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Technology for a sustainable future

Issue 136

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Investing in innovation, solar leading the world and more

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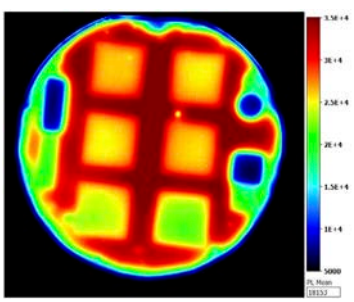
↑ Being a city dweller doesn't mean you have to be out of touch with nature. Discover the rewilding movement. Page 38.



↑ Australian solar technologies have led the world for decades. We take a look at some of those advances and see where PV manufacturing is headed. Page 50.

Features

↑ Solar One was Australia's first grid-connected solar home. Check out this piece of solar history. Page 46.

Special feature: Australian-made

↑ Cultivating grain is not a modern concept. Learn how it was done millennia ago. Page 48.

← **Cover image courtesy Viva Living Homes: It takes a community to build a strawbale home!** A lot can get done in a four-day building workshop when you've got a team like this. As one of the owners of this home, Andy Stevenson, notes, a great thing about strawbale building is the community-minded people who get involved with "dirty, muddy, earthy hands, connected to the materials and each other in a way you don't get with a traditional build." In this issue of *ReNew*, we cover the building workshops that can help make your strawbale dream a reality, alongside three case studies, starting on page 24. Community also features strongly in our Australian-made theme starting page 42, with articles on investing in innovation, community energy and much more.

Guides

Eco-paint Buyers Guide

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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 an ATA membership. *ReNew* subscriptions start at just $30.
www.renew.org.au

Sanctuary magazine

The ATA also publishes *Sanctuary: modern green homes* which offers inspiration and practical solutions so you can make your home or build more sustainable. The current issue celebrates small dwelling designs that are affordable and sustainable, and profiles 10 outstanding green granny flat and self-contained studio designs from across Australia.
www.sanctuarymagazine.org.au

Advocacy and projects

The ATA advocates in government and industry arenas for policies that support household sustainability. The ATA conducts research into new and emerging technologies and associated consumer behaviour. We also provide consultancy services based on our technical expertise in energy, water, transport and communications.

The ATA is currently conducting analysis to help advise owners of rooftop solar in NSW, VIC and SA on what to do once their premium feed-in tariffs expire at the end of 2016. We are also continuing to advocate to government and industry for a switch from gas to electricity.
www.ata.org.au/what-we-do/advocacy

Alternative Technology Association

The Alternative Technology Association (ATA) is a not-for-profit organisation that enables, represents and inspires people to live sustainably in their homes and communities. Established in 1980, the ATA provides expert, independent advice on sustainable solutions for the home to households, government and industry.

ATA has over 6000 members across Australia walking the talk in their own homes. ATA also conducts research on sustainable technologies and practices and advocates to government to make it easier for other Australians to live sustainably.

Become a member of the ATA and gain access to a large support network of knowledgeable people and receive a range of services to help you achieve your sustainability dreams. Your ATA membership provides you with benefits such as our free expert advice service, subscription to *ReNew* and/or *Sanctuary* magazines, free access to back issues online and discounts in the ATA webshop and on other green products and services.

Not only does your ATA membership provide you with independent, practical advice on sustainable living but, with your support, the ATA will remain at the forefront of the next wave of innovative sustainable solutions that will define our homes and communities in the future.
www.ata.org.au

International projects

Since 2003, the ATA's International Projects Group (IPG), comprised mostly of volunteers, has been working with East Timorese communities to provide clean, renewable lighting and electricity. We are currently in the planning stages to install hundreds of solar-powered lighting systems in remote villages in July–October this year as part of a Google Impact Grant.
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: 21 July 2016.

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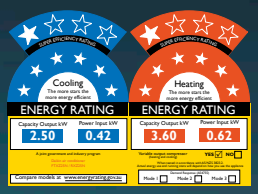

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Editorial

Aussie, Aussie, Aussie! Homegrown design and tech

CHEERING on Australian-made research and production in this issue has proved something of a conversation starter. Everyone has a favourite product or company, or an opinion on what we're doing well or not so well. But the 'we' has stumped me at times: against a backdrop of stalled climate policy and the way the on-again, off-again support for renewables has affected the industry, it can be hard to speak proudly of that 'we'.

Yet there is a story to be told of innovation (an overused word perhaps!) in Australia that is slightly different from the one we often hear. The stories of lost commercialisation opportunities and industry heading overseas are certainly one strand, but there's also a (very *ReNew*) story of DIY activists getting a renewables industry started in Australia, of researchers leading the world in solar cell design—with the Australian-invented PERC cell now featuring on about half of new solar cell production lines—and of a fast-growing community energy sector taking on the unique challenges of the Australian energy market, making projects work, then advocating for change to make them work better. And, of course, of architects slowly, slowly bringing sustainability into the mainstream of building design. Sustainability is another overused word, but it's been exciting finding these stories of research, investment, production and development.

It's not all about energy or household systems. One of the best stories comes from Bruce Pascoe, based on the research for his book *Dark Emu*. The oldest grain grinding stone in the world has been found in Australia, evidence of breadmaking 12,000 years before the Egyptians. As Bruce asks, why don't "our hearts fill with wonder and pride" in such innovation?

There's much beyond our Australian-made theme. Building with strawbales is one, with guidance on the workshops that can help, and case studies on people who love their houses 'built of straw'. We look at the important issue of keeping textiles out of landfill, and we also cover ways to reconnect with nature in the city. A reader tests whether battery-powered leaf blowers can compete with petrol ones (many may think that the job could be done with a broom, but the author suggests otherwise), and we look at what to consider to ensure you buy or build the most efficient computer possible. With gaming PCs using up to 350 watts just for the graphics card(s), it's particularly important information for parents of young gamers!

Many households are about to lose their higher feed-in tariffs, so we (via the ATA, *ReNew*'s publisher) look at what solar customers should do. Finally, our buyers guide this issue is on eco-paints. It's a good news story with many sustainable changes in the industry since our last buyers guide in *ReNew 107*, including a new scheme for recycling paints. It's a packed issue, enjoy!

Robyn Deed
ReNew Editor

In *ReNew 137*, out late September
A focus on off-grid and hybrid systems.

THE Australian-made green innovations in this issue of *ReNew* are a great testament to home-grown ingenuity. The ATA has been fostering sustainable technology since 1980, when a group of enthusiasts concerned about fossil fuels and pollution came together to form our organisation. Their can-do, practical approach has been at the heart of the ATA ever since.

The ATA has had many Australian firsts including owning a community wind turbine at Breamlea in Victoria, national sustainability education tours with our energy-mobile and Australia's first trial of greywater systems in response to growing interest in water saving during the millennium drought. We also led the way in making it easier for home solar systems to be connected to the grid by actively lobbying for consistent agreements and financial incentives. The now 1.5 million households in Australia with rooftop solar have benefitted from the ATA's pioneering work.

And the innovations continue: we played a key role in the installation of a 36 kilowatt solar system at the Kurrawang Aboriginal Christian Community near Kalgoorlie in WA. The project showed how you can be creative with community energy and impact investment for community and environmental benefits. Thanks go to ATA member Robin Gardner, who was instrumental in the success of the project.

ATA members were also instrumental in developing and assembling the new Village Lighting Scheme solar system that will be installed this year on hundreds of homes in East Timor as part of the Google Impact Challenge grant. Special thanks to Alan Hutchinson and Patrick Eijsvogel for their huge effort on the new system design, and the many volunteers involved. In recognition of our work in East Timor, the ATA recently won a United Nations Association of Australia World Environment Day Award!

Donna Luckman
CEO, ATA

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Up front

Independent battery testing project

In a world-first trial (supported by $450,000 of ARENA funding) at a purpose-built facility in Canberra, IT Power is about to commence a three-year project that will give consumers and industry stakeholders information on lithium-ion battery performance, independent of manufacturer claims.

The project will analyse the performance, simulating real-world applications under Australian conditions, of six major lithium-ion battery brands, comparing them to existing and advanced lead-acid batteries, to demonstrate how they could operate in large and small electricity grids.

Given recent reductions in the cost of lithium-ion batteries and their potential performance advantages over conventional storage options, this timely trial will help people make informed investment decisions.

The trial is due to commence in July 2016 and real-time outputs of the eight batteries in the trial will be able to be viewed at www.batterytestcentre.com.au

A 21st century energy plan for Australia

In a continuation of efforts to secure a 100% renewables future for Australia, The Homegrown Power Plan, a joint project of GetUp! and Solar Citizens, was launched in April this year.

Comprising two parts—a technical and economic scenarios modelling of 100% renewable electricity by Sven Teske at the UTS Institute of Sustainable Futures (ISF), and a suite of policies drafted by Miriam Lyons (GetUp) and Nicky Ison (ISF and Community Power Agency)—the plan shows how we can "repower the country with renewable energy, reboot our failing electricity system and remove the roadblocks holding back the renewables boom".

The ISF modeling is the first to examine a scenario where not just electricity but also all transport and heat used by industry in Australia are transitioned to 100% renewable energy. It suggests that a completely decarbonised energy system for Australia by 2050 is feasible. Although considerable investment into renewables infrastructure will be required, this will be more than offset by subsequent reductions in fuel costs. And by using a mix of different renewable energy sources, the modelled scenarios all maintain an electricity network that is as reliable as the current one.

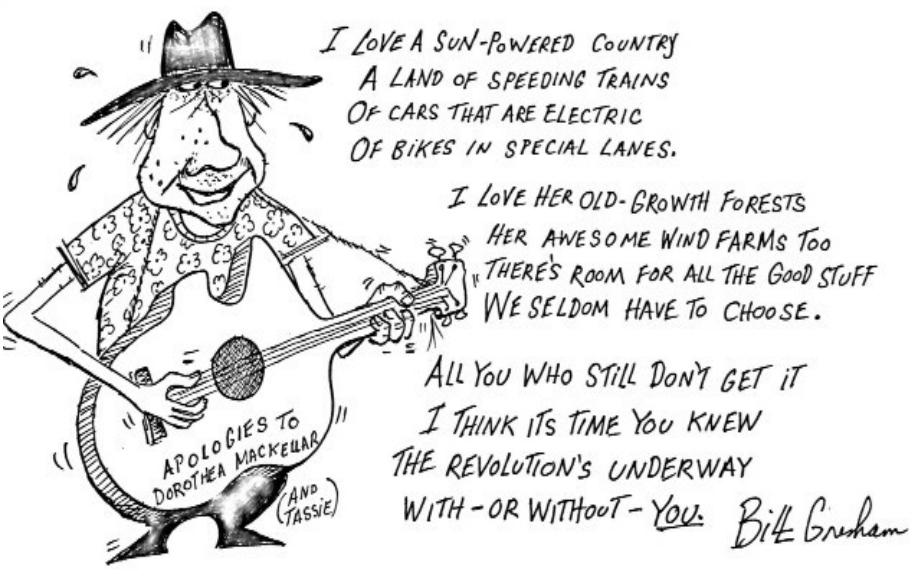
The authors consulted with the Clean Energy Council to ensure the scenarios grew the renewables industries at rates that would be feasible. It would require increasing wind installations by 2600 MW a year for 15 years, and solar PV would need to be installed at a rate of 4500 MW per year to 2030.

In a report on the ISF study recently in *The Guardian* (Australia), Olivia Kember from the Climate Institute said, "This modelling adds to the growing body of evidence that Australia is completely capable of decarbonising its electricity system."

To this end, the second part of the plan looks at the current National Electricity Market (NEM) model—centralised, fossil-fuelled—which, it says, is out of touch with current and future realities and needs to be re-designed. It outlines some short- and longer-term steps towards that.

Finally, it explores a number of factors currently blocking a renewables future, and what we can do about them.

To download the full report: www.getup.org.au/hpp



Butts and bricks reducing litter

Worldwide, 6 trillion cigarette butts constitute 1.2 million tonnes of toxic waste each year. Not only do they have poor biodegradability, but heavy metals trapped in the filters leach into the soil and contaminate waterways.

For years dreaming of a practical and sustainable solution to this problem, senior lecturer in the school of engineering at RMIT Dr Abbas Mohajerani believes he has found it, in the form of fired bricks made with a mixture of clay and cigarette butts.

Testing bricks with butt content of between 1% and 10%, and analysing factors including strength, leaching, mixing/heating time, and gas emissions, Dr Mohajerani and his team have found numerous benefits of adding cigarette butts to bricks: toxic pollutants are

Photo courtesy AAP Medianet

↑ Dr Abbas Mohajerani has shown that bricks with 1% cigarette butt content like these have numerous environmental benefits.

Renewables round-up

Ergon Energy has just signed a 15-year agreement to purchase power from the Mt Emerald Wind Farm in Far North Queensland. The wind farm will be the first built in Qld for 15 years. Its 63 turbines generating up to 189 MW of power will help the state to meet its renewable energy target of 50% by 2030, as well as providing jobs and millions of dollars into the economy during construction. mtemeraldwindfarm.com.au

Energy company AusNet Services is trialling a solar mini-grid with 14 households in the Melbourne suburb of Mooroolbark. Participating residences will be given 12 kWh of battery storage, solar panels for their roof and a smart control system to bring the elements together. For the first year of the trial, each household will just generate and use the solar electricity, backed up by the grid. After that, AusNet will start "playing" with sharing energy between the households. While of no immediate benefit to the company, it hopes to learn more from this trial about what consumers want and need, and to determine a payment model for shared electricity. http://ab.co/1XOpjDr

More than 5000 households in and around Canberra will get discounted battery storage over the next few years, subsidised from the proceeds (expected to be around $25M) of the latest round of capacity auctions for large-scale renewables in the ACT. This will be the largest subsidised roll-out of battery storage outside of Germany. www.bit.ly/1TJ6ZGQ

Queensland's Whitsunday Regional Council in May approved a permit for change of land use at Kelsey Creek, which paves the way for a 50 MW solar farm that will be operational for the next 20 to 30 years, and create 200 jobs during a year's construction. www.bit.ly/1VuVgR1

The Red Mud project in SA's agricultural Riverland region has the potential to boost revenues for struggling farmers while also boosting the nation's solar energy supply. Renmark-based Yates Electrical Services is hoping to build dozens of community-owned 100–200 kW solar farms, which will sell the energy into the national electricity grid via the spot market. Landowners have the option to lease their land to be used for a solar farm, lease the land and buy into a portion of the farm, or choose to own the entire solar farm outright. A 180 kW test site that has been operated by Yates for three months (as at end May) has shown up to a 10% return on investment. The first commercial site is on track to begin generating energy by early August. www.redmud.net.au

The City of Melbourne's Renewable Energy Project has taken another step forward, with tenders to build and operate a renewable energy plant in regional Australia having gone out in April. The first step in the project was bringing 10 large-scale energy consumers to invest in a long-term electricity contract spanning at least 10 years. It is now hoped that a plant could be up and running in two years. www.melbourne.vic.gov.au

Image courtesy Mark Yates; www.redmud.net.au

↑ Red Mud's 180 kW test site in SA's Riverland region has shown that a 10% return on investment may be feasible for landowners participating in this community-owned solar initiative.

In WA, Curtin University's Sustainable Policy Institute (CUSP) is trialling a world-first zero-carbon neighbourhood utilising solar PV and battery storage, within a new Landcorp strata development in White Gum Valley. The development will act as a quasi-utility that will own and operate the solar power infrastructure and sell power directly to around 40 householders and tenants. Researchers will monitor installation and management of the solar storage, as well as household energy use. The project will also include making electric vehicles available for rent to the public. With $1M funding support from ARENA, the trial will run for three years, and be informative on a global scale. www.curtin.edu.au

trapped in the brick during firing, eliminating problems of leaching and contamination; the energy required to fire bricks can be significantly reduced (thereby also reducing costs); bricks are lighter and have better insulating properties (improving a building's thermal performance).

The team's research paper (published in *Waste Management*, vol. 52, June 2016) proposes the use of bricks with 1% of cigarette butt content throughout the brick-manufacturing industry, as these bricks maintain properties very similar to those of normal bricks, and have the added advantage of helping solve a global litter problem.

The mechanisms are in place for collecting cigarette butts on a large scale, with businesses and governments around the world increasingly providing cigarette butt bins to help ensure smokers dispose of their butts responsibly. Rather than going to landfill or being incinerated, they could be diverted to this novel reuse instead. www.rmit.edu.au

Renewables report card for Oz

The Climate Council's new report, *Game On: Australia's Renewable Energy Race Heats Up*, finds SA to be the frontrunner overall, followed by Tas, Qld, WA, Vic and NSW. While lacking sufficient comparable data to be rated against the states, the ACT is noted as a strong contender, while the NT performs poorly.

The results are based on renewable energy policy settings and performance across a range of indicators including rooftop solar penetration, large-scale capacity per capita and percentage of renewable electricity.

