan as it must be enclosed to keep dust out. I am also thinking of gluing some polystyrene insulation to the corrugated iron to prevent direct radiated heat. The Arduino controller box and the battery bank are set down lower on the ceiling joists in the hope it will be cooler there in summer.

[Ed: Martin contacted us just before publication to say he is having problems with overheating of the Netduino on hot days. He is considering moving it out of the roof or changing to use a standard remote control. He says it's still been a useful learning experience with the Netduino.]

The Arduino box is a little crowded because I had to fit two voltage regulators. One drops the 24 volts DC from the battery bank down to 12 volts DC to run the slave relays; the small Arduino relays can't run the high current of the fan and pump. The other is a 12 volt to 9 volt regulator; although the Arduino board can run on voltages from 6 to 12 volts, it tends to overheat its internal regulator if run on voltages over 9 volts.

I had intended to use a popular fabric sock from Polyaire for distribution of the cooled air inside the roof space but ended up paying $165 to my favourite local sheet metalwork company, Air Quip, to make me a custom drop box with two 300 mm spigots to connect to air ducting. I also insulated the box with polystyrene sheeting purchased from Clark Rubber. A movable flap inside the box directs air to my study or the bedroom and is controlled by a small Belimo actuator motor. Eventually, this will be controlled from the web page on the smartphone.

The solar PV is wired through an isolator switch to the MPPT charge controller mounted on a wooden board. Also included is a row of spade fuses, an ammeter to show the PV charge current and a voltmeter showing the battery bank voltage.

The box is designed so that it can be unplugged and brought downstairs to work on or reprogram the software. But I have also run a USB cable down into my study so that I can re-flash the code without having to climb into the roof.

to the Arduino website (www.arduino.cc) and download the software. The editor allows you to write code, then compile and bootload your program to the Arduino. To replicate this project you can go to www.bit.ly/SolarCooling and cut and paste the code for the Arduino sketch.

System under test

The system has been tested on the ground. It is now in/on the roof and has the first 300 mm air duct connected to an air diffuser in my study. I have run the unit for test periods of several hours and found I had to put on warm clothes as it does work effectively! I am waiting for summer heat to conduct further tests.

Future improvements

I'm planning improvements including spark arrestor screens on the cooler's cellulose pads, a smoke detector inside the wet box to allow the Arduino to turn the pump on and the fan off should sparks from an outside fire ignite the cellulose pads, and a connection to a rainwater tank to try filtering and recycling the water. I am also looking into using rain or bore water to run the cooler.

Now that I am more Arduino-savvy, I also intend to build a new microcomputer control for my solar hot water system and another for my garden reticulation system.

I hope sharing this project inspires some to run out and replicate or improve on this idea. I believe this project helps deal with the waste stream of old coolers and that it may even help reduce the daytime peak electricity load generated by the air conditioners we don't seem to be able to do without these days. Perhaps companies like Bonaire, who have expressed an interest, may even one day offer a commercial version of this system. ✱

Find out more at Martin Chape's website: www.sustainabilitysolutions.net.au.

Safety first

This project has made me do a few other things around the house in relation to safety as my frequent need to climb on and in my roof space increases risk. I have attached some steps to the outside of the corrugated iron roof, installed pull-down loft steps to my manhole cover and added timber sheeting on the ceiling joists inside the roof space to mitigate the chance of me falling through. I can't stress enough the need for safety when you carry out this sort of project.

Solar cooling options

Solar cooling refers to any type of cooling system that uses solar energy, either directly or indirectly.

The simplest system uses an age-old technique based on the chimney effect. This system involves the use of a tower-like construct as part of the building. As the tower is warmed by the sun, the air in it rises up and out, pulling in air from inside the home. The air removed from the home is replaced by air from outside that is drawn through some form of cooling, such as a cool cellar or moist pads as used in an evaporative air conditioner.

Another approach is to include desiccants as part of an evaporative cooling system. The air to be cooled flows over the desiccant, which reduces the humidity of the air. The air is then cooled using conventional evaporation, which is more effective as the air has already been de-humidified. The desiccant is regenerated using solar heat; the absorbed moisture is driven off and it is then ready for reuse.

Active adsorption and absorption cooling systems use solar heat to drive an absorption cycle, much like the flame in a gas fridge causes the fridge to cool its contents. There are many designs and derivations of this approach.

You can also use PV panels for cooling. The electricity from the panels is used to operate air conditioners of various types, including evaporative or refrigerative units (such as common reverse-cycle air conditioners). This can be done either indirectly or directly.

In an indirect system, the output of the PVs feeds the mains grid and the air conditioner is set to run at the same time as maximum generation is occurring. Alternatively, the PVs can charge a battery bank which is used to run the air conditioner.

In a direct system, the PVs are connected to the air conditioner itself. They may drive the fan and pump in an evaporative system or the entire refrigeration cycle in a refrigerative air conditioner.

A number of these units are now available overseas such as the Kingtec Solar units (www.kingtecsolar.com). There is also a system available in Australia that comes as an air conditioner and PV package, the SolarAir. However, we have not verified its performance or the company's claims. The supplier is Aussie Solar World, www.aussiesolarworld.com.au.

The area of solar cooling is quite broad and would require a whole article to explain in detail, but there are some useful web resources that will give a basic grounding in solar cooling systems:

Australian Solar Cooling Interest Group: www.ausscig.org
Wikipedia solar cooling page: en.wikipedia.org/wiki/Solar_cooling
Solar cooling using ejectors (ANU): www.bit.ly/ANU-SCE
AIRAH solar cooling page: www.bit.ly/AIRAH-SC

↑ Echuca Hospital's solar cooling system uses 400 m² of evacuated tube collectors to heat water for the absorption chiller to generate cooling.

A home-built air conditioner
Waste thermal mass as cooling

What do you do with a big pile of old tiles left over from re-roofing your home? Turn them into an air conditioner, of course! Alan Leenaerts explains how.

AS part of my recent conversion to a low-energy house, I replaced my tiles with Colorbond roofing. The tiles were 50 years old, so the sub-frame required replacing and the tiles required resurfacing. A corrugated iron roof is cheaper, easier and quicker to install than tiles, and has less embodied carbon. It also facilitates the installation of a home roof heater system, which I have done (to be covered in a future issue of *ReNew*), and which has reduced my heating costs by 75%.

After the re-roofing I had some eight cubic metres of surplus concrete roof tiles. Rather than cart them away to landfill, I decided to use some of these to make a rockpile air conditioner.

Thermal mass for air conditioning has been used for thousands of years, as is evident when you visit such sites as the ancient city of Petra. There are also some examples from pre-Columbus America, complete with solar chimneys to create air flow.

I originally tried just pumping the cool air from under the house, but on a 35 °C day the performance wasn't up to scratch. Initially the air came out at 20 °C but after about an hour it warmed up to an uncomfortable level.

Instead, my rockpile system uses the surplus roof tiles as mass, with wooden spacers between the tiles to maximise the air-to-tile surface area, combined with a 30 watt air-transfer fan. The thermal mass is 'pegged' at ground temperature (about 10 °C in Melbourne) and provides an easy way of using this cooling resource.

This 30 watt low-energy solution easily matches the performance of the 2000 watt portable air conditioner I borrowed, before I modified my house to be energy efficient.

→ This tile pile would normally have been sent to landfill. Instead it is cooling Alan's home for almost no cost!