The report finds that policy support for renewable energy across the states continues to increase. And all states, except Vic and NSW, have increased the proportion of renewable energy in their electricity supply since the Climate Council's last update in 2014. Fossil fuels still account for 90% of the energy supply in NSW, Vic and Qld. On a more positive note, nearly a third of all homes in Qld and SA have rooftop solar, and 14 postcodes in Australia have 50% solar, with demand continuing to increase. www.climatecouncil.org.au

Up front

Image: courtesy www.genex.com.au

↑ Utilising existing infrastructure plus a new high dam, the proposed Kidston solar–pumped hydro facility is a value-for-money renewables project.

Image courtesy www.statoil.com

↑ The Hywind floating wind farm will be the world's largest; however, with more such projects in the wings, that record may not last long into the future.

Proposed solar–pumped storage hydro for Queensland

Genex Power—with the backing of ARENA and the Queensland Government—has nearly completed the feasibility study for a combined solar and pumped hydro project at the disused Kidston Gold Mine 280 km NW of Townsville. When commissioned, the facility will provide stability to the grid and potentially lower the grid price at times of peak demand.

The proposal utilises dams, water rights and other existing infrastructure at the site. The new solar farm will initially cover 300 ha and have 50 MW of solar panels with single axis tracking. A proposed additional transmission line will increase this to 150 MW. Excess power generated by the solar farm will be used in times of low demand to pump water from a low dam on the site to a new high dam. The water in the high dam can then fall back to the low dam through purpose-built tunnels and turbines to generate electricity on demand. It is estimated that the high dam will hold water sufficient to generate 450 MW over a 5 to 6 hour period.

www.genexpower.com.au

BYD adds electric trucks to its range

Chinese battery and electric vehicle manufacturer BYD will be adding four trucks to its extensive range of electric cars and buses. The trucks, ranging from 4.5 to 44 tonnes, all have lithium iron phosphate batteries that charge at 480 V, are covered by a 12-year warranty, and include vehicle-to-grid technology. All have a top speed of about 100 km/h, a range of between 160 and 250 km, and charge times between 2.5 and 4.5 hours.

This new line of trucks is being manufactured for the US market at BYD's facility in California.

BYD is the world's largest manufacturer of mobile phone batteries, and 10,000 of its electric buses are reducing pollution in cities all around the globe. In 2015 it manufactured about one third of the 188,000 electric cars sold in China. One of their models, the E6, will be available in Australia soon, retailing at around $80,000. It has a 75 kWh battery and a range of 300 km. Although not a direct competitor, it compares favourably with the Tesla Model S, which sells for $140,000 and has a range of 430 km.

www.cleantechnica.com

New battery storage guidelines

The Clean Energy Council (CEC) has introduced a set of comprehensive installation guidelines for home battery storage, greatly simplifying the process for installers and helping ensure the safety of consumers.

The guidelines have been established after a year of consultation and are based on a study of battery storage safety undertaken in partnership with CSIRO in 2015.

With the potential for home energy storage to go mainstream in the near future, the guidelines should help make that future a safer one. 'Install Guidelines for Grid-Connected Energy Systems with Battery Storage' is available for download from www.solaraccreditation.com.au

Floating wind farms

Floating wind farms are now set to become a key player in the renewables sector, with the world's largest destined for the seas off Scotland in 2017.

Norwegian company Statoil has just been granted the seabed licence that will allow construction of the Hywind wind farm to commence this year, with five 6 MW turbines to be installed, which will power around 20,000 households.

While standing offshore wind turbines become prohibitively expensive at depths of more than 40 m, floating turbines can operate at depths of up to 92 m. Rather than being statically attached to the sea floor, they are instead moored to a steel tube that has a ballast attached to the seabed, allowing them to float.

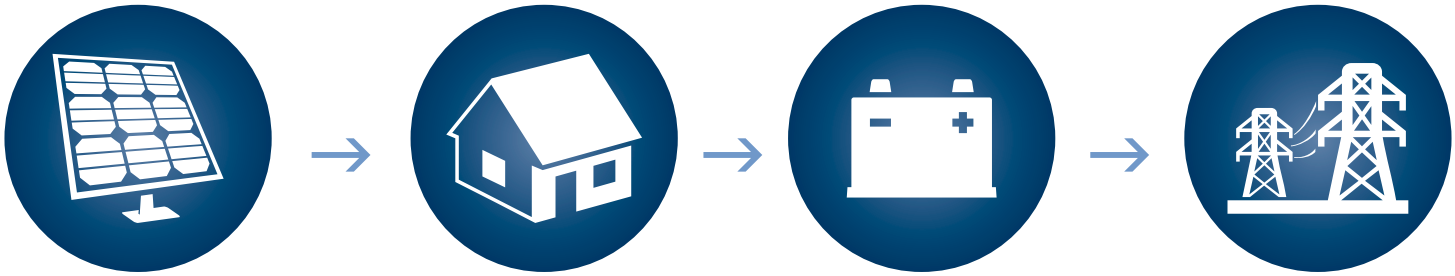
And while this project will be the world's largest floating wind farm to date, the largest floating single turbine was launched near Fukushima in Japan last year, and another farm is proposed for Portugal in 2018.

www.gizmodo.com.au

Congrats to our prize winner ...

Congratulations to David Shlager from Clovelly, NSW, the lucky recipient of our Australian Ethical $5000 managed fund subscriber prize. David and his wife are "travelling down the road of engineering a full off-grid existence", and he said this prize will make their dream a little more achievable.

See p. 80 for details of our new subscriber prize—a Daikin super-efficient reverse-cycle air conditioner. The prize is open to Australian and New Zealand *ReNew* subscribers and ATA members current at 28 October 2016. You've got to be in it to win it, as they say, so subscribe or join ATA for your chance to win!



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Letters

A crimson shade of green

Thanks Andrew Reddaway for the excellent article on solar and battery green credentials in *ReNew 135*. Having given considerable thought to the topic of grid-connected batteries, I concluded what Andrew said: they consume electricity while making no difference to fossil fuel use. The main impetus is that people feel ripped off being paid trivial feed-in tariffs for electricity which just goes to the house next door where the utilities charge full price. But from the environmental point of view, there is presently no benefit.

This may change when we get to over 50% renewables. Calculations show that we will need about 100 GWh to get to 100%. That would be two or three 7 kWh battery banks per household, if all households had batteries. Utility-size molten salt and pumped hydro are more appropriate solutions.

Another point which Andrew mentions is the issue of recycling batteries. Lithium chemistries are an entirely different proposition to lead-acid, which are almost completely recycled. Lithium batteries contain typically about six elements which are extremely difficult to separate. They also contain built-in electronics. So while there is a case for using them in electric vehicles and re-purposing them in stationary applications, I would not consider using new cells in stationary situations to be green, particularly if they are continuously discharged and charged purely for tariff purposes. In the end they wear out and you are then left with a box of toxic junk to recycle or dispose of.

A final point: many lithium batteries contain cobalt. This is mined in the Congo by children as young as seven in appalling conditions in which they inhale the toxic dust. At present, lithium batteries are a crimson shade of green—spend the money on more PV or efficiency measures.

Prof Peter Seligman

Batteries are worth it

Congratulations on Andrew Reddaway's recent article on embodied energy of solar PV + battery systems. Excellent work!

Andrew packed in lots of educative insights and achieved a very accessible style. I'm sure it will assist many folk in practical ways and will help raise general awareness of the important concept of embodied energy.

Andrew's result numbers give a really useful sense of proportion, which I think is a great contribution. Battery systems ended up not being too bad after all—with only a slightly longer energy payback period than grid-connected panels, and still very green over their lifeThanks for your work. I hope it stirs up a big response.

John Weir

A better toaster

Jo Prendergast asks in *ReNew 135* whether a toaster could be made to cook individual slices as required. I have clear and fond memories of a Sunbeam toaster my parents had. It was a gorgeous creation in black and chrome, with a sliding control along the base. A two-slice toaster, it was mechanically automated so that placing a slice in the front slot caused the bread to gently sink into the machine, rising slowly once cooked, the pertinent fact being that if only the front slot was loaded, then only the front slot got hot. No electronics, just springs and gears and contacts.

I think this device dated from the 60s, and it was the late 80s before its mechanism started to give trouble. Hit the op shops, perhaps?

Chris Hooley

We have in fact tracked down some Kenwood toasters that only heat one slot. See the Products section in this issue for details.

Lance Turner

Slab insulation

Love the mag and look forward to every edition. I was just wondering if you can clear up some info on the polystyrene insulation and under-slab blocks they now regularly use when building new homes. I understand the insulating properties are fantastic. But should we really be using so much of this material in new homes? Is it easy enough to recycle, or are we creating a big mess for the next generation?

Anthony Wasiukiewicz

Any time you combine two materials, it can be a problem when it comes time to separate and reuse them at the end of their lives. It's not just concrete and polystyrene in slabs, but is also an issue with many products in the building industry where different materials are combined in ways that make later deconstruction and recycling difficult.

However, we use polystyrene in wafflepod slab construction, particularly in Melbourne, and there are a couple of factors we consider. Firstly, in Melbourne at least, the polystyrene usually adds about a Star to the energy rating, which is a significant improvement on operational energy over a building's expected life of up to 100 years. These efficiency savings are in excess of the energy that goes into creating the product. Secondly, waffle slabs typically use less concrete than traditional sand slabs. Thirdly, we choose waffle pods with up to 30% recycled content, so that mitigates some of the production cost to the environment. At the end of the building's life, the slab material may end up in landfill, or it may get crushed and reused in such things as road bases—a 'downcycled' use, but at least some reuse of the material.

Jeremy Spencer, Positive Footprints

Using polystyrene under slabs in cool climates makes a useful difference to the thermal performance of the house in winter and is probably one of the more benign uses of the material. It's locked away for a good long time, and won't degrade in situ or off-gas. Summer performance will degrade a little but there will be a significant reduction in total annual energy use. It's not useful in warmer climates as it breaks

Feed-in tariff changes

I have a problem that is also about to be faced by many households that also have rooftop solar panels. My contacting you has been prompted by the recent receipt of a letter from the NSW Department of Industry reminding me of the cessation of the Solar Bonus Scheme, effective 31 December 2016.

At the moment I effectively have two systems in operation. The first was installed under the earlier available gross metering scheme, with 1.5kW of panels monitored by a Sharp solar inverter JH-1600E (single-phase), incorporating, at the insistence of the retailer, a smart meter recording peak, off-peak and shoulder usage of power drawn from the grid.

Subsequently installed under the net metering scheme were 3kW of panels, together with a Shenzhen JFY0-Tech Co JSI-3000TL single-phase inverter, bringing the theoretical combined maximum wattage to 4500 watts.

So with the imminent cessation of the gross metering scheme, I would value some unbiased advice about how to best adapt the system to cope with the imminent regulatory change.

As a minimum I suspect that I will need to reconnect both sets of panels to a new, single higher capacity wattage inverter—presumably also incorporating a smart meter?

Since there is also the prospect of adding batteries to my system sooner or later and adding a few more panels to store more production for night usage and cloudy days, I think that a bigger capacity inverter may be prudent—and some change to wiring may be required because I have the vague understanding that these changes, if implemented, may require a move to three-phase wiring?

Complicating the analysis is the operation of the pool pump and chlorinator which draw just over 1kWh per hour and consume about one-third of our daily power usage on average. I understand there are now variable-speed pool pumps which may be at least a third more efficient than the one I have at the moment, so I also need to consider this type of change as well.

As I said, there must be thousands of households facing a similar situation, and I am sure they would appreciate some unbiased advice on how it might be dealt with in an optimum way.

Charles Adderley

Your letter is timely, as the Alternative Technology Association (publisher of *ReNew*) has recently undertaken research on this issue; see the article 'Life after FiTs' elsewhere in this issue.

There are a number of ways that you can make better use of the excess energy you are generating without the need for battery storage or new inverters. These include using the energy to provide domestic hot water, or to run other larger loads such as air conditioning or heating, and for shifting loads that run at other times, such as your pool pump and chlorinator, to run at times of maximum solar generation—all that's needed is to put them on a timer, or have a solar diverter such as the SunMate installed. None of this requires a change to three-phase power, and unless your home has a three-phase connection, you would need to stay with single-phase anyway—adding a three-phase connection from the street would be unnecessary expense.

If you do decide to go with a new inverter, it is definitely worthwhile considering a hybrid inverter that can have batteries connected at a later stage.

Lance Turner

the link between the slab and the stable temperature of the earth underneath. It's important to realise that it's not one-size-fits-all: we recently assisted in the design of two 10 Star homes, one of which needed R0.7 insulation under the slab and the other R4 to reach 10 Stars, with the difference partly due to climate and partly to other thermal performance attributes such as surface area and window placement.

Tim Adams, F2 Design

Clean up Australia has a fact sheet on recycling polystyrene at www.bit.ly/25niSxa which reports very low recycling figures for polystyrene foam. The Recycling Near You website does state that recyclers can take building waste (see www.recyclingnearyou.com.au/polystyrene) but the Expanded Polystyrene Australia website which it refers you to has very little info and few recyclers listed. I suspect that the recyclers will only take clean offcuts from construction, not contaminated waste from deconstruction. As an alternative to foam insulated slab systems, see the Cupolex system in Products this issue.

Lance Turner

A good tap solution

In *ReNew 135* Lance Turner responded to Margaret McKenzie's letter on 'Poor Tap Design'. Lance asked if any reader knew of a tap which allows cold water to run in when the handle is in the centre position. I have a new bathroom and I selected the Roca L20 (142) Basin Mixer for my vanity. The handle starts in the centre for cold and only moves to the left for hotter water.

Eric Rodda

We take a look at the Roca mixer taps in Products this issue.

Lance Turner

Do less washing

Retired people need to use a washing machine rarely, for heavy washing only, as they have the time now to spend some of it on washing. Collect heavy washing until you have a full load. Most clothes can be washed by hand, as they need freshening only because they are not dirty. Soak beforehand in buckets that are used to water the garden, then wash by hand in one bucket of soapy water or detergent with a second bucket to rinse. If necessary, spin dry, such as in an old twin-tub washing machine.

Hang clothes outside for exercise and air drying, except in winter, when an inside clothes-horse is sufficient. Carry the buckets half full for healthy exercise. You will find you use less detergent, less water and less heating for water.

Valerie Yule

Write to us

We welcome letters on any subject, whether it's something you've read in *ReNew*, a problem you've experienced or a great idea you've 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.

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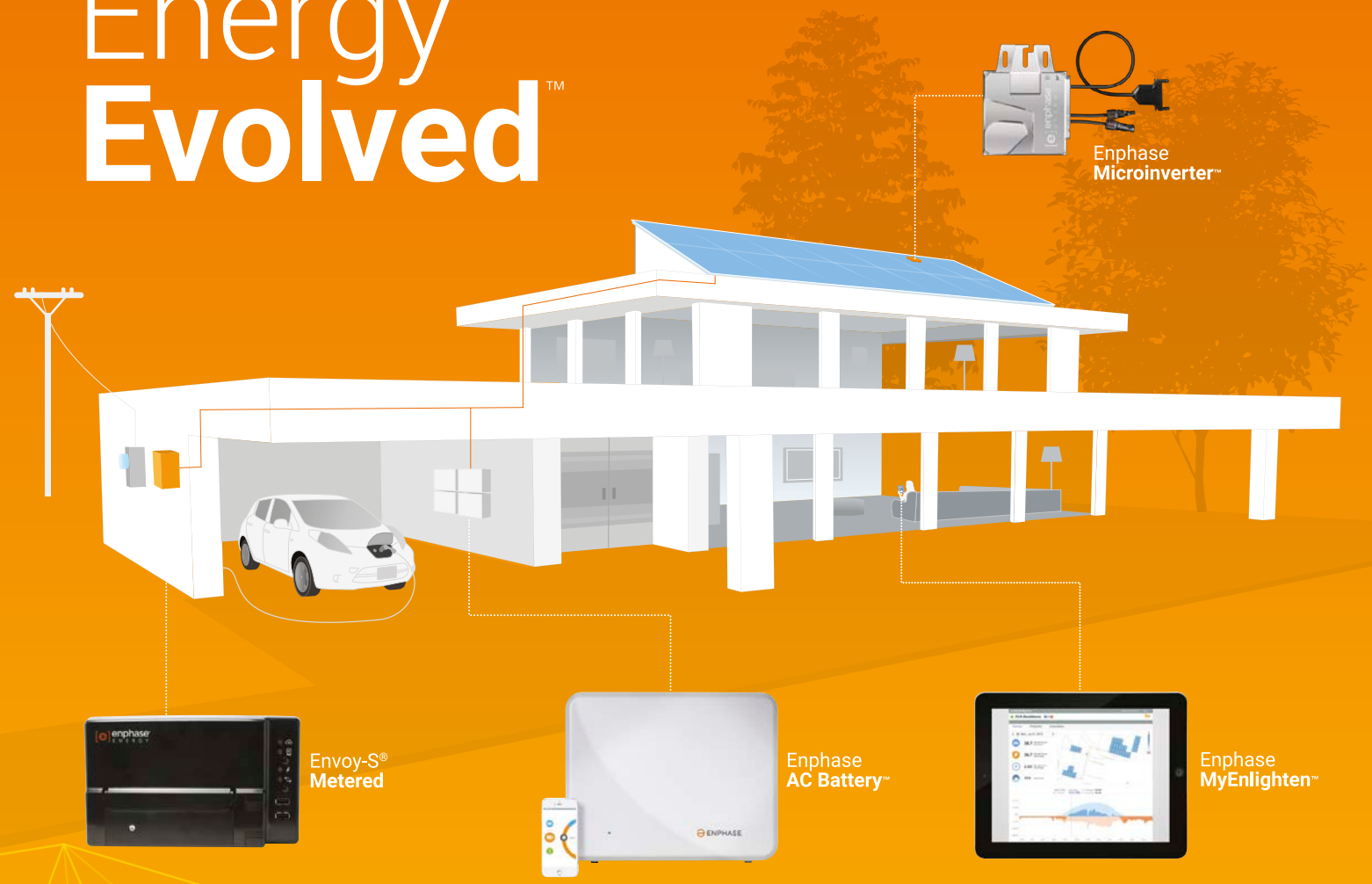

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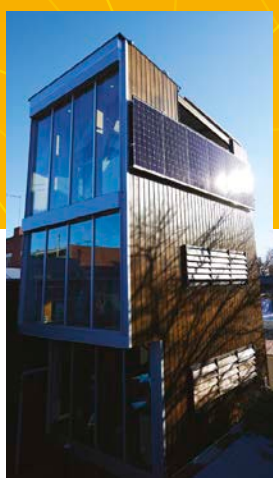

VIDEO: *See inside 5x4's Enphase solar system*

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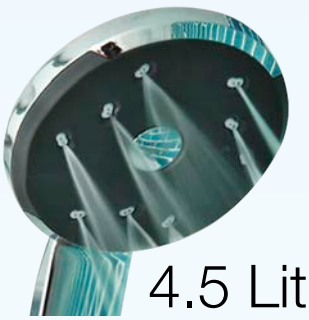

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Products

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

Combined PV and SHW

On many modern homes, roof space is at a premium, and often there isn't space for both a solar PV system and solar hot water.

The Tractile Eclipse solar roof tile system combines both solar PV and a solar hot water collector into a modular roof tile. It's part of a complete roofing system, along with the other tiles, caps and trims in the Eclipse range. By combining roofing material, PV panels and SHW collectors into one unit (there is also a SHW collector only unit, without the PV), you end up with a much neater looking solution than the regular PV installation while potentially reducing the cost of the installation, as the solar systems are installed when the roof goes on.

The Eclipse tiles measure 1105 x 690 mm, weigh around 20 kg and have a rated output of 76 watts per tile. The hot water collector in each tile has a rated volume of around 1 litre. The tiles come in a wide range of standard roof colours.

The Eclipse system is ideal for new builds as well as renovations and re-roofing. The Eclipse tiles are rated to withstand massive 90 mm hailstones and have a 30-year performance guarantee. Rated lifespan is up to 50 years, so most people will never need to re-roof.

RRP: POA. For more information, contact Tractile, Level 49, Governor Phillip Tower, 1 Farrer Place, Sydney NSW 2000, ph: 1300 008 722, info@tractile.com.au, www.tractile.com.au

02

This tap always starts cold

One of the big gripes with flick mixer taps is that most provide a mix of hot and cold water when the handle is in the middle position. This results in a lot of small draw-offs of hot water that never make it to the tap, wasting hot water and costing you extra on your energy bill.

The L20 flick mixer from Roca is designed to always start cold—the centre position provides cold water only. To get hot water you have to move the mixer handle to the left.

The tap is designed for domestic and commercial use and has a 4 Star, 7.5 litre per minute rating. It has a maximum continuous operating pressure of 1000 kPa, with a recommended pressure range of 150–500 kPa.

RRP: around $140. For more information and to buy, contact your local Reece store. Go to www.reece.com.au to find your closest store.

03

Smarter solar systems

As battery storage becomes more popular in domestic solar systems, there is a need for better system integration to reduce the number of components, while allowing simple automation and even control of appliances for automatic load shifting. Existing options in both hardware and software are not always simple to get to work together.

The Smart Hybrid System from Redback Technologies is a hybrid inverter that is capable of controlling household loads for the purpose of load shifting to maximise the use of solar-generated electricity. It also includes export control that can be set according to the local utility requirements, inbuilt wi-fi for smartphone and web monitoring, and generation and consumption monitoring. It can also act as a fully automatic UPS without batteries in daylight hours by powering designated loads directly from the PV array, or at night with the addition of a 48 V battery bank, either lithium-ion, lead-acid or other battery technologies, from 100 to 10,000 Ah capacity. The inverter also includes a three-stage 85 A battery charger.

Maximum grid-feed capacity is 4600 W, while in backup mode the inverter can supply up to 6900 W (for a maximum of 10 seconds). The two independent MPPT solar inputs can handle a total solar array of up to 6 kW.

RRP: TBA. For more information, contact Redback Technologies, ph: 1300 240 182, info@redbacktech.com, www.redbacktech.com

04

Sodium nickel battery system

Most energy storage systems use lead- or lithium-based batteries, but there are other, lesser-known technologies that work as well or better than the popular chemistries.

One of those chemistries is the sodium nickel chloride battery manufactured by FIAMM in Switzerland, which uses sodium and nickel metals with a solid ceramic electrolyte, with the entire battery running at an internal temperature of around 270 °C! While this sounds scary, it is a well-developed and mature technology with high efficiency and long cycle life, making it ideal for domestic and commercial energy storage systems.

The Quantum smart energy storage system from Grid Edge uses a FIAMM sodium nickel chloride battery to store energy for load shifting, backup power and self-consumption of solar generation. The system, designed and made in Australia, is available in 9.6 and 19.2 kWh usable storage capacities, has a 4.5 kW continuous/9 kW peak inverter and a cycle life of 3000 to 4500 cycles at 80% depth of discharge. Shelf life is rated at greater than 20 years! System ambient operating temperature range is -40 °C to 60 °C, making it ideal for use in extreme climates. Both battery and system are warranted for five years and the battery units are 100% recyclable.

RRP: none set, price will be set by installers. For more information, contact Grid Edge, Emerald VIC 3782, ph: 1300 474 333, info@gridedge.com.au, www.gridedge.com.au

05

Instant fire suppression

Every home should have a fire extinguisher, but they only suppress fires if you are there to use them. The Elide Fire Ball is a self-activating extinguisher that can be used two ways.

If you are present at the fire, throw the ball into the flames and it will detonate in between three and 10 seconds, extinguishing the flames almost instantly with non-toxic chemicals.

The Fire Ball can also sit in its purpose-made holder above any area that poses a high fire risk, such as above a stove, heater or bank of electrical equipment, such as a battery bank, battery charger or inverter. Should a fire occur, the heat will activate the Fire Ball, dousing the flames and potentially saving the home from total loss, even if no one is home.

The Fire Ball weighs just 1.3 kg, so even a child can use it. It requires no maintenance for at least five years, and it also features an inbuilt alarm that triggers after detonation to alert anyone close by that a fire has occurred. It has an effective extinguishing range of 360 degrees and up to four metres, so it can douse quite established fires. It is rated to handle all classes of fire including classes A, B, C, D and E.

RRP: $149. For more information, contact Elide Fire Ball Australia P/L, PO Box 4043, Hopetoun Garden VIC 3162, ph: 1300 035 433, info@elidefire.com.au, www.elidefire.com.au

06

Safer straws

Plastic straws are one of those often overlooked products that are actually an environmental nightmare. They end up in waterways and the ocean, injuring and killing marine life (if you don't believe us, watch this video: youtu.be/d2J2qdOrW44) and generally adding to plastic pollution of our oceans. But there are many better alternatives.

Reusable and single-use paper straws are available from many sources, and include straws made from materials such as stainless steel (www.goinggreensolutions.com.au), paper (www.greenpack.com.au and www.aardvarkstraws.com—we have tried the latter and they are great), bamboo (www.emporioorganico.com.au and www.brushwithbamboo.com), Australian-made borosilicate glass (www.biome.com.au), and even, yes, actual straw (www.strawstraws.com).

Reusable straws are designed to be washed and reused many times, ultimately being composted (for paper and bamboo) or recycled (stainless steel and glass, although these materials should last decades if cared for). You can even buy tiny bottle brushes for cleaning the inside of the straw.

So now there's no excuse for using disposable plastic straws!

RRP: varies. For more information, check the websites listed above.

Products

07

ProStar goes MPPT

The MorningStar ProStar has been a popular charge controller over the years, but the trend has been towards maximum power point tracking (MPPT) charge controllers due to their increased solar energy harvesting capacity.

MorningStar has recently released a MPPT version of the ProStar called, not surprisingly, the ProStar MPPT. It is available in 25 and 40 A versions, with or without the built-in meter, and is suitable for 12 and 24 V renewable energy systems.

The charge controller features the ability to be custom programmed in the field without the need for a computer, up to 256 days of data logging, MODBUS communications capabilities, self-diagnostics to warn against installation errors, automatic PV-based lighting control and compliance with new IEC62109 safety standards. It is fully compatible with lithium battery charging systems, and is designed to handle PV array oversizing without problems. The polycarbonate case and extruded aluminium heatsink also make for a mechanically robust device.

For more information, see www.morningstarcorp.com/products/prostar-mppt. Available from many good renewable energy suppliers including the 12 Volt Shop, www.12volt.com.au and RFI Solar, www.rfisolar.com.au

08

A four-slice, single-slice toaster

One gripe we have heard many times about the average four-slice and even two-slice toasters is that you can't just toast one slice of bread without running the elements for at least one more slice.

The Kenwood K-Sense four-slice toaster (model number TFM400TT) has a single slot function for toasting just one slice at a time, as well as a single-sided function for bagels and similar breads. It has the usual toaster controls of course, including browning adjustment and preview function, which lets you check the toast at any stage of the cycle so you can stop it browning too far.

The K-Sense features illuminated controls for making toast in the dark (turn the toaster off at the power point to eliminate this energy wastage) and a removable crumb tray, and has a maximum power consumption of 2 kW.

The toaster has a stainless steel body and is available in one colour scheme—white and silver. It measures 200 x 290 x 280 mm and weighs 2.7 kg.

If a four-slice toaster is more than you need, then check out Kenwood's Turin Toaster (TTM550), which also features a single-slot mode, illuminated controls and a stainless steel body.

RRP: $209 for the K-Sense, $119 for the Turin. For more information and to buy online, go to www.kenwood-australia.com

09

Filament LED bulbs

The big lighting brands have been a little slow to provide the range of 'generic' LED bulbs that have been available directly from Asia, but they are catching up. Philips has recently released their own version of the very popular filament LED bulbs, which provide a very traditional incandescent-lamp look while providing the low energy use of LED-based bulbs.

The filaments in LED filament lamps consist of thin strips with many LED chips connected in series, allowing them to run at a high voltage at low current, ideal for running from mains-level voltages. The strips are coated in a phosphor, like other white LEDs, and when lit they look like a glowing piece of wire, just like an incandescent lamp.

Available in wattages from 2.5 W (250 lumens, 25 W incandescent equivalent) to 7.5 W (806 lumens, 60 W equivalent), they come in a range of styles, including the common A60 (above left), ST64 (above right) and candle styles, in BC22, ES27 and ES14 bases. Colour temperature is a very incandescent-like 2700 K and CRI is around 80.

RRP: starting at around $14, depending on bulb wattage and style. For more information, check out www.philips.com.au. Available from LED-me, ph: 1300 13 48 13, www.ledme.com.au; Reduction Revolution, ph: 1800 611 322, www.reductionrevolution.com.au; Bunnings, www.bunnings.com.au and other LED lighting retailers.

10

Reducing concrete use

Wafflepod slab construction reduces concrete use and helps insulate the slab from the ground, but wafflepods are made from one of the most environmentally damaging plastics known—polystyrene foam. The foam is not easily recycled, especially when contaminated with concrete, so it usually just goes to landfill at the end of the building's life.

The Cupolex Building System from Australian Urethane and Styrene consists of polypropylene domes that link together to form the base for concrete slabs. They displace a great deal of concrete that would otherwise be needed, as well as base fill—one pallet of Cupolex units eliminates the need for three to four truckloads of fill.

The system also isolates the slab from the ground, eliminating moisture ingress into the slab from the ground, as well as providing a level of thermal insulation. Less reinforcing material (rebar) is needed for a slab as well.

Being polypropylene, the Cupolex units are fully recyclable at the end of the building's life, further reducing the environmental footprint. The Cupolex domes are available in a range of heights, although only the Australian-manufactured 260 and 350 mm domes are kept in stock by the supplier—other sizes can be imported on a project-by-project basis.

For more information, contact Australian Urethane and Styrene, ph: (02) 9676 8444, info@cupolex.com.au, www.cupolex.net.au

11

All-purpose workhorse EV

Although primarily designed as a golf buggy, the FourStar is also available as a general-purpose electric vehicle for carrying and transport.

The FourStar features a 1000 watt electric motor which is powered by a 36 V, 40 Ah sealed lead-acid battery bank that has a recharge time of six to eight hours. It has two drive speeds, as well as reverse capability and a top speed of 15 km/h.

Maximum gradient for the FourStar is 25 degrees, while maximum load capacity (rider plus cargo) is a very useful 150 kg. Other features include front and rear shock absorbers, fish-tail seat for extra ride comfort, rear hydraulic disc brake and locking handbrake and sprocket and chain drive. The unit can be folded down to 1330 x 860 x 560 mm for transport. The FourStar weighs in at 106 kg, so you will need ramps for loading it.

The FourStar comes complete with charger, carry rack, tow ball and hitch, umbrella holder and mudguards.

RRP: $2975 inc GST. For more information and to buy, contact Electric Vehicles Oceania, 220/354 Eastern Valley Way, Chatswood East NSW 2067, ph: (02) 9417 1547, info@lordco.net.au, www.electricvehiclesoceania.com.au

12

Go with the flow

Redflow has been developing flow batteries for many years, but they have always been commercially oriented battery systems. Their latest product, however, is aimed firmly at the domestic energy storage market.

The ZCell is a 10 kWh (100% of capacity is usable per day) zinc bromine flow cell unit that can add storage to existing or new solar energy systems. It has a rated nominal voltage of 48 V (typical operating range 40 to 57 volts), making it compatible with a number of hybrid and stand-alone inverters, although only the Victron MultiPlus range is certified for use with the ZCell so far.

Other features of the ZCell include an intrinsically fire-retardant design, operation in temperatures up to 50 °C ambient, a web-based smart control system which includes on-board battery management, control and monitoring, and 3.3 kW continuous/5 kW peak discharge-rate capacity. The ZCell comes in its own outdoor enclosure measuring around 1000 mm long x 500 mm wide x 1150 mm high and weighing around 290 kg.

RRP: none set, price will be set by installers. For more information and to reserve a ZCell unit, contact Redflow, ph: (08) 7120 8050, contact@zcell.com, www.zcell.com

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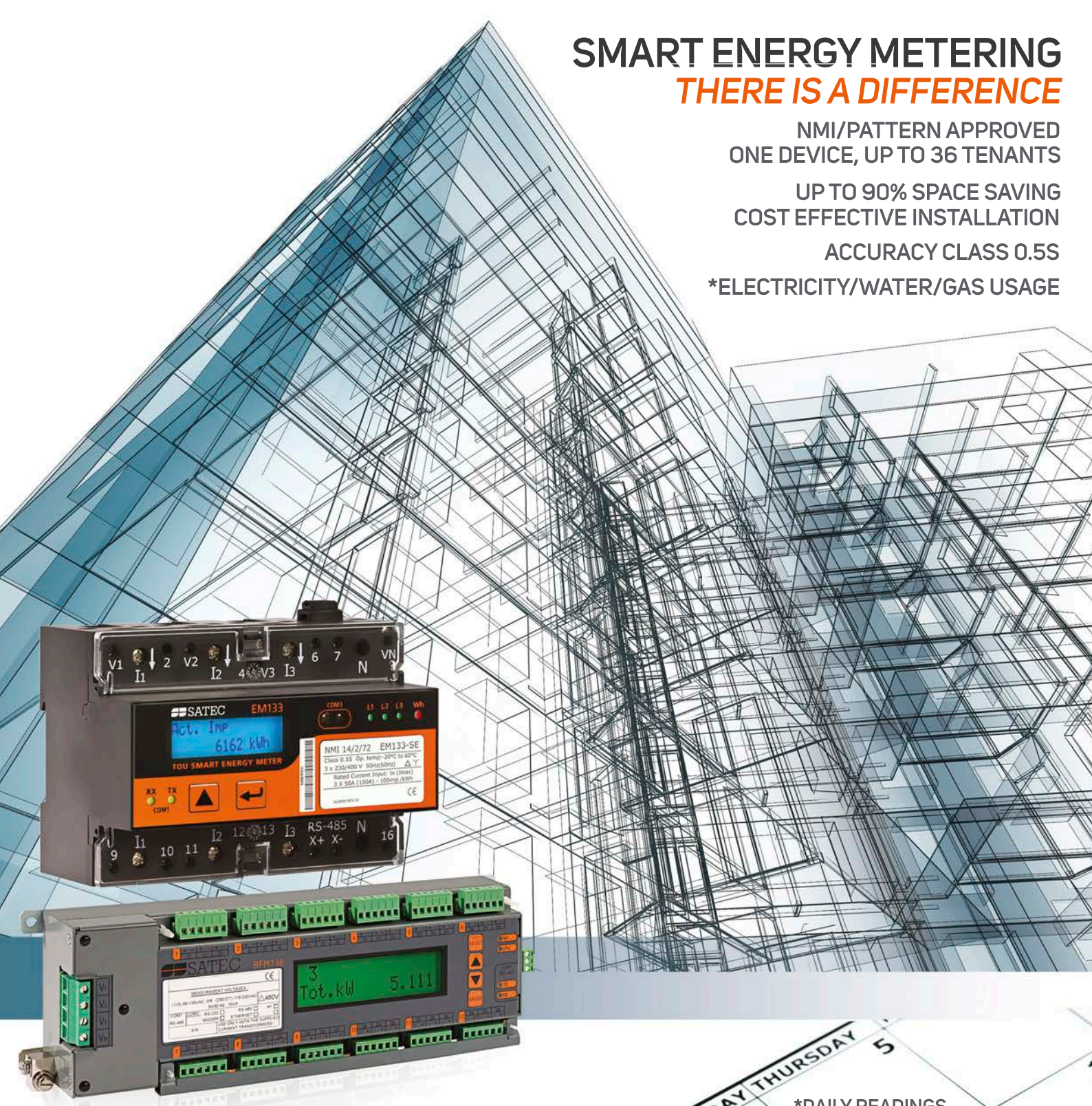

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A house built of straw
Learn how with a strawbale workshop

You're unlikely to go from building newbie to strawbale expert after a four-day workshop, but you should come out with basic skills, a better understanding of the process and the 'right' questions to ask. Enga Lokey explains.