Like all air conditioning, you are best to use it sparingly and for cooling a small space only. You must also have a thermally efficient house envelope. My house has R3 insulation in the external walls, R1.5 in the internal walls and R5.5 in the ceiling, but nothing immediately under the roof. The windows are double-glazed and I've maximised draught proofing.

The rockpile air conditioner will easily cool my main bedroom, which is 3.5 x 4.5 metres in size, in less than half an hour, and will happily supply cool air at around 11 °C to 19 °C for 10 hours. It gradually gets warmer with time, but usually the cool change arrives before this and I open the windows.

It is much more comfortable than an evaporative system as it generates no humidity, and is much quieter than a split-system air conditioner as the fan is 10 metres away, under the house.

Materials used

- five cubic metres (approx) of masonry
- a 30 watt air transfer fan and two ducts ($70)
- spacers to put between the tiles to maximise surface area—mine are 20 x 10 x 50 mm pine
- tarpaulin/envelope to make the pile air tight—I used a standard blue tarpaulin
- thermostat and timer—not essential, but I like the system to self-operate when I 'm asleep
- builders' foil insulation—also not essential, but it improves efficiency ($25 a roll)
- duct tape ($5)
- inlet and outlet with gauze filter to prevent bugs and dust ($30)
- closeable vents to prevent cool draughts in winter, one for the floor and one for the ceiling ($20).

Building the rockpile

I stacked the tiles inside the tarpaulin, using the spacers to provide air gaps between the tiles. The resulting 'rockpile' is about 1.5 m wide by 1 m high and 4 m long.

Material	Heat capacity	Density
Water	4.1 J/g.K	1000 kg/m³
Brick/concrete/rock	0.9 J/g.K	2400 kg/m³
Wood	1.2 J/g.K	500 kg/m³

Table 1. Heat capacity and density for common building materials.

→ The rockpile (or more accurately, the tile pile) uncovered.

The shape and size of the rockpile is important. You need to ensure that there is as much contact with the ground as possible, so that the tiles can discharge their heat into the earth when not in use. The pile also needs a shape about a square metre in cross-section and as long as you can make it. This ensures the air is in contact with the tiles for as long as possible.

I sealed up the tarpaulin with duct tape and taped in a section of duct at each end. I then wrapped reflective insulation around the five sides that are not in contact with the ground. This ensures the 20 °C sub-floor air will not warm up the mass. I then had my source of cool air—all I had to do was to duct it where I wanted it.

My system draws the cold air into the house through the floor, via a closeable floor duct. Warm air from the room escapes through a closeable vent in the ceiling, and then travels down through a cupboard and back through the floor to be recooled by the mass. Thus, it's a closed loop system. You can also run it as an open loop, venting straight into the ceiling, but it will be less efficient.

It is also possible to build such a system using water as the thermal mass. But although water has a greater thermal mass (see Table 1), it is harder to put under your house and the heat exchanger mechanism is much more expensive. Brick or rock gabions will work just as well. ✱

Could microbes be a problem in a rockpile cooling system?

Questions have been raised about the potential for these systems to harbour dangerous microbes, such as mould and the bacteria that cause legionnaire's disease.

The bacteria that cause legionnaire's disease can be found in very small quantities in the ground and in water. It becomes a problem when water stays at temperatures of 25 °C to 55 °C. Thus, it's important to keep the rockpile cool and dry, as mould and bacteria flourish in warm and humid conditions. Keeping the rockpile under 60% humidity and making sure the rocks are dry when installed will minimise fungal growth. Cleaning the rocks before they are installed will also remove some organic matter and may limit fungal growth. Regular inspection and cleaning of the system is also recommended.

Alan notes that his tile pile stays below these temperatures as it is pegged to ground temperature. He says that humidity is not a problem as the tiles will not condense out water in the atmosphere as their temperature never goes below dew point.

More info:
en.wikipedia.org/wiki/Specific_heat_capacity
en.wikipedia.org/wiki/Gabion

Can't DIY?

If making your own thermal mass air conditioner is not for you, there are companies that can create the thermal mass pile for you. Using techniques similar to making rock retaining walls, commercial systems such as this one at the Roberts McCubbin Primary School in Victoria include rock walls underneath buildings. This system was made by Ground Tech Geo Supplies & Services, www.groundtechgeo.com.au

Bushfire preparation
Wildfire safety in a bushland setting

John Hermans shares the ways he and his household have set up their house to increase protection of property and livelihood.

ON that incredible day in February 2009, now regarded as Black Saturday, the state of Victoria was subjected to weather conditions resulting in runaway wildfire with exceptional loss of life and property. Recently, the wildfires in the Blue Mountains have been identified as totally out of character for the month of October.

In its 2011 report *The Critical Decade*, the recently abolished Climate Commission discussed the link between climate change and increased bushfire risk in a sober and careful manner. "Extreme events that are closely related to temperature are also showing changes consistent with what is expected," it said. "The intensity and seasonality of large bushfires in south-east Australia appears to be changing, with climate change a possible contributing factor."

Given these threats, my intention in this article is to share with fellow bush-dwellers the ways my household has set up our house to increase protection of our property and livelihood. The subject of building protection against wildfires is something that we have been developing for the past 30 years.

↑ John's house with roll-down blinds and shutters in place.

Increasing a building's fire resistance

Apart from having a home which is specifically designed and built with wildfire resistance in mind, a rare building indeed, there is much we can do to increase a building's fire resistance

Most buildings are lost due to ember attack, the entry of small burning embers into areas that start fires which develop and eventually overwhelm the house.

Buildings with a cavity beneath a timber floor need the addition of tough metal fly wire, attached to the outside ventilation slats, to reduce the opportunity for embers to enter under the house. A concrete slab on-ground eliminates this problem.

For buildings with cavity roof spaces, combustible debris can build up in and around crevices and gaps, so ember exclusion patching needs to be carried out. Products are available to plug gaps between corrugated iron and sheet metal flashing. Fire-retardant underlay is a necessity under a tiled roof, but debris can build up on top of it, so this needs checking. Roofs with no cavities offer the best protection.

Gutters are also often a problem. Where they are used they should prevent the build up of leaves and be attached to a non-combustible eave. Gutter-less systems are a good alternative.

Windows being broken by either excessive heat or flying objects is another common point of ember and flame entry. Even though toughened glass has more than triple the heat resistance of standard glass, it is safer in high-risk locations to consider placing some form of shutter over the entire window. The type of shutter used is determined mostly by the possible heat load that the window will receive in a wildfire event. Sheet-metal and cement sheet shutters offer a high degree of protection, as long as they are securely fastened and flames can't find a way around them.

On our house we have also used tightly woven steel mesh and high-temperature fibreglass woven fabric with an outer radiant heat reflective layer, made into simple roll-down blinds. The bottom edge of the blind is clamped between two long rectangular sections of heavy steel, to help keep it in place and minimise wind access behind the blind.

Earth bricks or rammed earth offer the highest level of heat-resistance in wall materials. See *ReNew 110* for a review of the

Be prepared, but be cautious

There are no guarantees that a building or lives can be protected from a wildfire. In the Black Saturday fires, many people died in their homes, and, according to the Royal Commission, about 20% of those who died would have been considered well prepared.

Remember, a house can be replaced, lives cannot. The safest option is to leave early. Seek advice prior to the start of the fire season and prepare your fire plan.

fire-resistance performance of these materials.

Where timber is used externally on a building, the higher the durability class, the less flammable it is, so softwoods should be avoided, as should any timbers that have been CCA treated. On some of the more exposed timbers of our house, I have used spray-on fire retardant. It is easy to apply and not visible. Maintenance is needed as many of these coatings lose their retardant properties over time due to weathering. In high-risk areas, consider not having exposed timber to eliminate this risk or reduce the risk by removing fuel near exposed timber surfaces.