Image: Viva Living Homes

↑ Making half bales at a strawbale building workshop.

THERE are many good reasons to choose to build with strawbales—better thermal performance, non-toxic material, agricultural waste product, low embodied energy, very high levels of insulation, beautiful curved walls, etc. But once you have made this decision, it may be difficult to find an architect, engineer and builder to provide the assistance you require in working with this unique medium.

One of the best ways to give yourself the knowledge and skills necessary for a successful build is to do a strawbale workshop. If you have no prior architectural or building experience, a workshop won't prepare you to undertake your own project from start to finish unassisted; however, you will be able to gain enough understanding to ask the right questions of the professionals you choose to employ and also gain basic strawbale building skills yourself.

What should you look for and what should you expect from a workshop? At the most basic level, participation in a workshop should provide you with enough of an understanding of what you are getting yourself into to confirm your convictions or prompt a reconsideration of your building plans. Additionally, most workshops will give you hands-on experience with some of the unique aspects of building with bales, such as alternative framing techniques, bale tying, stacking walls and corners, prepping for render and rendering.

There is a huge variety in the offerings available. Before signing up for a workshop, ask yourself what you are looking to achieve and what level of participation you plan on having in your own project. The more you expect to do yourself on your own house, the more detailed and precise your level of understanding needs to be. Are you just interested in understanding the process so you can decide if this is the type of house you want to build? Are you interested in the theory and principles of good strawbale design? Do you want to participate in every aspect of the building process or just help with the bale walls and rendering? Asking yourself these questions will make it easier to pick the correct one.

Some of the major differences between courses are discussed below, followed by a chart that tries to summarise the various options on offer.

In person or online?

One initially thinks of a strawbale workshop as something that is done in person, and that is the most common approach; however, there are also at least two excellent sources of extensive online and DVD instruction (listed in table). One advantage of an online course is that there is opportunity for plenty of theory and the demonstrations are best-case examples. There is also opportunity to pause, rewind or review anything that wasn't clear and to refer back to it when needed during your building process. With this in mind, if you do an in-person workshop, I would suggest taking lots of pictures and notes for later reference. It is amazing how much of the specifics you will have forgotten after a few months.

Theory or practice?

The proportion of theory to practical hands-on skills training can vary considerably. Workshops that call themselves 'courses' tend to be more theory and the hands-on component is often working on something specifically for the course, while 'wall-raising' workshops may have almost no theory and participants will work on a real building. Many workshops incorporate some general design

Image: Enga Lokey

↑ Some workshops let you learn your skills on simple, 'practice' structures rather than tackling the complexity of a real home build.

Images: Viva Living Homes

↑ Hands-on learning: straightening strawbale walls with 'Thor's hammer'; filling holes in walls with cob and learning to render.

principles that would apply to any well-built sustainable home (proper orientation, air tightness, insulation, etc), but are not always part of a mainstream house (hopefully concepts that are well understood by *ReNew* readers).

Educational structure or real home?

Some would argue that it is better educationally to build a simple wall designed specifically for the workshop (possibly deconstructed afterwards), while others see the value in working on a real strawbale home. Certainly, the sense of satisfaction, inspiration and camaraderie achieved when building a real home is much greater. However, this has the increased challenge and pressure of having to finish each stage before moving on to the next, which can be frustrating if things get bogged down or a glitch is encountered. If a specific aspect of the building process is important to you, confirm that issue is covered with sufficient time and in sufficient depth.

Cost

The range of workshop costs is huge. The least expensive are free in exchange for labour; these generally don't provide much instruction but do offer hands-on experience. The most expensive offer a well-structured learning progression, often on a real structure, with sufficient opportunity for discussion and practice. Additionally, some courses include opportunity for camping on-site and meals. When comparing costs, be aware of exactly what is included.

Is it worth it?

Everyone I spoke to after doing a workshop raved about the experience. Most left more inspired than ever by the beautiful medium, while the odd one or two were forced to question if they were up to the task of building their own strawbale home. The single most consistent comments from workshop participants are that they had a great time, learned more than they could have imagined and made new friends. There is nothing like getting dirty and working hard on a common project to bring people together. In this modern fast-paced, overscheduled world we live in, many of us don't get a chance to do this often enough. In addition to being just plain fun, a workshop can also be a chance to get to know people in your area who may be a resource for your future project!

More than one workshop

Why might you want to do more than one workshop? If you have read many strawbale building books, you will have noticed how different the advice is from one author to another (some may be outdated; I'd suggest that you look for consistencies in advice from different sources and don't go back further than mid-1990s for more than pretty pictures). The same will be true of the builders running workshops. If you are someone who wants to know all of the options before choosing a course of action, you might want to attend several workshops to see the many different ways of achieving the same result. You might also start with an online course that is mostly theoretical and demonstration and then follow it with 100% hands-on training. The more you can educate yourself before you begin your own home, the better. Of course, at some point, you will need to accept that you probably don't have all the answers, but you have enough and it is time to go forward with your own project.

Hosting a workshop

So what about the other side of the workshop coin? At first glance, it sounds great to have lots of free labour to build your house, and it definitely can be, but it does not happen without its own challenges. If you are considering having your building project be the site of a workshop, make sure you understand exactly what your responsibilities are (such as liability insurance, tools, food, accommodation etc) . Also clarify the priorities of the instructor. Is their priority to get the highest quality outcome for your home or to move quickly to give the participants the most in-depth educational experience? Keep in mind that you will have novices working on your house and someone else overseeing the activities and pace of progress. You may need to make a much bigger investment in tools and equipment in order to accommodate so many active workers.

Where do I find a workshop?

We have contacted everyone we could find in Australia and New Zealand who offer strawbale workshops and listed them in the following table. Some specific details are included for those that provided them. Additionally, Ausbale (www.ausbale.org) is an excellent resource and is usually up-to-date with workshop offerings around the country. If you just want to drop in on some building

Image: Viva Living Homes

↑ Strawbale workshops offer the opportunity to meet like-minded people and share in a great community spirit.

or rendering, you may also find listings on this site.

Just remember that no matter how huge a task you imagine building a strawbale house will be, the reality will dwarf your expectations. However, the sense of pride and satisfaction of creating a beautiful, comfortable, non-toxic, environmentally sensitive space will quickly outweigh all the stress and challenges involved in achieving your dream. ✱

Enga Lokey is enthusiastic about energy-efficient and environmentally friendly building, and is a member of Ausbale. She is currently completing her own strawbale home in Western Victoria.

Table 1. Strawbale workshops in Australia and New Zealand.

Organisation	Instructors	Location	Length	Cost	Theory/practical percentages	Food/lodging	Other offerings
Anvill www.straw-bale-houses.com 0428 246 868	Brian Hodge	Online training course	8 hours	$575 or $50 per month x 12 = $600	100% theory	N/A	Design, engineering and general consulting throughout construction
Australian Rural Education Centre www.arec.com.au (02) 6372 3899	Sam Vivers / Viva Homes	Mudgee, NSW	3 days, 8.30am to 5pm	$660	50% theory/ 50% hands-on	Morning/afternoon tea and lunch; tea and coffee facilities; free camping on-site with excellent amenities, including a camp kitchen	Traditional Timber Framing with Chris Nance
The Food Forest www.foodforest.com.au (08) 8522 6450	Annemarie Brookman, Graham Brookman, Lance Kairl	Gawler, SA	2 days	$445	50% theory/ 50% hands-on	Morning/afternoon tea	Other short courses include Permaculture Design, Organic Gardening and Fruit & Nut Growing
House of Bales www.houseofbales.com.au (08) 8555 4223	Lance Kairl	SA, other states by arrangement	Weekend to 3 days; can precede a wall-raising event	From $500	40% theory/ 60% hands-on	Morning/afternoon tea and lunch; camping and cooking facilities may be available	Workshops as educational events, wall-raising events, consulting and construction assistance
Huff 'n' Puff Constructions www.glassford.com.au (02) 6927 6027 / 0412 116 157 john@glassford.com.au	Susan Glassford, John Glassford	All states in Australia	3 to 5 days	$500 to $605	See www.bit.ly/1WbVltV for a typical breakdown of theory and practical	Lunch and afternoon tea	Other workshops including on permaculture and mud brick
Sol Design Ltd www.soldesign.co.nz 0211 513 239	Sarah Johnston, Sven Johnston	Geraldin, NZ	7-day design and construction workshops	NZ $1450	40% theory/ 60% hands-on	Food and accommodation provided by Struan Farm Retreat; camping option	Tadelakt and lime plaster workshops
Strawtec www.strawtec.com.au (02) 4443 5282 / 0408 415 806 info@strawtec.com.au	Frank Thomas	All states in Australia	2 to 5 days	$0 to $380	20% theory/ 80% hands-on		Rendering, permaculture, Tadelakt, timber framing, straw wrap
StrawBale.com www.StrawBale.com Andrew@StrawBale.com	Andrew Morrison	WA, NSW, SA, VIC, Canada, Europe and USA	7-day hands-on, andinstructional DVDs/online resources	US $800	99% hands-on with lots of Q&A and evening fun	Three meals per day, plus camping on-site with bathroom facilities included.	DVD training courses, consulting
Viva Living Homes vivahomes.com.au (02) 4759 1286 info@vivahomes.com.au	Sam Vivers	Canowindra, NSW	4 days	$66	100% hands-on (wall-raising)	Morning/afternoon tea and lunch provided, plus camping on-site	Natural building, contract building, design

Case studies
Owner-built strawbale homes

Robyn Deed talks to three owner-builders about how workshops helped their strawbale building.

Case study 1: Bayside Brisbane

"I thought about having a workshop to help build my own house, but I got too selfish!" says Kurt Piccardi. "Building with strawbales is the fun part, it's nice to do." It's also a relatively quick part of the process. It took just a couple of weeks to put up the bales for his own house in bayside Brisbane, yet the whole project took about three years, one month and 21 days, "but I'm not counting," he says.

Kurt is an architect and also has a permaculture background, which is what led him towards straw. He liked the idea of reusing a waste product, such as straw. He began with an experimental granny flat on his own property in 2007, built using load-bearing construction.

Straw construction can be load-bearing or infill—in the latter, a standard framed construction is used, with the strawbales simply providing insulated infill. Which approach works best can depend on how much rain you're likely to have during construction, says Kurt; in his granny flat build, rain wet the top layer of bales and they had to be replaced. With straw used as infill, you build the frame and roof first, so the strawbales are protected during construction. "Load-bearing can work well though, in a drier climate like in western NSW," he says, though he also notes that building engineers generally prefer infill.

He went on to build two more straw buildings for himself: an office and finally his family's home (completed in 2013), both using an infill approach. He's gone on to specialise in alternative building materials including strawbale in his architecture practice, Studio Green Architects, and he's a member of Ausbale, a group aiming to further strawbale construction in Australia and NZ.

He learnt his strawbale skills through workshops. He went to a five-day workshop run by Huff 'n' Puff Strawbale Constructions and two or three wall-raising workshops, where you're helping out on someone else's build. He had the design skills through his architecture background, and an understanding of building, but through the workshops he gained knowledge of straw and just how easy it is to build with. "Anyone can do it," he says. "It can be very empowering to realise that."

↑ Kurt Piccardi's owner-built strawbale home in bayside Brisbane.

The worst part? "Rendering!" he says. It's hard work, applying 50 mm of render in three coats on springy straw walls. "It almost killed us doing that for the granny flat and office," he says, so for their house they paid someone to do it. Even the commercial company took four to five days per coat, with one person doing mixing and two rendering, with a trowel. A pump to spray on the render can be quicker and penetrate a bit better, he says (the company did have a pump, but it wasn't working for much of the time).

The house is brilliant to live in, says Kurt. They rarely use heating (a small bar heater is required by some family members!) and have only fans for cooling, in a climate that gets seven days of frost per year and gets up to low-to-mid-thirties in summer. It's a different climate from central Brisbane, closer to the bay, with both cooler temperatures in winter and a sea breeze in summer, though still humid. They have two or three "stinking hot" nights a year and they just cope with that. The insulation factor is great (R8), though he says the building could be better sealed—"but we like to live like that, with fresh air and everything open." ✱

↑ Kurt giving the bales a 'haircut' prior to rendering.

Case study 2: An organic community

For Andy Stevenson, one of the most important things about building with strawbale has been the community he and his husband Jeff Miller have become a part of. At their own recent building workshop, which saw the strawbale walls raised and partly rendered in four days, he looked around at the people volunteering their time to help and saw "all these community-minded people, with dirty, muddy, earthy hands, connected to the materials and each other in a way you don't get with a traditional build."

Andy and Jeff's building has been designed and organised by Sam Vivers at Viva Living Homes. Andy's background is in landscaping, but he also has qualifications in architecture and construction, so he's been able to assist in the building, including laying the foundations and building a basement (using concrete blocks rather than strawbale). Viva's builders came in after that stage to build the frame and strawbale walls, but Andy and Jeff have retained responsibility for the internals—for cobbing and rendering the internal walls, and the internal fitout—to keep costs down and because they "like to be hands-on."

Prior to their own building, Andy helped out on several strawbale wall-raising workshops, which gave him an insight into the process, but was also part of giving to the natural building community: "You have to give a bit to get back."

Their wall-raising workshop involved about two days of building with the bales—"wrestling them to the ground, putting them in and tensioning them" and pushing the walls into line with a large "Flintstone-style" hammer—and then two days of cobbing and rendering most of the external walls and some of the internal ones. "It was so satisfying to see walls finished during the workshop," he says. Some of the participants were disappointed that the building wasn't completed in the four days, so there can be a need to manage expectations and to "convey your gratitude," he says.

Andy admires Viva's building system which he describes as streamlined and "patentable". Impressed with the accuracy of Viva's work, at one point Andy expressed concern to Sam that the internal walls, which he and Jeff were responsible for, might not be up to scratch. But Sam assured him that the material is forgiving and you can "smear some more mud on it if it's wrong: it's a low-tech process with tolerances built in." That fits well with Andy's own more organic approach, in both landscaping and life—in landscaping, for example, he says his former work was aimed at "getting people into a relationship with the real world, rather than providing them with a stain-free, leaf-free backyard." ✸

Case study 3: Fire-rated strawbale

Rolf Schönfeld and his partner moved into their owner-built strawbale home near Mount Feathertop in Victoria in April 2015 after a four-year building process. "There's still an odd piece of wood to machine," Rolf says, but they love the result. "It's warm and looks beautiful; I try to talk everyone into building with strawbale," says Rolf.

Rolf has a practical bent and has been "building all his life", so he didn't do any building workshops himself. His partner, Narelle, did a weekend strawbale course with Huff 'n' Puff. The course gave her the confidence to "understand what strawbale is all about" and to get involved in the building work. The workshop was also important to help "avoid the divorce papers" that so often come with building projects, Rolf says, as they both understood what was in store.

One technique Narelle learnt in the workshop was how to cut strawbales to size. "I'd yell out a measurement and a minute later get the bale from Narelle in the size I needed," Rolf says.

The building includes a Hebel block basement to keep the strawbales off the ground, because of the area's high rainfall. The straw they used for the build came from Narelle's parents' wheat farm, and they baled it themselves. "It's almost like the house was grown on the farm," says Rolf.

The hardest part was the rendering, which took three to four months. They were doing it at the hottest time of the year, during a heatwave, with 40+ °C days. Because of the heat, they would start rendering by floodlight when the sun went down, often working until 11.30 at night. Friends helped when they had time. Rolf says, "We still have friends and only some didn't come back!"