Our home is earth covered, with the intention of minimising wildfire risk, but a corrugated iron roof is also a good option.

Fuel reduction around buildings

Vegetation close to dwellings should be minimised or removed and the use of low flammability plants considered. Reducing the amount of fine fuel (less than 6 mm stem diameter) will reduce the likelihood of fire spreading through your property.

The crowns of large trees, even eucalypts, when spaced apart and with a managed understorey are less likely to carry a crown fire, and can assist in reducing wind loading on your house during fire events. They also act as undergrowth vegetation suppressors. I believe that too many trees are removed in the name of fire safety, when it is the lower-growing vegetation that creates the greater flame and heat threat. An expression commonly used is 'spaced trees are safe trees'. [Ed: More information on managing fuel can be found at www.bit.ly/APZstandards.]

Keeping the building perimeter clear of combustibles is an important fire-preparation job. Things like firewood, door mats, chairs

↑ Standing on the ladder, placing the cement sheet over the bedroom window. I use an assortment of heat shielding; this one is perhaps the most awkward.

and windblown dry leaves and grass need removing. Leaves and grass against buildings and fences often create a weak link.

We use a vegetation shredder in areas near to the house, with this pulverised material used in our vegetable garden. For areas over 30 metres away we carry out small mosaic burns, or rake and burn in piles; check with your fire authority prior to doing this. Using a trailer to cart dead organic matter away is another strategy that is highly effective, right through the summer season.

Water saturation around buildings

A good proportion of households in forested areas provide themselves with a water supply and a fire-fighting hose. This basic setup is far from adequate in many cases. Many water-based home fire-fighting setups fail for a variety of reasons including insufficient water to adequately protect life and property; failure of the motor which drives the pump; ineffective water distribution; or the fire being beyond the capability of people to attack.

Often during fires, mains water supply is overdrawn so is too risky to rely on. If you are planning to stay and defend your home, then you need assurance that sufficient water is available for fighting fires when needed. As the most disastrous fires have come after the end of a long dry period, household water supplies are usually very low when a fire is on its way.

↑ Clerestory window blind end-joiner. Wind is the nemesis of lightweight materials. Here I am attaching a plate of aluminium to join the two blind edges together, clamping them against the window frame to keep out wind and embers.

Dedicated fire-fighting water tanks should be considered, and kept full for this purpose.

Grid-dependent electric pumps are out, as blackouts are the norm in a fire. Petrol- or diesel-powered pumps need to be started weekly to give some confidence that they will start when really needed. Regular maintenance and a cover to prevent mudwasp access and protect the pump from fire are required. It should also be shielded from radiant heat.

← Valve assembly for a fire hose. Standpipes for fire hoses need to be suitably sized, and hoses easy to find.

"Even though toughened glass has more than triple the heat resistance of standard glass, it is safer in high-risk locations to consider placing some form of shutter over the entire window."

The most effective water-pressure system is derived by having a water-supply tank up on a hill, preferably with over 10 metres head. This means you will always have pressure as the pumping has already been done.

On our property, we have a concrete tank that is mostly earth bermed, with a volume of 220,000 litres. It delivers water to our living zone through a 100 mm PVC pipe buried to 40 cm, allowing for over 50 sprinklers to be run with minimal pressure drop. This may sound excessive, but it is designed to defend a rainforest garden on the property. The DIY nature of the plumbing made this system very affordable.

Another option is a compressed-air driven water tank. We use a 400-litre mains pressure hot water service as the storage tank and a 45 kg gas bottle charged with compressed air. The two tanks are connected to give a high-pressure fire-fighting unit (see *Renew 108* for details). We have two of these homemade units available as last lines of defence, one in the house and one in our workshop.

Being able to direct water quickly and effectively is what counts. If an adequate water supply is available then surrounding structures with sprinklers inhibits the ignition of buildings and gardens in the first place. If enough sprinklers are set up, then the need for running around with hand-held hoses in a dangerous environment is significantly reduced.

Two points on the use of sprinklers: The delivery rate of water to the combustible vegetation or buildings needs to be greater than the evaporation rate, in conditions that are more severe than you will ever be able to test in. Regardless of this, try test running all sprinklers at once, on hot, dry, windy days. When a fire is approaching, the volume of water that needs to be released is very high, and in order to avoid excessive pressure drop and hence a reduced flow from sprinklers and fire hoses, the size of the distribution pipes needs to be sufficiently large. Be aware that excessive heat may burst exposed plastic pipes or sprinkler risers, leading to gushing leaks and system failure. Above-ground pipes need to be steel or copper; PVC and poly pipes need a minimum soil cover of 30 cm. Underground pipes should not melt when water is flowing through them.

The placement of sprinklers on steel roofs is wasted effort and water, as steel roofs do not burn. Only wet down surfaces that can combust or that are weak points such as doors.

Having exposed plastic water storage tanks is an issue that is often overlooked. Even when full, plastic tanks can melt and burst when exposed to enough heat.

[Ed: The use of sprinklers and their location is complex and advice should be sought from your local rural fire service. More information on sprinklers can be found at www.bit.ly/NSWRFSESS.]

Fighting fires

Given the measures we've put in place, we do have a fire plan that includes staying to defend our home. However, fighting wildfires can be very dangerous and people planning to defend their own homes must take this fact seriously. They must be in good physical condition and must have a place to take shelter if the situation gets beyond their control, including fallback options. Suitable footwear, clothing, breathing and eye protection need to be kept in a box along with a written fire plan and functional torches.

The decision to evacuate or to stay and defend your property against a wildfire must be made based on the forecast weather conditions leading up to a fire and the decisions in your fire plan. If evacuation is required, allow plenty of time to reach safety. Many people who die in wildfires are trying to evacuate too late.

This article only gives a brief outline of our preparations and people will need to research further to protect themselves and their properties effectively. ✱

John Hermans is a regular contributor to *ReNew*. His primary interests are in low emission technologies along with local ecological sustainability. John is president of Gippsland Environment Group and holds a BSc in forest ecology.

Fire plan

A written fire plan adds significantly to personal and house protection. For those situations where you choose to evacuate, it can simply be a list of things to take with you and when to leave. On 'code red' days, it should be with sufficient time to get to an area unlikely to be affected by fires and certainly before a fire starts; on less severe days, evacuation might be initiated by news of a fire in your area. For those who intend to stay and defend, depending on the severity of the fire, the plan needs to be far more detailed. The stay-and-defend choice is more likely to lead to some level of panic and a plan on paper gives clarity to the actions to be carried out.

A plan can also be used annually to re-familiarise household members with the fire-preparation process.

Bunkers

If considering a fire bunker, seek advice on their design and location, as seven people died in bunkers in the Black Saturday fires (e.g. they must be away from other buildings). One useful reference is: *Performance Standard for Private Bushfire Shelters from Australian Building Codes Board* www.bit.ly/StandardPBS.

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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.

3W LED strip light

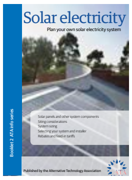
Price: $28

A 30cm long, stackable LED strip light. Demonstrates high efficiency at over 90 lumens per watt. It's wide input voltage range (9–30V DC) makes it suitable for use in an LED skylight powered directly from a solar panel.

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.



Solar electricity booklet

Price: $5

This recently updated booklet is now available for download as an eBooklet from our webshop. Includes infomation on solar panels and other system components, siting considerations, system sizing and feed-in tariffs.

Water cube starter pack

Price: $645

Invented in Melbourne, this DIY-installable 800-litre water tank adds capacity where and when you want it. Harvest and store rainwater for your garden, toilets, laundry and car washing (i.e. non-drinking water).

Solar dynamo radio/torch/USB charger

Price: $38

Emergency radio/LED torch/USB charger dynamo in one, with a built-in solar panel, hand-crank dynamo and a radio that supports AM/FM and three SW bands. It's also capable of charging a mobile phone via a USB port.

Sunrocket portable kettle

Price: $70

This kettle will heat and boil water using the sun's heat captured by an evacuated tube and reflective panels. It can heat water in as little as 30 minutes (weather dependent), can boil in 90 minutes and also closes to act like a thermos, keeping water hot.

Sanctuary: modern green homes issue 25

Price: $11.95

Sanctuary's summer issue features resilient design, designing for universal access and a hemp and rammed-earth home. *Sanctuary 25* also includes great articles on tiny spaces, natural pools and keeping bees in the city.

18W LED outdoor bulb

Price: $49.50

At over 80 lumens per watt, this Par38 bulb is an energy-efficient replacement for 150W bulbs commonly used in driveways and outdoor entertaining areas.

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ATA member profile
A passion for information

Jenny Paradiso is an ATA business member. Green at heart, her solar installation business began after helping out family and friends with buying their solar systems, writes Beth Askham.

SUNTRIX is a South Australian solar installation business started by Jenny Paradiso and her husband Dave Hille in 2009. It's been growing rapidly ever since and so far they've supplied and installed over 10,000kW of solar.

Their interest in renewable energy came long before the business. Jenny says a reason they initially started Suntrix was because they were greenies at heart and wanted to make a difference. "It was about making solar accessible, helping people understand how solar works and how every person can make a difference."

Suntrix began when they decided to install solar themselves and couldn't find the information they needed. It motivated them to do their own research to find a system they were confident investing in. It didn't take long until friends and family asked them to install their systems and Suntrix was born. Initially, both Jenny and Dave kept their day jobs as a librarian and network engineer while they worked on the business from the kitchen table in the evenings.

Jenny and Dave became subscribers to both *ReNew* and *Sanctuary* magazines when they were thinking of building their house. These plans were put on hold, however, when they mortgaged the land to start the business. Luckily the risk paid off and Suntrix has grown from its small beginnings to a company with a turnover of $11 million in the last financial year.

The company now employs 25 staff with both in-house installers and long-term subcontractor teams. Most staff are trained in solar installation as Jenny believes everyone who works for them should understand their business. This means they have a high proportion of electricians on the staff, including the Chief Business Officer. Even the team's solar designer has a CEC accreditation for installing solar for both off grid and on grid.

"Most staff are trained in solar installation as Jenny believes everyone who works for them should understand their business."

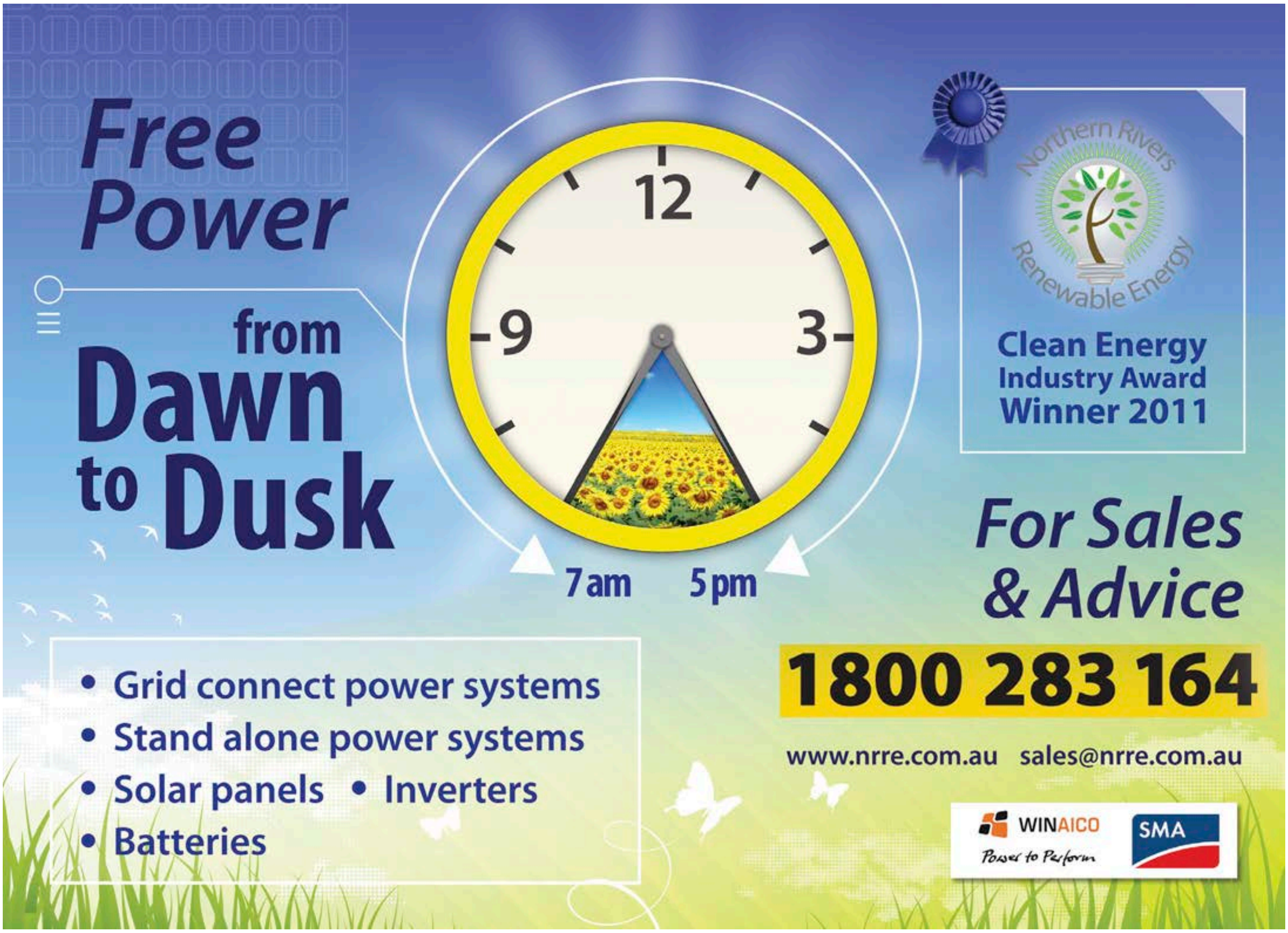
When discussing the barriers people face when installing solar, Jenny thinks that a confusing marketplace is a major one: "There are so many companies and so many products, not all of which are equal," she says. It certainly makes it hard when you need to make sure the products you use are good quality. "When you buy solar you are spending a minimum of $2000 to $3000 and you want to make sure that investment will last."

There are also great differences in the deals offered by energy providers so solar customers need to shop around. Jenny advises people to install solar first as changing retailers can delay your solar installation while you wait for your meter to be read.

One interesting element of Suntrix is that they design products themselves, including an energy monitoring system called myWatt. Jenny says that monitoring your system's production and your energy use is important to make sure you are getting the most out of your panels. "We come across people every week who have invested in solar and have no idea if their system is working to its full potential," she says, giving an example of a system where a cockatoo had chewed through a cable, disabling half the system.