Bushfire is a risk in their area. At one stage, they were rendering at night with the glow from a bushfire visible just two kilometres away. New BAL requirements came in during the design process, which meant there was uncertainty about what was required for a strawbale building. Rolf increased the external render (from 45 to 65 mm) to meet the code and the building gained approval after 12 months. ✸

↑ Narelle and Rolf placing the first bale on the west wall.

↑ The west wall ready to be rendered. The construction uses standard structural framing with bales as infill.

Life after FiTs
What to do when your feed-in tariff expires

With feed-in tariffs about to drop dramatically for many, what's a solar household to do? ATA's energy analysts Damien Moyse and Nick Carrazzo discuss six steps to consider.

BY THE end of 2016, more than 275,000 households with solar PV across NSW, Victoria and South Australia will receive much lower payments for their solar exports to the grid, as several premium feed-in tariff schemes expire. A key question for these households is how to mitigate the financial impact of the reduced feed-in tariff.

Feed-in tariffs are likely to drop to around 5 to 10 c/kWh for these customers, from around 16 to 60 c/kWh. Full details of the schemes affected and the likely new feed-in tariffs are shown in Table 1.

This article considers how to maximise the return for solar generation given low feed-in tariffs. Many of the considerations here apply not only to these existing solar homes, but also to new solar homes as these will also receive these lower feed-in tariffs.

1. Ensure the correct metering

An important first step for the solar homes about to lose their premium feed-in tariff is to ensure they are using net metering (also known as import/export) rather than gross metering. Net metering recognises the use of solar electricity on-site to reduce more expensive imports from the grid. This isn't possible with gross metering.

Victoria and SA both used net schemes, so a metering change is not required for solar customers in these states.

In NSW, the Solar Bonus Scheme offered a gross scheme. Given the new reduced feed-in tariffs—much lower than the grid rates charged—affected NSW customers will need to change to net metering to maximise the financial benefits of their solar system.

The costs and technical requirements to switch from gross to net metering for Solar Bonus Scheme customers are still under discussion and vary depending on the distribution area (to work out which distribution area you are in, see www.bit.ly/1U6pk0i). As at May 2016 the situation is:

- Endeavour area: Customers will need to install a new meter, at a cost of about $600 if done by the distributor; costs of subsidised options via the retailer are unclear at this time.
- Essential Energy area: Instead of a new meter install (costs similar to Endeavour), customers may be able to use their existing solar meter with a minor wiring adjustment, at an estimated cost of $150, but Essential Energy has not yet confirmed if they will accept this solution.
- Ausgrid area: Instead of a new meter install (costs similar to Endeavour), Ausgrid has confirmed customers can use their existing solar meter after a minor wiring adjustment, at an estimated cost of $150. Ausgrid has also proposed they could use the two existing gross meters to calculate net energy flows, but it is unclear if retailers will accept this option; if this is accepted, no meter change would be required.

Retailers may also offer a subsidised or even free net meter for solar customers. However, at this time little information is available on how much this will cost or the range of tariffs and contracts the retailers will offer in lieu of these subsidised meters.

As noted, the exact solutions on offer are still unclear so ATA advises that customers should review all options at the time of the closure of the scheme, particularly the zero or low-cost options. The last resort should be to request the local distributor to install a net meter at a cost anywhere near $600.

Note: whether the solution ends up being the replacement of the meter, rewiring or changes to billing arrangements, if these solutions are being offered through an energy retailer, then the customer must ensure they understand the full implications of agreeing to a particular solution as this may have implications for that customer's retail tariff or other related considerations.

Image: Lindsay Edwards Photography

↑ More than 275,000 solar homes in Australia will be affected by reduced feed-in tariffs as several premium feed-in tariff schemes expire in 2016. The ATA, *ReNew*'s publisher has recently completed modelling and analysis to help advise consumers during this transition.

"The biggest opportunity lies in shifting the two largest energy-users—water heating and space heating/cooling—to solar generation hours."

State	Current tariff	End date	Feed-in tariff rate for 2017	No. affected
NSW	The Solar Bonus Scheme: a FiT of 20c/kWh or 60c/kWh for all solar generation	Dec 31, 2016 (started 2010)	No mandated FiT for NSW. IPART determines a benchmark range (in 2015/16: 4.4–5.8 c/kWh), but up to retailer to decide the FiT offer	146,000
Victoria	The Transitional FiT: minimum 25c/kWh for excess solar electricity fed into grid	Dec 31, 2016 (started 2011)	~5c/kWh	67,160
Victoria	The Standard FiT 'one-for-one': based on the retail electricity rate paid	Dec 31, 2016 (started 2012)	~5c/kWh	Unknown
South Australia	16c/kWh FiT	Sept 30, 2016 (started 2011)	Minimum retailer payment of 6.8c/kWh	62,742 at end 2015
Total affected				275,902

↑ Table 1: Breakdown of solar customers for whom premium feed-in tariffs (FiTs) are closing in 2016. Note that the Victorian feed-in tariff known as the 'Premium FiT' of 66c/kWh does not expire until 2024.

2. Use your solar electricity on-site

With lower feed-in tariffs, there is much greater value in using your solar electricity on-site rather than exporting it to the grid. To maximise usage of your solar generation, the aim is, where possible, to shift electricity usage from the evening to the daytime when solar generation is occurring.

Most households, even those with relatively small solar PV systems (e.g. 1.5 to 2kW), do not use a large proportion of their solar generation during the day. As an example, a 1.5kW PV system in Sydney will generate around 10kWh between 9am and 5pm in summer and around 5 to 7kWh in autumn/spring. Many homes consume not much more than 1 to 3kWh between breakfast and dinner, so even this small system has a relatively high export rate to the grid.

Even those who are at home during the day often run little more than the fridge, a computer or audiovisual equipment, plus maybe an oven, washing machine or dishwasher once every few days.

Running your washing machine, oven and dishwasher during the day is a first step, but there's more you can do. The biggest opportunity lies in shifting the two largest energy-users—water heating and space heating/cooling—to solar generation hours.

SHIFTING WATER HEATING

Electric water heating can be done using a traditional electric resistive hot water system or a heat pump (both using storage tanks).

If you have either type of electric hot water system, to power it from your on-site solar generation it must be connected to your main electrical circuit, rather than any dedicated off-peak hot water circuit. You must also set it up to operate during the day, when the solar system is generating electricity.

A simple way to do this is to change the timing of the heating cycle to peak solar generation hours (say between 11am and 3pm, depending on location, season and shading). Heat pumps generally have timers built in; some traditional electric resistive systems do too, or an electrician can install a timer at relatively low cost.

Another (more expensive) approach is to use a dedicated solar diverter, although most of these are only suitable for powering a resistive hot water system (the SunMate is programmable to divert only if enough power is available, so it is able to run a heat pump water heater if set up correctly).

An emerging technology, diverter devices measure the amount of surplus generation that would normally be exported and divert that energy to an appliance such as a water heater. Examples include the new Powerdiverter, the immerSun and the SunMate. These cost around $1000–$1100 installed, but hopefully prices will fall as the market expands.

Similar in concept to the diverters above, some modern inverters also come with energy management relays that can switch on or off and control certain loads (like hot water) to match excess solar generation. These may be a cheaper option as they come inbuilt in the inverter. However, many customers may not have an appropriate inverter, and it may be best to wait to upgrade if considering batteries in the future.

Note that if you are using solar electricity to heat water during the daytime, then you want the water heater to retain as much of that heat as possible for use overnight and the next morning. Many older water heaters have lower levels of insulation, so it might be worth investing in a highly insulated tank. You can search the Energy Ratings database at reg.energyrating.gov.au/comparator/product_types to find the tank with the lowest heat losses in the size you need. Alternatively, you can super-insulate your existing tank by adding more insulation. Previously, Autex and at least two other companies manufactured cylinder wrap products for this purpose, but these have disappeared from the Australian market. However, there are numerous insulating wraps and materials that can be used to insulate water cylinders; if your cylinder is external then you may need to cover it with a waterproof layer as well. There is a useful instruction page on water tank insulation at http://1.usa.gov/1Pas1lf

PURCHASING A NEW HOT WATER SYSTEM

Heat pump systems are more efficient (up to four times as efficient) as traditional electric systems, but cost three to four times as much to purchase, so which is the better option?

ATA recently compared the cost of purchasing, installing and running a traditional electric resistive hot water system versus a heat pump hot water system for a Sydney home with existing solar PV and about to lose the premium feed-in tariff. Irrespective of PV system size, the analysis suggested that, given maximum possible use of the PV to run the hot water system, most households would be better off or at least

no worse off over 10 years with purchasing a heat pump system compared to an electric resistive system.

SHIFTING SPACE HEATING/COOLING

Space heating/cooling is the other big energy user (in fact, the biggest in most homes). Electric space heating/cooling can be via a split system air conditioner; ducted reverse cycle; low wattage panel heaters or heat pump hydronic systems.

With many people at work during the day, a lot of space heating/cooling occurs at night or in the morning before work. However, an electric space heating/cooling appliance can be programmed to at least partially run during the daytime, using excess solar energy. The aim is to pre-heat or pre-cool the space and reduce the evening energy requirements.

To do this pre-heating or pre-cooling, you will need to be able to program your heating/cooling appliance to switch on during the day (e.g. at 3pm), but at a relatively conservative setting (e.g. 16 to 18 °C in winter or 28 to 30 °C in summer). Less energy is then required to bring the house to a reasonable temperature in the evening.

Bear in mind that while many heating and cooling systems can be preset to run at specific times, some will use whatever temperature settings were used previously, so make sure that is set correctly when setting the timer. Of course, this will depend on the system and its degree of programmability.

A key factor is the thermal performance of the building itself. The building must have good draughtproofing and decent levels of ceiling insulation (and potentially wall and floor insulation) for this to work. In addition, curtains/blinds and internal doors should be closed, the latter for zoning.

ReNew 130 modelled the financial and environmental aspects of pre-cooling using Sunulator and found that slow pre-cooling may have a small financial advantage over a year, but a slightly negative environmental impact (as less solar energy is exported to the grid).

In winter, pre-heating the water in a hydronic storage system is also a suitable use of excess solar generation. Just like a hot water system, this may be done through the use of resistive elements or using a heat pump (with an energy diverter suitable for heat pump use, such as the SunMate).

3. Get off gas

With space heating and hot water typically comprising between 50% and 75% of a home's stationary energy needs, it is difficult to maximise solar use on-site if you don't use electricity to power one or both of these loads.

Some NSW, Victorian and SA solar customers will currently be using gas for one or both of these uses. Switching away from gas for space heating and hot water will involve considering the kind of electric hot water and space heating solutions discussed above.

If designed and implemented well, a transition away from gas will allow most NSW, Victorian and SA solar homes to reduce their annual stationary energy bills (for electricity or electricity and gas) to no more (and potentially less) than $1000 per year. This is in the context of the majority of NSW, Victorian and SA non-solar homes currently paying $2000 to $3000 per year for stationary energy.

4. Get the best retail deal

ATA recently conducted an analysis of retail feed-in tariff offers, including their associated consumption tariffs, in NSW, Victoria and SA.

Currently in Victoria, every retailer with 5000 or more retail customers must offer a mandatory minimum feed-in tariff payment to any new solar customer. SA takes the same mandatory minimum approach as Victoria—with regulators in each jurisdiction setting a minimum rate each year.

In NSW, there is no mandatory minimum feed-in tariff rate that must be offered by retailers to any new solar customer under the current NSW legislation. Retailers can choose whether or not to offer a feed-in tariff at all.

ATA's review found that lower pay-on-time discounts were offered to solar customers than non-solar customers, particularly in NSW and SA. Non-solar customers in those markets were offered discounts that were on average 7% higher.

ATA's retail tariff analysis considered only a subset of available offers in each of the three markets so the full range of offers may vary more widely. Irrespective of the solar and non-solar offers in these markets, our advice to existing and new solar customers is the same: shop around to get the best overall deal, taking into account feed-in tariff, consumption tariffs, supply charge, discounts and any other relevant offer elements.

Image: Lindsay Edwards Photography

5. What about batteries?

ATA recently conducted modelling to consider the value of installing new lithium-based storage for homes with existing solar PV systems in Sydney, Adelaide and Melbourne. The modelling looked at installation in 2017 and 2020 of both small (3kWh) and large (7kWh) battery storage systems as add-ons to existing small (1.5kW) and large (4kW) solar systems.

The results suggest that retrofitting energy storage to solar is unlikely to be cost-effective for existing solar PV customers prior to 2020, but is likely to become cost-effective in some locations/scenarios by 2020. Specifically, the results suggest that:

- systems with smaller batteries, that have more chance of being fully used over the course of the year, are likely to be economic in these three (and likely other) locations by 2020
- systems with larger batteries, that have less chance of being fully used over the course of a year, may remain uneconomic in these three locations in 2020, and potentially beyond. A key factor will be how much the cost of storage technologies declines over this time frame
- Adelaide offers better economics than Sydney or Melbourne, largely due to higher electricity retail tariffs (approximately 30% higher on average than Sydney/Melbourne) and higher solar insolation levels in Adelaide on an annual basis.

6. Am I battery ready?

The majority of the NSW, Victorian and SA solar customers affected by the feed-in tariff expiry this year will have had inverters installed in 2010–2013. These older inverters will not have the full capabilities of many of the inverters available in Australia now and many will not be suitable for hybrid solar-battery systems.

Given the poor economics of storage in 2016, it is advisable to wait with regards to battery investment and an inverter upgrade and instead:

- ensure you have net metering
- maximise your existing solar electricity by shifting major appliance usage to the daytime
- implement a plan to get off gas
- get the best possible feed-in tariff offer.

These steps may take some time to implement, by which time battery prices will have reduced and your existing inverter may be close to needing replacement anyway.

Following these steps, and with battery prices low enough by 2020, it should be achievable for most solar homes to be consuming the majority of their own solar electricity while at the same time reducing their annual stationary energy bills to below $500 per annum—a reduction of around 75% to 80% on what most Australian households currently pay. ✱

Damien Moyse and Nick Carrazzo are energy analysts at the ATA, *ReNew*'s not-for-profit publisher. This article is based on a report prepared by the ATA for the Total Environment Centre, NSW. The full report and consumer guidance will be available on the ATA website at www.ata.org.au (likely in July).

Mottainai vs methane
The case for textile recycling

Sarah Coles explores the environmental and social benefits of diverting textiles from the waste stream, looks at industrial fabric recycling and takes inspiration from the Japanese practice of maintaining clothing for a lifetime.

IN THE 1965 film *The Sound of Music*, while the Captain is away in Vienna, Maria makes playclothes for the children out of old curtains. Perhaps taking this iconic filmic moment of upcycling as inspiration, my mother made a kaftan out of bright orange curtains in the 70s. "I was up there with the fashion," she says. The orange kaftan was both fashionable and ethical, it seems.

According to the Australian Bureau of Statistics, Australians throw out approximately 570,000 tonnes of leather and textiles per year, only 12% of which is recycled. This means each year roughly 500,000 tonnes of leather and textiles end up in landfill in Australia. Once textiles are in landfill they decompose and release methane, a harmful greenhouse gas. Dyes and other chemicals may leach into the soil, potentially contaminating groundwater.

The ecological and social burden of new clothes is well documented. The introduction to the 2013 book *Sustainability in Fashion and Textiles* reads: "Considering the whole textile chain, from spinning to finishing... large amounts of water and energy are used and, in general, non-biodegradable wastes are produced." According to the report 'The State of the Apparel Sector 2015', it requires 2720 litres of water to produce one new white cotton T-shirt. In the textile manufacturing sector, sweatshops and child labour are prolific, and working conditions abysmal. The fashion industry promotes continual consumption; according to a Food and Agriculture Organisation (FAO) report, worldwide demand for textile fibres was 69.7 million tonnes in 2010. In short, the textile industry is brutally unsustainable.

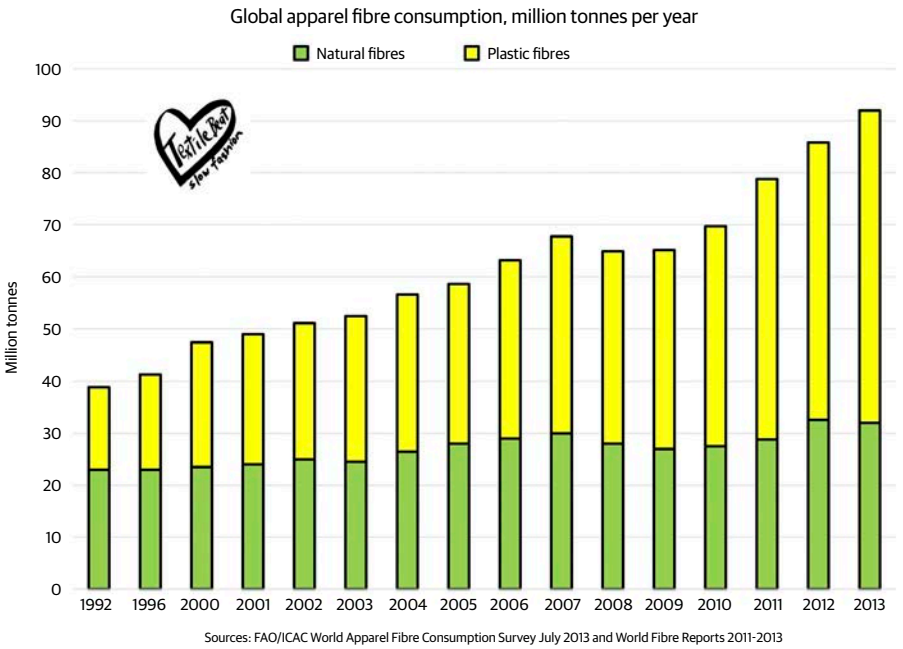


Image courtesy Textile Beat

↑ Global textile consumption is increasing. Jane Milburn from Textile Beat quotes figures from FAO, "On a global average, individual consumption has gone from 7 kg per person of apparel fibre per year to 13 kg per person. That figure is what you're adding to your wardrobe."