Jenny points out that Suntrix encourages people to keep track of their energy use and aim for energy efficiency instead of suggesting they buy a bigger solar system. "We focus a lot on educating people about energy use in the house. We wouldn't go in and suggest that they get a massive system as we don't believe it will help them in the long run. Also, if you have a good understanding of your energy use patterns then you're going to be more likely to make behaviour changes."

It's not just residential properties that are installing solar; Suntrix has installed solar for many churches around Adelaide and in the last six months they have seen a surge in commercial solar installations. So far their commercial installations include wineries, a large mushroom farm and a yoghurt company. "It's a no brainer for businesses to install solar," says Jenny. ✱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The Pears Report
Desperately seeking policy

Along with climate policy and energy market messes, a fridge purchase makes Alan Pears ask: are we condemned to waste energy because we live in Australia?

WE SEEM to be on track to shift from the well-proven 'polluter pays' approach to carbon emissions (and other forms of pollution) to a 'pay the polluter' approach, using public funds. The government will limit how much will be spent, so we may not even meet our international emission reduction obligations, let alone our equitable share of abatement as estimated based on science.

Luckily the combination of grassroots action, technology change and the structural changes being driven by our over-valued Australian dollar is damping emission growth to some extent. And, under international and local pressure, the government may become desperate enough to reform energy markets to promote energy efficiency and even stop its attacks on renewable energy.

There are some potential positives from the shift away from using the carbon price as the 'silver bullet' to fix everything. As I explained in my last column, this led to serious cuts in energy efficiency programs, failed to confront our deeply flawed electricity market and disempowered voluntary local action by households, businesses and local and state governments.

However, a carbon price is a basic element of any effective climate response. It provides a (fairly imperfect) signal to emitters and investors, while also generating revenue to support adaptation, innovation and stronger abatement—forms of 'direct action'.

Developing countries and energy

I recently came across a very interesting paper published by the World Academy of Sciences for the Advancement of Science in Developing Countries (*Sustainable Energy for Developing Countries 2008*, twas.ictp.it/publications/twas-reports). Two points really stood out.

First, the $137 billion increase in developing country oil import costs in 2005 exceeded the value of all official aid ($84 billion) to those countries. So if we can help them to reduce oil dependence through sustainable energy strategies, we can improve their wellbeing while also reducing pressure on oil prices and cutting greenhouse gas emissions.

Second, to provide access to the 1.5 billion people currently without basic electricity services would increase global electricity consumption by only around half a percent.

Since most of these people are in rural areas, small-scale renewable energy systems and energy efficiency are the most sensible solutions. A major sustainable energy transition could transform their lives and help to reduce sustainable energy costs for the rest of humanity.

Australia could also do with a strategy to reduce oil dependence. The Bureau of Resources and Energy Economic's latest estimate is that by 2035 our net oil import bill would be over $40 billion and, by 2050, over $50 billion each year (assuming $100/barrel).

Some personal experiences and their implications for policy

I finally decided to replace my early 1990s fridge and old (but still comparatively efficient) TV in recent months.

The TV replacement was easy. I used the energyrating.gov.au website, then tweaked the brightness of the display to cut energy use to 25 watts for an 80 cm TV. My old 51 cm TV (by far the most efficient available when I bought it) used 55 watts.

The fridge was a different matter. I have been waiting since 2004 to buy the European A++ fridge I'd discovered being made in Turkey. I finally gave up and chose the most efficient 320 litre fridge available in Australia, rated at 300 kWh per year after finding I could not buy a similarly sized A+++ fridge made by the same manufacturer that's available in Europe (see www.topten.eu). It is rated at 172 kWh per annum (around 210 kWh for Australian test conditions). The manufacturer's Australian representative told me they had no plans to sell that more efficient unit (with a bigger freezer) here.

My new fridge is still quite impressive. It has a variable-speed compressor, hydrocarbon refrigerant and eutectic panels in the freezer that stabilise its temperature. But why am I condemned to waste energy because I live in Australia?

In comparing my new fridge's performance with the old one, I have found that its efficiency and variable-speed compressor cut my peak demand by around 100 watts. Using the Productivity Commission's recent estimates, this saves my electricity suppliers around $30 each year in infrastructure investment. It's saving me around $75. Since I had to buy a new fridge anyway, and I paid no more than I would have for a less efficient one, I'm avoiding CO_2 emissions at a cost of minus $300/tonne!

My old fridge went off to the Phoenix Fridge recycling program, where its refrigerant CFCs can be recovered and its components recycled.

"I have reduced my utilisation of the existing electricity supply assets, depriving their owners of revenue. Should I be charged more for this?"

→ This Samsung refrigerator (model RB31FEJNBSS) wasn't available for Alan to buy, so he had to make do with their SR319MW model.

But I have reduced my utilisation of the existing electricity supply assets, depriving their owners of revenue. Should I be charged more for this? See below.

AEMC contempt for 2 million voters

The Australian Energy Markets Commission has released a new report. In the introduction, the report states: "Effective consumer participation can contribute to more efficient markets..." AEMC should check its economics text books. Informed, empowered consumers are fundamental to the efficient operation of markets. Yet after 15 years, it's still not happening.

The report argues that owners of rooftop PV should be charged more for reducing utilisation of energy supply assets. Can it point to any other market where this happens? Do gas suppliers compensate the electricity industry when people install a gas heater to replace an electric one?

Those who install and use large air conditioners and halogen lights have benefited from large subsidies for many years, yet no action has been taken to make them pay.

The AEMC is taking on over two million PV-owning voters on behalf of the incumbent businesses. When will our political leaders in COAG and the Standing Committee on Energy and Resources step in to sort them out?

Will a 'thin pipe' approach help electricity networks to survive?

The latest idea to help electricity network owners adjust to our rapidly changing technologies is to use low-capacity wires combined with distributed energy storage, generation and smart controls—instead of building capacity to supply peak demand.

This is similar to the 'green grid' approach that was proposed by solar identity Dale Butler at the 1993 Australian Solar Conference for fringe-of-grid electricity.

It sounded really sensible to me when I originally heard it. It still does, especially given cost reductions and technology improvements.

A typical all-electric home might use 10,000 kWh a year—if it could smooth its demand perfectly over time, it would only need supply capacity of 1.2 kilowatts: most homes have supply cables with capacity of 10 to 20 kilowatts. My latest calculations suggest a three-person best-practice all-electric home with all 'mod cons' could now use around 2000–2500 kWh per year. That's a 'smoothed' demand of under 300 watts.

But is this the salvation of network owners? The answer depends on many variables. If a cluster of consumers can share back-up generation and storage, they may not need the grid at all. This back-up generation could be a small cogeneration unit, a fuel cell or output from hybrid cars.

So the challenge for network owners is to diversify their activities. Their market position will be sensitive to policy on whether non-networks can transfer power across property boundaries, or the capacity of smart businesses to find ways of getting around such limits by, for example, moving fully charged batteries to where electricity is needed.

In low-density areas on the fringe of networks, the 'thin pipe' will compete with stand-alone energy solutions. In existing areas, it may not be a lot cheaper to maintain a thin-pipe solution instead of a higher capacity one. But changes such as increasing development density and depreciation of network asset values may allow network owners to develop viable business models.

Apartment buildings, offices, retail and small-to-medium industry may provide ongoing markets for network owners. But they are also potential competitors if they gain the right to sell power to neighbours.

Nothing is clear cut in today's rapidly changing situation. ✷

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 much heating you need or how to reuse a PV array from your home on an RV? Ask *ReNew* your question via renew@ata.org.au.

Reusing a PV array

Q —

I currently have a 1.5kW PV array on my roof in a grid-interative system. It consists of eight 190 watt panels. In a couple of years time I am hoping to do up a bus as a motor home. I was wondering if I could transfer the panels from the roof of the house to the roof of the bus. The bus will most likely have a 12 volt system but the panels put out 36 volts. Is there any way I can transform the output of these panels to charge a 12 volt battery bank?

—Peter Belz

A —

There is indeed and it's quite easy. Many off-grid systems are now using MPPT (maximum power point tracking) charge controllers to both maximise energy input from the panels and enable the use of cheaper higher voltage panels designed for grid-interactive systems on battery systems. There are many charge controllers available, but some of the cheaper ones seem to have problems, and some are not true MPPT controllers. You might want to consider one of the brandname units like the Midnite Classic Lite; see www.dcsolutionsaustralia.com.au.

There is also a range of them at www.mpptsolarcontrollers.com as well as www.solaronline.com.au/solar-regulators.html, but any good renewable energy installer who deals with off-grid systems should be able to supply you with a suitable controller.

—Lance Turner

Instantaneous hot water

Q —

We live in bayside Brisbane in a four-bedroom, two-bathroom house with an old-style 250-litre electric hot water system. We are investigating which way to go if or when the system needs replacing. It is on the south side of the house and it does not appear to me to be a straightforward job to change to a solar hot water system. It is also near the main bedroom and I understand there can be noise issues with a heat pump system.

We installed a 1.5kW PV system three years ago and have happily paid no electricity bills for that period and are $700 in credit. I have looked at Stiebel instantaneous electric hot water systems which, at the top of the range, seem to be appropriate for two-bathroom apartments and can cost around $1500.

The technology looks smart and I cannot see any regulatory objection to this option in Queensland. Are there any practical or plumbing issues in making this replacement? I am not a tech tragic—I would just like an opinion as to the appropriateness of instantaneous electric hot water for a house.

—Ray Barker

A —

The main issue with a whole-house electric instantaneous system is that it needs a 3-phase power supply, as power draw may be up to 20kW. Many houses have these now but many don't. So whether you can install one depends on that. Bear in mind that, while energy use will be less than with an electric resistive storage system as there are almost no standing losses, it will still use a lot more energy than a heat pump or solar unit.

There's no reason why you can't install a solar unit. You would use a split system with the tank in the same place as the current tank and the panels on the roof on a tilt frame to overcome the south-tilted roof.

As for heat pumps, most are pretty quiet but noise ratings are given in the specs. You can also put them on a timer so that they don't run overnight, instead kicking in at, say, 7am. The most efficient domestic unit on the market seems to be the Sanden, which uses CO_2 as the refrigerant. See www.sanden-hot-water.com.au

—Lance Turner

Mini Urn not available

Q —

It was with great excitement that I read the article on the Kambrook Mini Urn in *ReNew 125*. I proceeded to see where to buy one the same day I read the article. I just wanted to let you know that the product is no longer in production and I have been unable to find one anywhere from any of the retail outlets that Kambrook sells through. The staff member at Kambrook who I spoke to said there is no substitute at this time and he did not know why it had stopped production.

You may get other frustrated buyers out there keen to buy such a wonderful concept kettle/urn. The only other one I have found is the Tefal Quick Cup with filter but as it is no longer on their website either, it is probably out of production too.

—Cheryl Bean

A —

Some retailers were selling it as late as September but it seems to have now disappeared. We asked Kambrook if they plan to replace it—they don't. They advised that they stopped manufacturing it as it was not popular with retailers. Annoyingly, it is still listed on the Kambrook website!

The only option along these lines seems to be the Eco Kettle (www.ecokettle.com). However, there are quite a few regular kettles that have water level markings down to one cup, and some mini kettles such as the Tefal Ultracompact 0.8L kettle, but there's nothing comparable to the Kambrook Mini Urn. However, finding these types of kettles for sale in Australia is a different matter—they are readily available in the UK, but uncommon here, so you may need to shop online.

—Lance Turner

Electric heating

Q —

I'm hoping you might have some ideas about what size reverse-cycle air conditioner to choose. Our house in Penola Street, Preston, featured in *Sanctuary* in 2012 and is rated at 9 stars, but I have to say that in sunless stretches it feels as though that counts for nothing. Each winter we procrastinate about buying a heater, but this year it must happen—it's freezing in here tonight!

The reason for our procrastination is, in part, “The range tends to be 100 to 1000 watts of heating capacity per square metre, depending on house performance. With a 9 Star house you would be near the bottom end of that range.”

that we keep getting conflicting advice about what size system to buy. We would definitely prefer an energy-efficient reverse-cycle air conditioner over other forms of heating, but when we ask for quotes they have all been recommending large systems, between 7 and 8.5 kW. Then we speak with people who have building thermal performance backgrounds but are not heating experts, and they say we should be able to get away with something much smaller. This represents a cost difference of thousands of dollars.

We're interested in your thoughts on what to do. I'm really worried that heating experts just don't get our house, but then we also worry that if we buy too small a unit we'll end up needing to have it running for longer and costing more (although maybe we just don't get how air conditioning works!)

The space in question is an L-shaped living area. The long side is roughly 3.5 x 10 m with a 2700 mm ceiling, and then there's the lounge, roughly 4 x 5 m, which has a curved ceiling. The space has: Bradford Enviroseal reflective foil and R2.5 batts in the ceiling, and two walls that abut the bathroom are also insulated; high-performance double-glazed windows with about two thirds covered with Luxaflex blinds or thermal curtains; excellent draught blocking; and a concrete floor with pretty good solar access.

We're unlikely to use the unit for cooling—we've now weathered two summers without any great sense of hardship.

I'm also wondering if you know of any manufacturers that don't use nanotechnology in their filters. I'm profoundly uncomfortable with the idea of the air I'm breathing being filtered through something that is as yet unproven in terms of human health and impact on the environment.

—Elizabeth Wheeler

A —

It sounds as though you should be able to use something smaller. The range tends to be 100 to 1000 watts of heating capacity per square metre, depending on house performance. With a 9 Star house you would be near the bottom end of that range, so with 55 square metres to deal with, a 5 to 6 kW unit should do it. My preference is for the Mitsubishi Heavy Industries units, especially the SRK-ZJX (hyperinverter) range; see www.mhiaa.com.au.

You will note that the COP (coefficient of performance) goes down as the system size goes up. This is mainly due to the same-sized indoor unit being used for all systems, so it's a bit undersized in the larger systems.

This is a common issue with most brands, and the way around it is to fit two of the smaller ones. This would also give you more flexibility with how you use them. A pair of the 25 or 35 models would do the job I would expect, and give you a COP over 4 most of the time (except in heat-boost mode, which is designed to warm the room quickly).

The filters used in these units use naturally occurring enzymes to kill bacteria. The product brochures don't mention nanoparticle filters, but I would recommend checking this with the manufacturer.

—Lance Turner

Mythbusting electric vehicles

Q —

I was a little confused with one aspect of the ‘Mythbusting electric vehicles’ article in *ReNew 118* (a very interesting edition that I have only just read having picked it up from Baw Baw Sustainability Group in Yarragon).

It appeared to imply that it was okay to use ‘normal’ off-peak electricity to charge an electric vehicle from an emissions point of view. Is off-peak electricity any less emissions-intensive than peak electricity?