In a 2006 report by the European Science and Technology Observatory, 'Environmental Impact of Products', clothing accounts for between 2% and 10% of consumers' environmental impacts. A great deal of what we throw away can be reused and recycled. Significant environmental savings are achieved by choosing recycled textiles over new clothing. A 2010 report by researchers at the Technical University of Denmark 'Environmental benefits from reusing clothes' looks at the life cycle impacts of clothes that are disposed of by incineration compared with that of clothes that are reused by charity groups. (Incineration is a common waste management practice in some countries, where space for landfill is at a premium.) According to the report, reuse of textiles saves 4 kg of CO_2 for every kilogram of textiles saved. Although incineration is less common in Australia, textile waste in landfill still forms leachate and methane gas as it breaks down.

One method of diverting clothes from landfill is donating them to an op shop. Members of the National Association of Charitable Recycling Organisations (NACRO) operate thousands of op shops around Australia and are the largest and oldest recycling/reuse cohort in the country. Kerryn Caulfield, CEO of NACRO points out, "While

↑ Jane Milburn, Textile Beat founder, runs workshops with people of all ages, and has been surprised to find some pre-teens have never used a needle and thread. "I feel that we need to have another look at what is going on because sewing is a life skill, just like home cooking." Jane equates the burgeoning interest in the sensory aspects and integrity of the slow food movement with the growing interest in slow textiles.

↑ Elizabeth Kingston creating a pinafore from old jeans during a Textile Beat workshop. Jane Milburn says, "We are overusing our resources. Only one-third of new clothing now is made of natural fibres, while two-thirds use synthetic fibres that are mostly derived from petroleum."

Images: Textile Beat

charitable recyclers rescue secondhand clothing from landfill, their governing principle is one of benevolence; they accept donations to clothe those without and raise money for charitable purposes and to provide work for the disadvantaged." She adds that the function of charitable recycling was "formed before federation—long before the term 'landfill'—as a system to care for those in Australian communities who are in need."

There are three sources of textile waste: pre-consumer, post-consumer and industrial. Pre-consumer waste is produced during the production of fibres and textiles; examples include off-cuts, selvages and shearings. While some of this is recycled (cotton off-cuts into cotton wipes for example), most is sent to landfill. Post-consumer waste is household waste such as sheets, towels and clothing. It is common for post-consumer waste to be recycled as secondhand items sold in op shops or exported to third-world countries. Industrial waste is generated from the manufacture of items such as carpet and curtains, and the end of life of things like conveyor belts and hospital sheets. This category is deemed 'dirty waste' and is sent to landfill.

Clothing that is too worn to sell in op shops can be recycled into such things as car insulation, roofing felts, rag rugs, loudspeaker cones, recycled fabrics, car polishing rags, cleaning cloths, mattress filler or furniture padding. The Smith Family's commercial enterprise recycles textile industry waste and surplus clothing donated to the charity to produce things such as carpet underlay, furniture removal felt and weed suppression felt. Textile recyclers grade material according to type and colour. Textiles are shredded into 'shoddy' fibres, which are then blended with other fibres for weaving or knitting.

Japan has many cultural traditions encouraging the avoidance of waste through the practice of using objects for their entire life cycle, by prolonging their use through repair. 'Mottainai' is a Japanese term conveying regret over wastefulness; the English version being 'waste not, want not'. In 2002 the government of Japan released 'The 2002 White Paper on the Recycling Society', urging citizens to end the vicious cycle of mass production, consumption and disposal.

In years past, it was normal for Japanese families to purchase new clothes for the first child, which were mended, patched and handed down to younger siblings, and eventually repurposed as cleaning rags. Kimono robes were handed down from mother to daughter. These days, demand for recycled clothing is on the rise in Japan as are 'custom shops' that specialise in vintage blue jeans. Custom shops allow customers to bring in clothes that they no longer wear to be refashioned, a practice known as 'Mottainai fashion'.

Jane Milburn is no stranger to refashioned textiles. Jane founded Textile Beat, an enterprise that "taps into growing interest in ethical and sustainable ways to reduce our clothing footprint." Jane has an agricultural science degree and her first job was as a rural reporter with the ABC. With Textile Beat her skills are all coming together; her childhood on a sheep farm in New Zealand, her love of natural fibres, her knowledge of agriculture and her experience working in communications. "I'm using all those skills to highlight the fact that we are overusing our resources. Only one-third of new clothing now is made of natural fibres, two-thirds use synthetic fibres that are mostly derived from petroleum."

Image courtesy NACRO

"Modern day slavery was exposed in 2013. The collapse of the Rana Plaza in Bangladesh shows that modern supply chains are constantly chasing the cheapest workforce...we need to think more about why clothing is cheap and seek out ethical makers."

← Kerryn Caulfield, CEO of the National Association of Charitable Recycling Organisations (NACRO), pictured in front of sorted donations at the UnitingCare Communities sorting and distribution centre in Brisbane. Kerryn points out, "Charitable recyclers don't exist to 'rescue landfill'. The governing principle of charitable recycling is one of benevolence."

In 2014, Jane embarked on the Sew it Again Project, which she describes as "an upcycling project where I was rejigging things in my own wardrobe or that I found in the op shop." Jane wrote 365 blog posts that year, most of them documenting her own creations and the work of other "adept recyclers".

In 2016, Jane started The Slow Clothing Project, a project aiming to spark a conversation about clothing reuse. 130 people around Australia are "making something, and taking photos of the process, to showcase their ideas about clothing, making for themselves, and reusing existing textiles." Jane says, "It is all about using natural fibres, handmaking and the story of the maker." Forty garments will be generated across 40 weeks from February to November 2016. All of them will be documented through the Textile Beat website.

The textile trade is an ethical minefield. On a global average, individual consumption has gone from 7kg per person of apparel fibre per year to 13kg per person, according to the FAO. Jane says, "The sheer volume is a problem. That figure is what you're adding to your wardrobe. Developing nations of course wouldn't have anything near that, which means that in countries like ours it is probably a lot more than 13kg."

Research by Dr Mark Browne, an ecologist, documented in 'Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks', shows that synthetic fibres are shedding microplastics into the waste water stream with every wash, particularly the fleecy fabrics. Experiments sampling wastewater from household washing machines demonstrated that a single synthetic garment can produce more than 1900 fibres per wash. This suggests that a large proportion of microplastic fibres found in the marine ecosystem originate from washing machines.

In 2013, an eight-storey building in Bangladesh housing textile factories collapsed killing over 1000 workers. Jane says, "Modern day slavery was exposed in 2013. The collapse of the Rana Plaza shows that modern supply chains are constantly chasing the cheapest workforce...we need to think more about why clothing is cheap and seek out ethical makers."

Jane equates the burgeoning interest in the sensory aspects and integrity of the slow food movement with the growing interest in slow textiles. Jane is well-versed in the Japanese culture of recycled textiles. "There is a huge amount of potential in natural fibres. They are worth valuing and giving a second life. I feel that the more that you wear them, the softer and more beautiful they become. The Japanese culture really values that. They've got Boro stitching (see box), and they are continually reusing."

Jane says that the lost art of sewing has huge potential. "At Woodford Folk Festival on the weekend I had several men come along to workshops who were darning their jeans." She adds, "It is so empowering to be able to apply your own creativity and energy and to be able to say 'I made it myself'. You can't put a price on that." ✷

Tips for recycling end-of-life clothing

Charities are not dumping grounds for unusable clothing. But some do collect poor-condition clothing that can be recycled into industrial rags, sound-absorbing materials, insulation and stuffing. You need to check if your local charity accepts 'rags' and label them accordingly. To be recycled clothing needs to be clean (no dirt, oil, grease, paint) and absorbent (t-shirts, towels, flannelette, sheets, but no denim). You can search for outlets in your local area at www.recyclingnearyou.com.au. Your local community garden, Landcare or Bushcare group may also be interested in some clothing, preferably natural fibres, which can be used for weed matting.

Boro and sashiko

Japan is famous for its silk kimonos, but as the practices of upcycling and zero waste gain traction, the style of clothing worn by peasants in pre-industrial Japan is experiencing a comeback. 'Boro', a term that describes mended and patched fabrics, was the clothing worn by peasants, merchants and artisans in Japan during the 19th and early 20th centuries. Boro describes clothes or household objects (such as bed covers) that are made from rags and patches of homespun hemp and cotton. The garments are repaired and maintained throughout the owner's lifetime.

The rural population of pre-industrial Japan couldn't afford new clothes and the thrifty techniques of Boro emerged. Japanese people repaired and recycled objects such as fishermen's jackets and futon covers, handing them down from generation to generation. Boro fabric is almost always indigo in colour, because laws during the Edo period (1603–1868) restricted the working class from wearing bright clothes. Indigo is made from cotton dyed using the fibre of the indigo plant in the genus Indigofera (or in colder climates like Japan's Ryukyu Islands, *Strobilanthes cusia*). In Japan, the fibre was fermented into a dye pigment called sukomo, then the fabric was added, before being dried in the sun. Indigo dyeing strengthens the fabric, one reason for its use in work clothes.

Sashiko, or 'little stabs', is a type of stitch developed in rural Japan, in a culture that prized mending over consumption. Made using a thick embroidery-like thread, sashiko stitches are visible and often follow a regular pattern. Originally a rough, free-form stitch, sashiko developed into an elaborate decorative style.

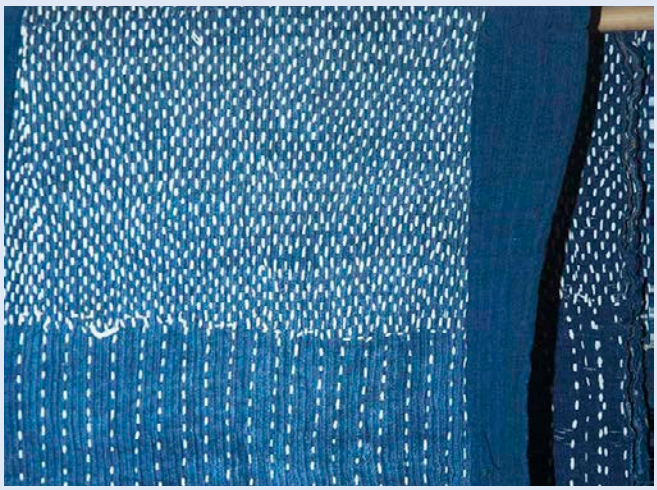


Image: www.designsponge.com

↑ A Boro kimono with sashiko stitching. Pre-industrial Japan prized mending over consumption. As Jane points out, "Visible darning is evidence of care."

FURTHER INFO

Research paper by Dr Mark Browne showing the increase of synthetic fibres in marine environments: pubs.acs.org/doi/abs/10.1021/es201811s

Textile Beat website: textilebeat.com

India Flint 2011 Second Skin: Choosing and Caring for Textiles and Clothing

Research paper by Technical University of Denmark "Environmental benefits from reusing clothes": www.researchgate.net/publication/226848184_Environmental_benefits_from_reusing_clothes

Textiles Environment Design: www.tedresearch.net/research

← A pinafore made by Elizabeth Kingston during a Textile Beat workshop.

Getting back to nature
Rewilding in the city

With technology-focused jobs and lives, we risk losing touch with nature. Claire Dunn explores simple ways to reconnect via urban 'rewilding'.

FOR the vast majority of human history, our environment has been predominantly natural. In a historical tipping point, however, more than half the world's population now lives in urban areas, a proportion that is expected to increase to 66% by 2050 according to a 2014 UN report[1]. We are stacking high and wide in high-rise apartments and suburban sprawls, in a scramble for housing, jobs and resources, in a life that is increasingly devoid of green. The nature most of us now get on a daily basis is seeing a rat or a pigeon. An ABS report in 2003 found 98% of Australian children spent most of their recreational time out of school hours watching TV or videos[2].

American journalist Richard Louv coined the phrase 'nature deficit disorder' to describe the experience of today's generation of children who are missing out on time playing in nature. His book *The Nature Principle* applies the same thinking to the adult world of work and leisure.

Richard's research suggests that in disconnecting from nature we are losing a fundamental source of wellbeing, and perhaps even an essential element of our humanity. How can we maintain our connection with that world we evolved in, as we plunge ever deeper into a man-made technological landscape?

The 'back to the land' movement of the 1970s was an early response to the trend, but available only for those with the opportunity and the predisposition to live simply and in a remote location. More recently, a movement known as 'rewilding' is reframing the project of reconnection to incorporate city living. Originally referring to a conservation biology strategy of introducing top-order predators to a wild landscape, rewilding now also refers to the human movement of returning to a more 'original' or 'wild' state of being.

Image: Emily Herring

↑ Garlic farmers on the edge of the city in Bundoora, Melbourne. Farmer Incubator is using garlic as their first crop to connect locals with growing food.

Popular US rewilding podcaster Daniel Vitalis defines rewilding as "strategies for genetically ancient humans to thrive in a modern world, awakening our instincts, freeing our bodies--and minds—from the degenerative effects of domestication."

Though often associated with traditional skills and knowledge of wild plants and animals, rewilding asks us to redesign and reconsider our lives with "full aliveness" as the mission statement, rethinking everything from our diets and footwear to where to place our attention. Rather than wilderness, rewilding asks us to think more in terms of wildness, reconsidering our individuality and our wider human and ecological relationships.

Finding the wild where you are

Moving back to Melbourne to be closer to her family after a year living on an organic farm in New Zealand and prior to that at an environmental education centre in East Gippsland, Melissa (Mel) Turnbull was full of

↑ Beans with beans! Find a recipe for this great dish using homegrown fresh and dried beans, kale, capsicum, basil and more at www.thebackyardvegetable.com.au.

trepidation about losing the connection she felt with the "more than human" world when she returned to the city's grey.

"Suddenly not having access to fresh food and rainwater was really challenging. I could smell the chlorine in the water and my skin was drying out."

Mel initially tried to develop relationships with rural farms, but found they were too far away to be practical. Instead, she discovered Gnomes, an urban farming co-operative and not-for-profit organisation which grows organic vegetables in empty urban spaces.

More recently, Mel has joined up with Farmer Incubator, an organisation linking wannabe farmers with underutilised land and resources near the city. Planting and tending to a garlic crop has linked Mel back not only to her food source, but to a community of other urban farmers.

Moving to the leafy eastern suburbs has also given Mel a large backyard in which to play.

"We love watching the birds coming through the mature trees; even from our bedroom we wake up to see birds in the morning, and at dusk we sometimes see them hawking clouds of insects. We even had a family of tawny frogmouths visit for a few nights."

She's also got the space to grow food at home. "I'm able to grow much of my food with the remainder from local organic farmers."

Mel and her flatmates are regular foragers—hawthorn for tea and homemade ketchup, blackberries from along the train line and edible weeds such as chickweed, mallow, dandelion and fennel.

"Not having much money in the city makes me more resourceful. I've found a source of free fish frames to make broth and for a while I was swapping singing classes for bone broths and ferments."

It's relationships with others though that have allowed Mel to rewild more deeply.

"My flatmates and I were doing regular 'sit spots' in nearby parkland and reflecting on our relationships with trees."

"Kiri, my partner, took me on an early date for a walk along a back creek near where she grew up. Seeing wild patches amongst the urbanisation helped me remember that this land is a lot older. Honouring those parts that tell a different story is important."

This year Mel launched a business running school holiday nature connection programs and a home-school nature club.

"Rewilding for me means finding the wild where you are and connecting to what's available."

Weaving a connection

Textile artist Shelley Krycer approaches the wild within the city's confines through her craft of basket weaving. She's often seen trailing ivy, long grasses, sheoak needles and other plant materials along Melbourne's creeks and beaches in preparation for her weaving workshops. "It's a great conversation starter," says Shelley.

"When I'm weaving on the tram, I'm often approached with a smile and a question. People seem to feel a yearning for what I'm doing. It's a beautiful way to connect with people in a public space, by engaging with the environment."

Foraging also provides a powerful way for Shelley to connect to place.

"It changes my relationship to my environment, noticing for example how sheoaks change through the seasons with their flowering and when there's more moisture in the soil. Seasons are much more noticeable when you're a gardener and a forager."

For Shelley, foraging is more than just gathering materials.