This is particularly relevant in Victoria where brown coal electricity has the same emissions as a relatively high-petrol-consuming car. On my calculations the ‘break-even’ is about 11.4 litres/100 km.

I realise that GreenPower would get around the problem but I am interested in whether off-peak is any less emissions-intensive than peak power.

—Steve Walsh

A —

Off-peak coal-fired electricity does have a higher emissions rating per kilowatt-hour due to the nature of this type of generation. The boilers used in coal power stations have a huge thermal lag and so can't simply be turned on and off—they have to be kept at running temperature regardless of the load. For periods of lower load such as during the night, the effective emissions increases. This is one of the reasons off-peak electric water heating was common—it used up the glut of night-time electricity.

As resistive electric water heaters are being phased out, there is effectively more coal being wasted. Most of the fuel is burnt regardless of whether there is a load on the system or not, so moving large loads like EV charging from peak to off-peak times makes sense as it makes use of that wasted fuel and reduces strain on the grid during peak times.

Thus, it's not just about the numbers, it's also about the type of generation in use. As coal is slowly phased out and replaced with more natural gas and renewable generation, which can be controlled more easily, the emissions of the off-peak energy will go down. It will still make sense to charge EVs at night, as the grid is lightly loaded and it will take the strain off the grid at peak times.

However, EV manufacturers have realised that EVs present an opportunity to act as energy storage for smart grids. It is expected that as EV charging systems become smarter and more interactive, the growing number of EVs on the grid during peak times will actually act to smooth out the consumption peaks and improve grid stability.

—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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When selecting any service provider, get two or three quotes and check accreditation/references.
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Ultra low current LED flasher
Turn an old clock into something useful

You can turn an old electric clock into an incredibly low current draw LED flasher and it will cost you almost nothing. Julian Edgar shows how.

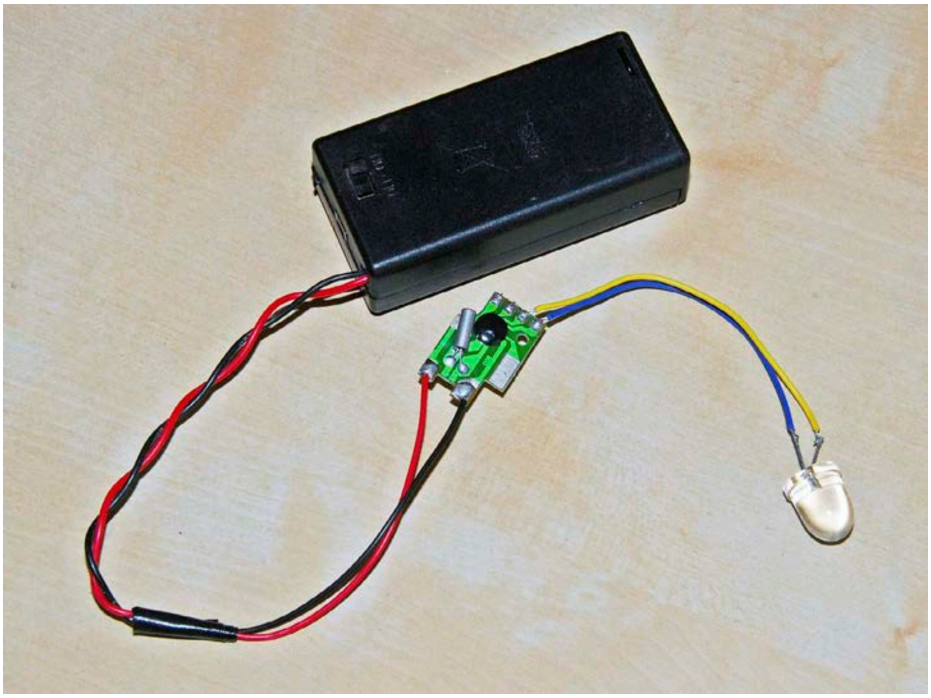
DO you have an old battery-powered electric clock around the place? Maybe it fell off the wall and damaged the dial—or even broke the glass? Or perhaps you have a small alarm clock that you picked up at a garage sale for 10 cents—but you've never used it ... and never will. Well, here's a great project that makes use of the clock, an LED and a few batteries.

What we have here is an ultra low current LED flasher. So what use is that then?

Well, if you need to have a 'power on' indicator on battery-operated equipment, this LED will consume far less power than a conventional LED. That way, the 'on' indicator is contributing only fractionally to flattening the battery.

Or take an indicator that needs to provide a security warning, like the flasher now fitted to many car dashboards. Again, the requirement is for an indicator that takes very little current. Or when you want to be able to find a camping lantern in a dark tent: just fit this flasher and you'll always know where it is. And you can leave it flashing all night without taking any more than a tiny current draw from the battery.

So wherever warnings or indicators are needed, or the requirement is for a flashing LED that can operate in a low power environment, this is the LED flasher you need.



↑ The completed LED flasher, ready for mounting in a box. The flasher will operate continuously for many weeks on a pair of alkaline AA cells. Used as a 'power on' indicator in battery-operated equipment, it draws only the tiniest of currents.

The building block

The circuit board for this project is taken straight from the battery-operated clock. Remove the circuit board from within the clock module. Carefully study (1) the polarity of the power connections to the board, and (2) the connections for the external solenoid coil that powers the clock mechanism. Many small alarm clocks also have a remote piezo buzzer. You don't need this so it can be removed by snipping its wires.

So how do you make this module into a flasher? Simply connect a high intensity LED to the solder pads that once went to the solenoid coil. Then connect a 3 V power source to the power connections, observing the original polarity.

It doesn't matter which way you connect the LED, and despite the clock originally being powered by 1.5 V, it will work fine on 3 V.

But hold on! It doesn't matter which way you connect the LED—how can that be so?

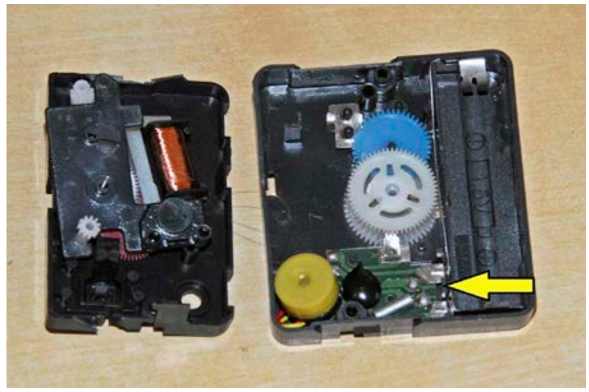
The clock module outputs a pulse every second, but one is negative-going and the other positive-going. The LED lights only when its connection polarity matches the direction of the pulse. Furthermore, because the pulse is so short and the internal current source appears limited, you can drive pretty well any high-intensity LED directly from the output without using a current-limiting resistor. (If you are worried by that, you can of course insert a series resistor.)

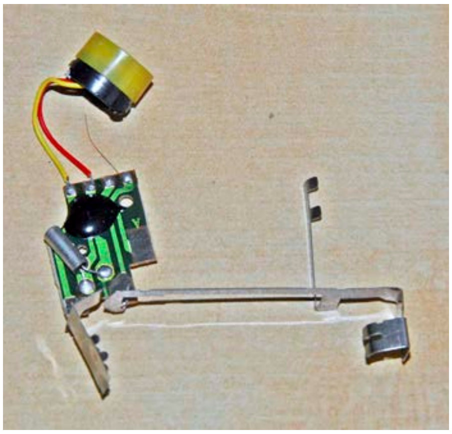
Flashing

The LED will flash once every two seconds for a 31 millisecond pulse—a duty cycle of just 1.56%. (At a measured 20 mA current, you can now see why battery life is so long!) If you want a faster flash rate, just parallel another

← Any small battery-powered clock can be used as the basis of this project. You can buy them new very cheaply or salvage the workings from a discarded clock.