"I just listened to a podcast recently by forager Katrina Blair and she was talking

↑ Urban weaver Shelley Krycer forages for materials for her baskets to connect with nature in the city. She can often be found on public transport trailing ivy, long grasses and sheoak needles—a great conversation starter!

↑ Olwyn Smiley and her family grow more than $2000 worth of vegies a year in their standard Melbourne suburban block. Olwyn posts on Facebook about the garden's treasures such as this 'salad bowl'—rescued from hard rubbish and converted into a simple self-watering lettuce pot. To do that, Olwyn drilled holes 3 cm above the base (for drainage), put in a 3 cm layer of gravel covered with weed mat then soil on top of that. At right is Olwyn's first choko (in the cucumber/zucchini family) from March 2016. Described by her as delicious and tastier by far than a shop-bought one, some in the family begged to differ: "It's a delicate flavour which those without discernment call 'tasteless'!"

about how dandelions have long tap roots and are incredibly resilient; when you eat them you're consuming that quality."

While content right now to be an urban weaver, Shelley is planting seeds for a treechange.

"I definitely feel more expansive when I'm out of the city, more connected to the elements. I have my garden and my pots planted with native grasses, waiting until such time as I have space for a weaver's garden.

"Right now though the forest of the city is my community—the people are the trees. It's a different type of richness."

A permaculture connection

Permaculture—which advocates for ecological and sustainable living integrating plants, animals, buildings, people and community—is a way many have found to rewild where they are.

Olwyn Smiley is one of a growing number who are living the pastoral idyll in the 'burbs, transforming a standard suburban Melbourne block into a green oasis of edible and native plants, and in doing so, providing a nature-connected upbringing for her kids.

"We grow nearly $2000 worth of edibles a year, based on standard greengrocer prices. At the moment we have cherry guavas, more plums than we know what to do with, lashings of chokos, citrus usually, and eggs from our chooks."

More than just vegies, Olwyn's garden encourages visits from native wildlife.

"We have a pond which attracts dragonflies and damsel flies and, at times, frogs. Native plants which attract birds are planted along one side of the property as a kind of corridor to link to the bit of remnant bush along our back fence."

"We were delighted to have a pair of butcherbirds nesting last season. Logs and dense shrubs encourage blue tongues and bird baths are placed at different heights."

Despite sometimes wishing for more space, Olwyn believes her patch of wild is enough to connect.

"To be out on a bigger property would be too time-consuming and expensive. It's more important to us to be in proximity to schools, ageing family and public transport."

"You're absolutely able to connect to cycles and seasons in the city, particularly if you grow food. Rain becomes very important and your awareness of the climate becomes much greater."

Olwyn has now started The Backyard Vegetable, a business helping others rewild their home and garden.

"The kids of one family I'm working for are so excited to see the insects and wasps and little bits of life in their backyard. It's all new and exciting." ✱

↑ Olwyn's backyard became home to a butcherbird family in late 2015. "We love their music, and we love that the blackbirds and Indian mynahs are keeping away from our berries while the butcherbirds frequent our yard."

Claire Wren Dunn is a journalist, rewilding facilitator, barefoot explorer and author of memoir *My Year Without Matches: Escaping the City in Search of the Wild*. See more at www.naturesapprentice.com.au.

Resources:

The Farmer Incubator: www.farmerincubator.org

The Backyard Vegetable: www.thebackyardvegetable.com.au (also on Facebook)

Shelley Krycer textile artist: www.shelleykrycer.com

Daniel Vitalis rewilding podcasts: www.danielvitalis.com/rewild-yourself-podcast

References:

1. The 2014 revision of *World Urbanization Prospects* by UN DESA's Population Division.

2. 'Children's Participation in Cultural and Leisure Activities, Australia', ABS, 2003.

Still a clever country
Australian innovation in sustainability

Energy efficiency consultant Geoff Andrews admires Australian innovation, but, as has often been noted, finds the next step—commercialisation—is lacking. Collaboration, governments and risk-taking could all improve that, he suggests.

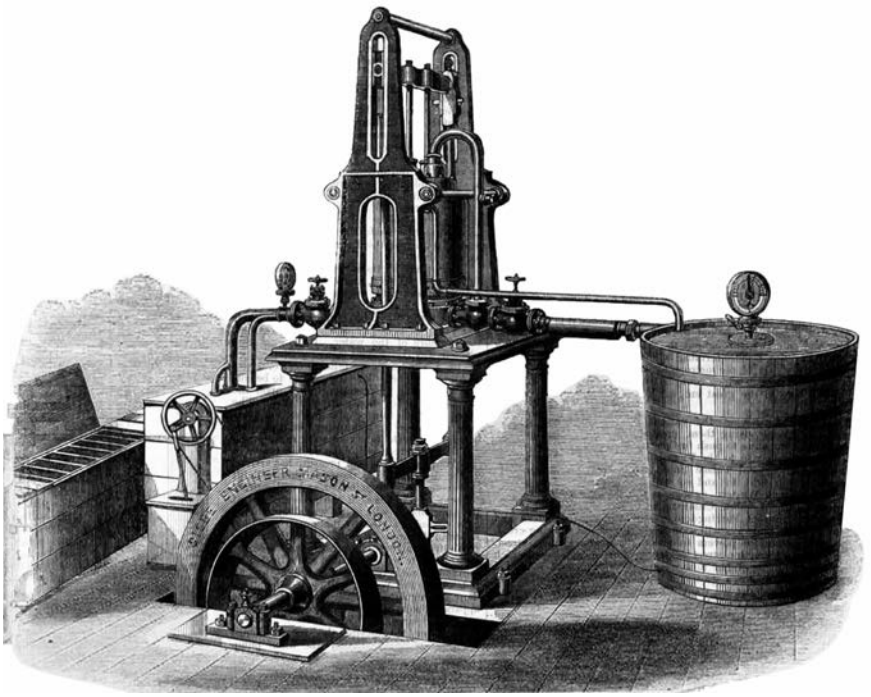


Image courtesy The Engineer

↑ James Harrison designed and built one of the first successful ice-making machines in Geelong, Victoria, and went on to commercialise his design. Parts of one of his early working machines have been recovered and are planned for display at a museum in Geelong (a working model is on display at Scienceworks in Melbourne, driven by electricity rather than steam, and without the refrigerant). James worked in printing in Scotland and established and edited the Geelong Advertiser; it's the printing link that led to his discovery: he noticed that sulphuric ether, a fluid used to clean the printing type, left the type freezing cold as it evaporated, thus paving the way for its use as a refrigerant in his invention.

I VIEW innovation as change for good, so change which improves sustainability clearly qualifies. Most readers of *ReNew* would agree that we have to improve the sustainability of our society, so we must innovate. But, how do we do that, and what lessons can we draw from Australia's sustainability innovation performance to date?

There is no question that Australia has provided the world with more than its share of innovations, including in sustainability. In renewable energy alone, Australia has led the world in PV efficiency for decades, pioneered many improvements in solar water heaters, and is now developing wave energy. We've been first or early implementers of two flow battery technologies (vanadium redox by Maria Skyllas-Kazaco at UNSW in 1980 and zinc bromine by RedFlow). Scottish-born James Harrison built one of the first working refrigerators for making ice in Geelong in 1851 (before that, ice was imported from Canada), and we invented wave-piercing catamarans and the Pritchard steam car. We even had manned (unpowered) flight by heavier-than-air craft a decade before the Wright brothers with Lawrence Hargrave's box-kite biplane.

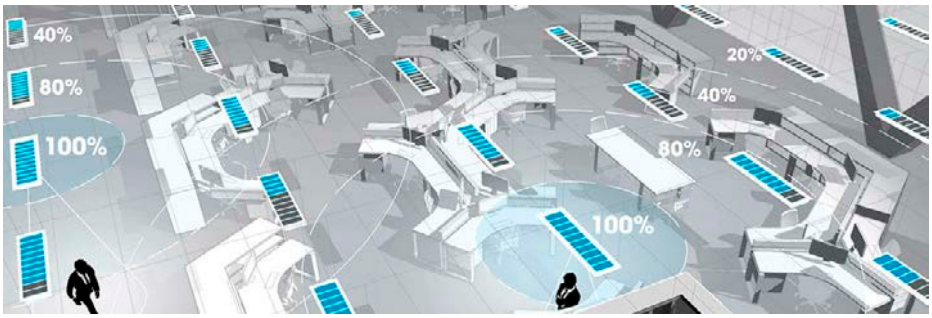
Of course, Australian innovations are prevalent in many other sustainability areas including medicine, construction, agriculture and fisheries, but space is limited here. What we could have done a lot better is commercialising those innovations in Australia. Imagine if Australia led the world in the manufacture of solar panels, refrigerators, air conditioners, wi-fi devices and evacuated tube heat exchangers, the way we do with wave-piercing catamarans and bionic ears.

Improving commercialisation would provide funds to improve our budget bottom-line and allow us to do even more innovation and more commercialisation. To achieve this, I think we need to do several things.

Collaborate more, and I don't just mean between industry and universities. We need to talk about and work on our ideas with friends, colleagues and potential funders and collaborators (with appropriate IP protection), and accept that a small piece of a huge pie is better than 100% of a brilliant idea that goes nowhere.

Build the innovation and commercialisation eco-system, including both physical infrastructure (incubators etc.) and systems (standard agreements, networks of innovators, investors (Angel investors, venture capitalists, banks, ethical funds, green superannuation and government), and service providers such as IP professionals, designers and manufacturers.

Be brave, accepting that a low success rate with some spectacular successes will result



↑ In the Australian-designed Organic Response lighting system, a 'sensor node' in each light detects if someone is present and instantly outputs a pre-determined amount of light, say 100%; it then communicates that it can 'see someone' to its neighbouring lights, which adjust accordingly (to say 80%), and those neighbours also let the lights next to them know—creating what the designers call the 'occupancy information cloud'. The result is less energy use and better lighting. The system has won several awards since its commercial release in 2013 and has been installed in offices and schools around Australia and in Europe, and is now heading to the USA.

What is Angel investing?

'Angel' investors contribute know-how, contacts, coaching and time, as well as funds. So the value to the entrepreneur is much higher than the dollar figure alone. Unlike venture capital funds, Angels invest their own money and they don't want to take over the company (typically limit ownership to 30%; and lower for initial investments). Funding rounds are typically $100k to $500k, but can be more, and some are syndicated with other Angel investor groups. There are Angel groups in Melbourne, Geelong, Perth, Brisbane, Sydney and NZ, and around the world. More info at www.melbourneangels.net

in many sustainability improvements and financial success.

Help innovators to commercialise by using government purchasing contracts to encourage the development of greener, more efficient products. This does not mean direct financial support, but rather providing the incentive for their development. Done well, it should result in a net saving for government and the creation of many more tax-paying companies.

Redesign government funding, which now seems to go mostly to companies that can prove they don't need funding because of their financial resources and the technical readiness of the product to be commercialised. This could mean deliberately increasing the acceptable risk on individual projects, but improving the overall risk profile by taking on more projects. Including early stage projects will increase the number of successes and provide assistance at the stage of development when it will be most effective.

Finally, we should continue the pure research that has no obvious immediate commercial application, but has a way of spawning commercial opportunities and products down the track. ✱

Geoff Andrews is the founder and managing director of energy efficiency company Genesis Now, a co-founder of Snowy River Innovation which is commercialising clean-tech innovations, founder or co-founder of five other sustainability-focused businesses, a foundation shareholder in five startups and a Melbourne Angel investor. He has been a member of the ATA for 18 years.

Image: Carnegie Wave Energy

↑ Australian company Carnegie's CETO wave energy technology is being used in a world-first commercial-scale wave energy array, in a project supported by ARENA. It will deliver energy to the naval base on Garden Island near Perth, WA, and produce desalinated water, with commissioning due in 2017. A fully submerged buoy is tethered to a pump on the seabed; the oscillation of the buoy transfers energy through the tether (a marine-grade rope) which causes the pump to extend and contract. The pump pressurises fluid which is then sent onshore through a pipeline to operate an off-the-shelf hydroelectric power plant.

The innovations Geoff built

Energy innovations Geoff has driven or is helping to drive now include:

- Organic Response, an elegant lighting control and IoT company, based on his invention and initially funded by him, then by Commercialisation Australia and equity investors. It is now exporting Australian-made high-value controls to Europe, the UK and the USA (organicresponse.com)
- Through Snowy River Innovation: a 150kW modular solar concentrating technology with thermal storage which will generate electricity for eight hours after sunset; and a system to capture the kinetic energy of braking vehicles, for reuse in acceleration (snowyriverinnovation.com)
- The Eco Inn on French Island run mostly on wind and solar power since 1996.

From engineer to activist
A renewables industry is born

ATA member Trevor Berrill has been involved in the renewables industry in Australia since it began, as an engineer, academic, trainer and 'alternative technologist'. He gives a personal take on the slow emergence of an industry.

Image: Richard Gifford, www.flickr.com/photos/rgifford

↑ The White Cliffs solar power station in NSW, constructed in 1981, was Australia's first solar power station.

MY OWN interest in alternative technology sprang from disillusionment with the engineering education I'd received at QUT in the early 1970s. It was a time for challenging the establishment, but engineering seemed all about fostering the status quo. I worked as assistant to the maintenance engineer in a coal-fired power station near Ipswich, and also down Mt Isa Mines. I saw and smelled the pollution, and I wasn't impressed.

I entered an essay competition on energy futures run by Engineers Australia. My essay outlined a decentralised power system run from renewable energy. I came second in the competition. The winning essay promoted the status quo, more fossil fuels.

There had to be a cleaner, greener way. With Friends of the Earth, I was involved in activism, campaigning hard against nuclear power. But I thought we shouldn't just be against something; we had to present an alternative energy future.

Then I was given a copy of *Radical Technology*, edited by Godfrey Boyle and Peter Harper. Therein lay the foundation of a future I could believe in—renewable energy, energy-efficient buildings, organic food production and sharing resources in self-sufficient, ecologically sustainable communities.

Defining alt tech

It was one of those editors, UK scientist Peter Harper, who coined the term alternative technology, to refer to "technologies that are more environmentally friendly than the functionally equivalent technologies dominant in current practice." Peter went on to be a leading researcher and educator at the Centre for Alternative Technology in Wales, a centre that's been showcasing sustainability since 1973.

Birth of an alternative technologist—and an industry

I went on to become a technical officer at the University of Queensland in the mid-1970s, and there I worked for leading academics in renewables research, Dr Steve Szokolay, a solar architect, and Neville Jones, a wind energy researcher. We tested solar collectors and built low-speed wind tunnels, an artificial solar sky and controlled environment rooms. In my spare time, I became an 'alternative technologist' at home, building solar water heaters, pedal-powered contraptions and small wind generators—perhaps in common with many ATA (*ReNew*'s publisher) members!

Then I got invited by Adrian Hogg, owner of Alternatives to work part-time designing and installing small PV systems throughout south-east Queensland. Adrian was a founding member of ATRAA, (the Appropriate Technnology Retailer's Association of Australia) along with Stephen Ingrouille and Tony Stevenson (Going Solar in Melbourne), Brian England (Self-sufficiency Supplies, Kempsey) and Sandy Pulsford (Solaris Technology, Adelaide).

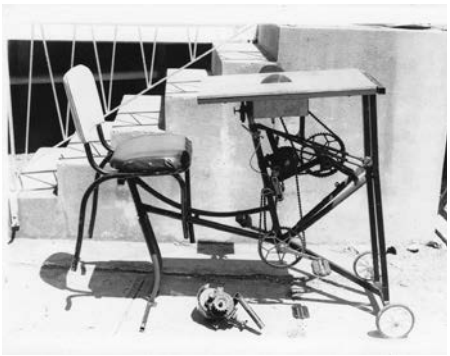
These business owners were leaders in the

→ History of an 'alternative technologist', mirroring the development of the renewables industry in Australia.

Right: Trevor installed this wind generator in 1985 to power his family's rural cabin near Brisbane, in combination with a 100 watt PV array. It was later replaced by a restored 1952 model 750 watt Dunlite wind generator on a 16 metre tower.

Far right, top: A pedal-powered circular saw with drill, grinder and 12 volt generator attachments built by 'alternative technologist' Trevor in the 70s. He notes that it worked but could have benefited from added flywheel mass for the saw and grinder.

Far right, bottom: Trevor ran the Renewable Energy Centre at Brisbane Institute of TAFE throughout the 1990s, developing and delivering national training in renewable energy. The test rig used for testing his early wind generators was later used with students to test and measure the performance of a simple wind generator at bay-side Wellington Point, near Brisbane. He says, "There was always a reliable sea breeze to get the wind generator working."



uptake and expansion of renewable energy and energy efficiency industries for ordinary families and businesses across Australia. They took a holistic approach to energy service provision and sold a range of energy efficiency and renewable energy products. Alternative communities around Australia often became the first place small PV, wind and hydro systems were used for off-grid power. Some innovative businesses developed out of these communities, such as the Rainbow Power Company in Nimbin, NSW, who developed some of Australia's first microgrids.

Recognising renewables

Up to the early 1980s, renewable energy was largely unrecognised as an industry sector even though we were using large amounts of hydropower in many states. In Queensland, colleagues and I in the Australasian Solar Energy Society estimated that hydro and biomass from sugar cane supplied about 18% of end-use energy in 1990.