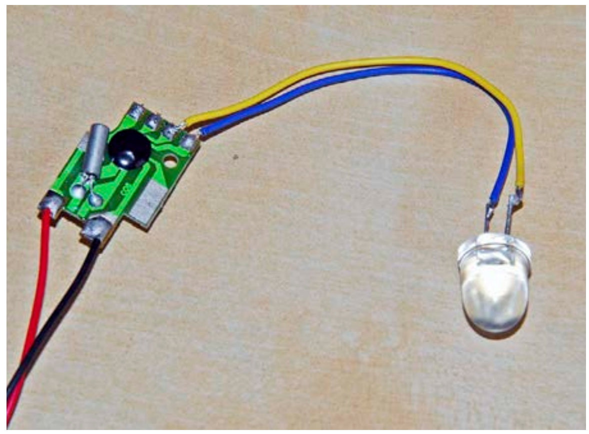
→ Disassemble the clock until you can remove the circuit board (arrowed). Before you do so, take special note of the polarity of the battery connections, and which solder pads connect to the solenoid coil.





← Remove the electronics. In this case, the clock had an alarm – we don't want it in this application, so the buzzer wiring can be cut off. This PCB design uses battery clips that can be slid off the board; other designs will require the battery wiring to be unsoldered.

→ Connect 3 V of battery power to the original power terminals (use the correct polarity!) and solder an LED directly across the solenoid coil outputs. Use flexible thin insulated wire for these connections.



LED in reversed polarity to the first. The LEDs will flash alternately, an LED lighting once per second. You can also use two different coloured LEDs; for example, you can have a green/red flasher.

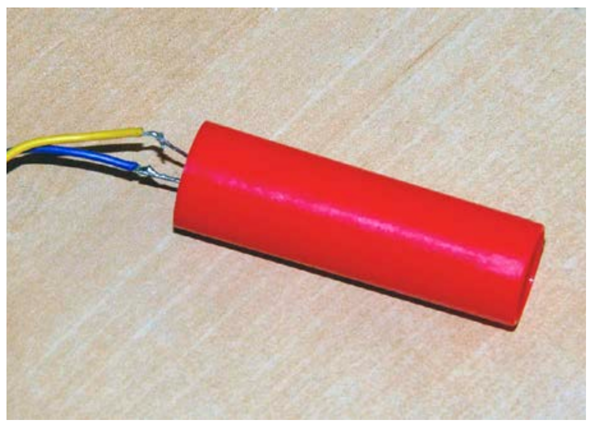
Be very careful when soldering to the board. Always use small diameter flexible wires rather than solid-cored copper (as is used on the LED leads). If you don't use flexible wires, it's very easy to lift the solder pads off the board by bumping the connection.

The LED you use can be as large as the 10 mm design used here, or as small as a 1.8 mm unit. Even smaller LEDs are available. If you want a prominent warning, use a 10 mm LED and cover it in a tube of semi-translucent plastic—I used the cap from a thick marker.

Conclusion

What a great project! In my household, where everyone can see the 'test' LED flasher happily beavering away, it's become a conversation piece—when will the battery finally give up the ghost? Anywhere you need a low current 'power on' indicator or warning, it's perfect. ✱

→ A coloured cap from a marking pen can be used over the LED to give a more diffuse glow.



How long will it flash?

So how long will the LED flash for? I can't tell you—I have just about given up waiting for the battery in the test unit to go flat!

To try to test this, I rigged up a clock module and an LED with a couple of old alkaline AA cells I had lying around. They were certainly not new—I think their combined voltage was about 2.9 V.

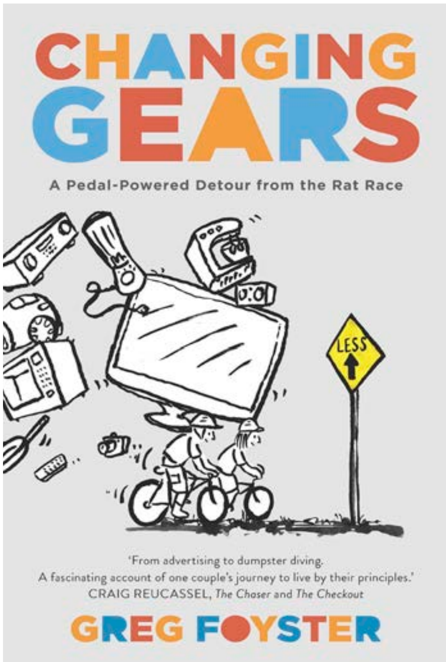
I started the LED flashing and then left it to its own devices, working 24 hours a day.

After a week, it was still flashing happily. After another week—over 330 hours—it was still going. And the battery voltage? It had dropped only 0.1V to 2.8V!

Given that a new pair of AA cells have a voltage of about 3.2 V, you can see that it's very likely that with new batteries, the LED would flash for months. Fit two D-cells and it may well flash for years.

Told you it was low current!

Taking time to change gears



CHANGING GEARS
A pedal-powered detour from the rat race
by Greg Foyster
Affirm Press 2013
$24.95
ISBN: 978-1-922213-13-6

Changing Gears is not your average road-trip book just as Greg Foyster is not your average advertising wonk.

At the ripe old age of 25, Greg has a 'mid-life' crisis that sees him question his chosen profession and its link with consumption—or overconsumption. With an increasing gap between his values and the advertising industry in which he's working, he decides to quit his job and attempt to discover what a sustainable life could look like.

After spending a month touring Tasmania, camping in a secondhand Aldi tent, Greg and his partner Sophie embark on a cycling trek up the east coast of Australia from Melbourne to Cairns. Their plan: to visit people their research suggested would help in their search for a low-impact way of living.

From suburban greenie to permaculture guru; from co-housing projects to a solitary figure walking the roads with a swag on his back; from suburban gardening to dumpster diving; and from vegetarianism to eating roadkill, this book covers as much lifestyle territory as Greg and Sophie cover in distance on their bikes.

Along the way, Greg questions what it means to live in today's society. Without being judgmental, theirs is a journey of self-discovery and enlightenment about how we might change the way we live to create a simpler, more enriching world. It's written in a self-deprecating style that will often have you smiling to yourself.

They learn many lessons along the way and come back to Melbourne with a strong sense of the difference individuals can make. When compared with the lives our parents led or, indeed, the majority of the world's population lead, most of us in Australia live in extreme luxury, yet by and large we're unaware of the privileged position in which we find ourselves.

"From suburban greenie to permaculture guru; from co-housing projects to a solitary figure walking the roads with a swag on his back … "

Greg says, "Maybe the things we think are normal are just collective habits. The process of changing them is painful for a short time, but once you've adjusted to a new normal you don't feel deprived of the old way." Greg sums up with a quote from Gandhi: "Live simply so others may simply live."

Most people go through life content to simply 'go with the flow'. This book asks: what if more people questioned the raison d'être of modern life and changed gears for a simpler, more rewarding existence? Imagine if, by doing so, we could help provide for ourselves as well as making sure those that come after us can also live well. Wouldn't that be a change worth considering? ✱

Review by John Knox
Changing Gears is available at Dymocks and from booktopia.com.au

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