Many renewable energy uses were simply not accounted for, such as crop and salt drying, solar passive gain and windmills for water pumping—even though there were an estimated 70,000 Southern Cross windmills in Queensland alone by the 1990s.

Business partner Peter Fries and I undertook the first wind energy survey of southern Queensland in 1985 with the University of Queensland. This project lasted two years and mapped out the wind resource from the coast near Brisbane to Windorah 1200 km inland. It clearly showed there was potential for wind power on elevated terrain and coastal sites.

Solar water heaters were gaining a foothold in the eastern states with Solahart, Edwards and Beasley (now Rinnai) all trying to expand their market share against standard electric and gas water heaters. Photovoltaics (PV) had started being used for telecommunications and navigation.

Then, leading companies such as Bob McKnight Trading (now RF Industries) began marketing PV for household use. Innovative products were starting to be developed. At the University of Queensland, young graduate engineer Stuart Watkinson designed a highly efficient maximum power point tracker (MPPT). This DC to DC converter (AERL brand) revolutionised our ability to pump water from PV and power electric vehicles, and improved the overall efficiency of solar PV battery-charged and grid-connected systems. When Peter Fries and I toured the USA with Stuart in 1985, we visited NASA to demonstrate Stuart's MPPT. They were blown away with the efficiency achieved.

Solar revolution

In the 1980s, solar centres were established in several states with supportive government agencies such as the Victorian Solar Energy Council. There were centres at CSIRO in Melbourne, University of NSW in Sydney and Murdoch University in WA. Queensland University hosted a dedicated solar energy research centre undertaking work on solar power generation and solar drying.

But by the end of the 1980s, oil prices had slumped and government support for solar followed. Fortunately, a new agenda emerged to drive interest in renewables again. The UN report 'Our Common Future' put sustainability and global warming firmly on the agenda. As a result, throughout the 1990s and 2000s, a range of supportive policy for both renewable energy and energy efficiency was implemented by state and federal governments. This included programs to improve the energy efficiency of our building stock and appliances, and support of off-grid and on-grid renewables such as wind farms, rooftop solar PV and hot water.

By the mid 1990s, companies such as Selectronic, Latronics and Plasmatronics were manufacturing robust quality inverters and charge controllers in Australia. In 1994, Peter Fries went on to coordinate Australia's first grid-connected home, Solar One, on the Sunshine Coast. A solar revolution was on the horizon.

40 years of insights

What are some insights from my 40 years in renewable energy? Firstly, don't rely on

government policy. Witness the boom/bust cycles in the Australian rooftop PV industry caused by changes in policy. Compare this with the carefully implemented bipartisan policy in Germany where about 400,000 people are now employed in renewables and 30% of their electricity is from renewables. Germany's plan is to increase renewable electricity to 80% by 2050 and halve primary energy for all uses through efficiency.

Secondly, the power of the fossil fuel industry to influence government policy remains a major barrier to long-term deployment of renewables and to addressing global warming. This was already evident in the 1990s in the Queensland Department of Mines and Energy's building where large pieces of coal were beautifully displayed in immaculate cabinetry in the foyer. Just recently, the giant Adani coal mine was approved, as the Great Barrier Reef suffers from a massive bleaching event. Fortunately, the financial viability of renewables is now out-competing fossil fuels even when one ignores the billions of dollars of social and environmental costs fossil fuels cause.

Thirdly, beware of greenwashing. Both the corporate world and governments are very good at this. BP's Beyond Petroleum advertising campaign around 2000 was a classic example. AGL, Energy Australia and Origin Energy have all been criticised for similar marketing.

Finally, have we achieved the decentralised, ecologically sustainable society that I hoped for, driven by clean renewable energy? No, but we have come a long way, with lots of public support and many innovative researchers and products. We are most certainly on the wave of a renewable energy revolution. Let's hope it's in time to avert catastrophic climate change. ✸

Trevor Berrill lives in a fully solar-powered, energy-efficient home which includes the first grid-connected solar PV system in the Redlands. He windsurfs regularly at Wellington Point, just to test the power of the wind.

Solar One: The story of the first grid-connected solar home in Australia

With around 1.5 million rooftop solar systems connected into the electricity grid in Australia today, it would be hard to find a suburb without at least one house producing solar energy. But in the early 1990s, grid-connected solar was unheard of in Australia—a reality Peter Fries was determined to change.

At the time, Peter was a journalist working with a range of organisations, including the Australian and New Zealand Solar Energy Society. When travelling in Japan and the USA in 1991 he came across a number of grid-connected solar projects, including an entire grid-connected suburb in Arizona. On return to Australia he discovered there were no examples here, although there was a developing off-grid solar industry.

"I wanted to build that state-of-the-art solar home, so I called Tony Booth at the South East Queensland Electricity Board (now Energex) and asked if he would be interested in a project," says Peter. "To his great credit he said it sounded interesting, and invited me down to Brisbane."

Over the next few years, Peter worked on the idea, while at the same time building a rammed earth home near Coolum in Queensland. With ideal solar access and the help of supporters, by 1994 he had enough funds and in-kind support to install a $30,000 solar system. It consisted of 16 x 83 watt Solarex panels and an early-model grid-interactive inverter, developed and built in Australia by Dale Butler working with Siemens.

"We also signed the first electricity purchase network agreement which was for 9.3 cents per kWh—about 20 cents per kWh in today's money, so around three times today's rate," he says. "The first cheque we received for solar power was for $7.00!"

Peter has since sold the house but visited it in 2013 and the system was still operating. The inverter had been replaced: "It had failed after about 18 years, impressive considering it was the first one in Australia."

With the high cost of solar PV cells at that time, the house attracted thousands of visitors and was closely monitored, but not everyone was convinced of the technology. "At the end of the project, my builder said 'this won't catch on'," says Peter.

"Solar One was a modest effort by a group of curious and committed individuals. It wasn't particularly original or technically challenging, but it was that proverbial first step along what has become a twisting path towards a clean energy future." ✸

↑ Peter's first cheque from his energy company for solar exports.

The world's first baker
Australian Indigenous innovation

Why don't we know about the oldest grinding stones in the world, found in Australia, or the crops cultivated by Aboriginal Australians? Bruce Pascoe is helping change that.

Image: Dwayne Bannon

← Lake Mungo bread made from Panicum descompositum.

IF you were asked who the world's first bakers were, what would your answer be? Most would think first of ancient Egypt where it is believed bread was first baked around 17,000 BCE. And yet there is evidence to show that grindstones in Australia were used to turn seeds to flour 30,000 years ago.

Archaeologists found the evidence for this at Cuddie Springs in New South Wales in the shape of an ancient grinding stone which had been used to reduce grass seeds to flour. These were the bakers of antiquity. It took Egypt 12,000 years to repeat this baking experiment. Why don't our hearts fill with wonder and pride?

Australian sovereign nations cultivated domesticated plants, sewed clothes, engineered streams for aquacultural and agricultural purposes, and forged spiritual codes for the use of seed in trade, agricultural enterprises, marriage and ceremony.

This was and is an incredible human response to the difficulties of fostering economic, cultural and social policies. It may be unique in its longevity but also in its ability to flourish without resort to war.

Australia's reluctance to acknowledge what was lost can be witnessed in our ignorance of the birth of baking, the gold standard of economic achievement.

Why is this? Is it a malicious refusal to recognise the economic triumphs of the people from whom the land was taken or a simple culture of forgetting fostered by the bedazzlement of Australian resources and opportunities?

If we could rid ourselves of the myth of low Aboriginal achievement and nomadic habits, we might move toward a greater appreciation of our land. We might begin to wonder about the grains that explorer Thomas Mitchell saw being harvested in the 1830s, and the yam daisy monoculture he saw stretching to the horizon of his 'Australia Felix', the early name given to western Victoria. These crops must have been grown without pesticides and chemical fertilisers and in harmony with the climate; surely they are worthy of our investigation.

"If we could rid ourselves of the myth of low Aboriginal achievement and nomadic habits, we might move toward a greater appreciation of our land."

If you search for Australian research into yam daisies you inevitably come across, Beth Gott, an honorary research fellow at Monash University. She has almost single-handedly led the interest in this wonderful plant. Inspired by her work, a Landcare group and Aboriginal and non-Aboriginal people in East Gippsland have begun field trials into the staple of the southern Aboriginal economies.

Similarly the fish traps at Brewarrina seen by Mitchell and other explorers created economic conditions that allowed the people to live in semi-sedentary villages of over 1000 people; Mitchell marvelled not just at the villages' size but also their comfort and elegance.

Since Mitchell's report, however, you will look in vain for later reference to the Brewarrina fish traps even though some archaeologists have speculated that they may be 40,000 years old and as such the oldest human construction on the planet. Even if you accept the more common age of 15,000 years, these structures are still amongst the world's first. Until recently, the sole publication about them was a 50-page book published in Brewarrina in 1976.

When we eventually acknowledge the food plants adapted to Australian conditions and domesticated by Aboriginal people, let's hope we don't just celebrate them every 'Baker's holiday' but recognise the intellectual property Aboriginal Australia has vested in them.

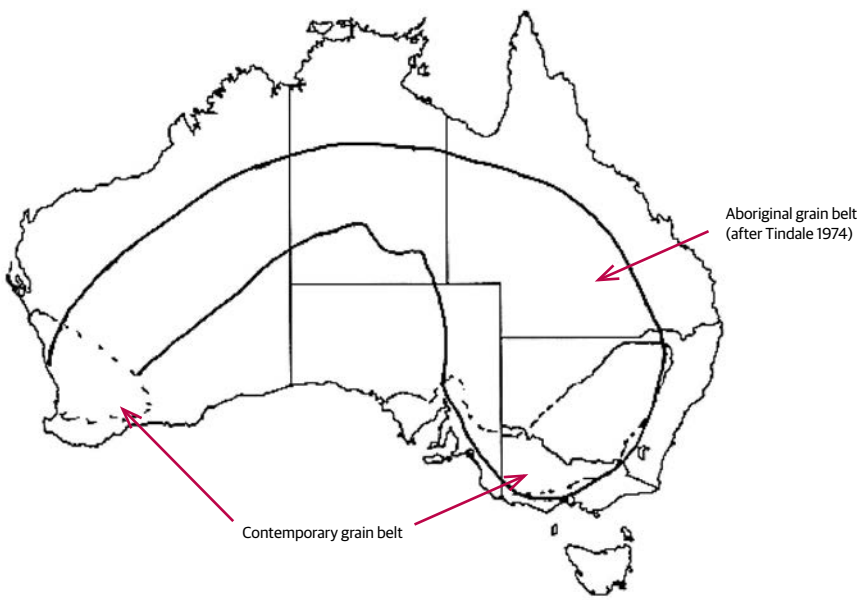
Criticism of the accepted history of Australia is not unAustralian; it is an invitation to rejoice in everything the land offers and not just those things we inherited from the British. ✱

Bruce Pascoe is an award-winning writer, editor and anthologist of Bunurong/Tasmanian heritage. His book *Dark Emu Black Seeds: agriculture or accident?* is published by Magabala Books. It was named Book of the Year in the 2016 NSW Premier's Literary Awards.

↑ Grinding grain into flour.

Image: Lyn Harwood

↑ A yam daisy garden under trial as a crop in East Gippsland.



← This map gives an indication of how much we can learn from Aboriginal grain production. Norman Tindale documented that Aboriginal grain harvests occurred over most of the Australian continent but contemporary grain areas make up less than a quarter of that area. Image courtesy Bruce Pascoe.

Solar sells
Australian PV research and innovation

From PERCs to heliostats to improving PV quality, Andrew Blakers from the Australian National University describes high-impact innovations that found their way through Australian-led, government-supported research.

↑ RayGen's PV Ultra solar power system utilises an array of flat 'smart' mirrors that concentrate the sun's rays 1000 times onto a small receiver fitted with RayGen's multi-junction gallium-arsenide solar cells. The PV Ultra system requires just 1/1000th of the photovoltaic material and half of the solar collector area to produce the same power as flat panel photovoltaics.

THROUGH consistent government grants for innovation over the past 40 years, Australia has punched far above its weight in renewable energy innovation, particularly when it comes to photovoltaics (PV). The potential benefits for the Australian economy are substantial. PV now constitutes about a quarter of new electrical generation capacity installed worldwide each year; wind comprises another quarter; and coal, oil, gas, nuclear, hydro and all other renewables combined constitute the other half. In Australia, PV and wind comprise practically all new generation capacity.

Support for research and innovation lies at the heart of accelerated growth of the renewable energy industry. It supports later-stage commercialisation directly through technology development. Additionally, university research groups underpin undergraduate and postgraduate education and training of engineers and scientists.

High-impact Australian innovations

What are some of the ways Australia has contributed to solar research, and what are some of the commercial successes? Here are eight examples of high-impact innovations that emerged from Australian-led R&D.

1. PERC SOLAR CELLS

The PERC silicon solar cell is an Australian invention (see box), which is now used in about half of new solar cell production lines worldwide. It's set to soon dominate the worldwide solar industry, according to the International Technology Roadmap for Photovoltaics (www.itrpv.net). So far this is the most successful renewable energy technology to emerge from Australia.

2. PHOTO-LUMINESCENCE

BT Imaging's advanced photo-luminescence characterisation systems for research and industry (www.btimaging.com) emerged from the University of NSW. They enable researchers and industrial engineers to visually assess silicon quality in great detail and to modify processes to maximise quality.

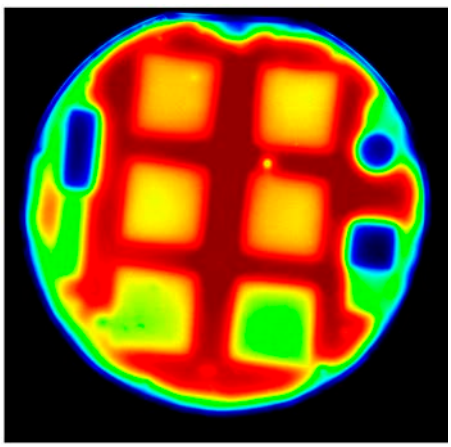
3. HYDROGEN-PASSIVATION

Hydrogen-passivation of defects, flowing from work currently underway at the University of NSW, may become widely adopted by the world's silicon PV industry in order to increase cell efficiency.

4. SLIVER SOLAR CELLS

Sliver solar cell technology was invented at the Australian National University and was the subject of a $240 million commercialisation endeavour by Origin Energy and Transform Solar. The commercialisation was halted at pilot production stage at the depths of the PV industry depression in 2012, at which time large investments were frozen throughout the PV industry. Alternative commercialisation pathways are being explored. Sliver cells were developed to increase cell efficiency (the cells are bi-facial, so collect light on both sides) while reducing the amount of silicon required.

"The PERC silicon solar cell is an Australian invention now used in about half of new solar cell production lines worldwide."



↑ A 100 mm diameter silicon wafer containing six 2 x 2 cm² laboratory cells, imaged using photo-luminescence. The redder the colour, the better the overall quality; here, the bottom two cells have lower quality than the others. The technique enables quality across the whole wafer to be visualised.

5. RAYGEN'S HELIOSTATS
RayGen's heliostat-based PV concentrator system follows on from earlier PV dish-concentrator systems developed by the same team (see image).

6. BURIED CONTACT SOLAR CELL
The Buried Contact solar cell, developed at the University of NSW by a team led by Stuart Wenham and commercialised by BP Solar, had a substantial impact upon the PV industry in the 1990s, although production has now ceased.

7. THERMOSIPHON SOLAR HOT WATER
CSIRO played a major role in the development of the modern thermosiphon solar hot water system (which relies on thermosiphon flows to circulate water to the tank located above the panels, rather than a pump) during the 1950s and 1960s, in a program initiated by Roger Morse.

The PERC solar cell

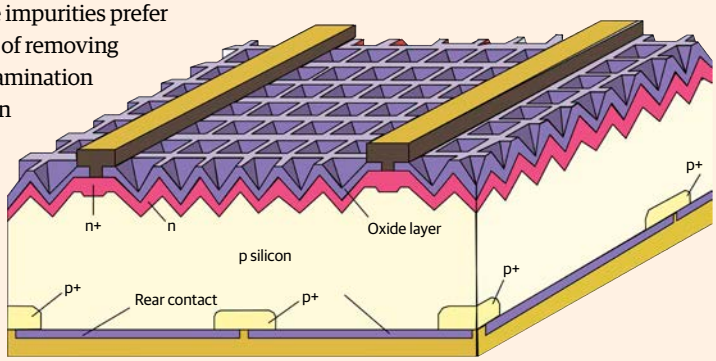
PERC (passivated emitter and rear cell) silicon solar cells are an Australian invention that is becoming the dominant photovoltaic technology. PERC has a 15% share of the current PV market, worth billions of dollars per year. The International Technology Roadmap for Photovoltaics suggests that silicon PERC cells will dominate international PV markets within a few years (www.itrpv.net).

During the 1980s a high silicon solar cell efficiency program, led by Andrew Blakers, was established in the research group of Martin Green at the University of New South Wales. Initial improvements arose from passivating (reducing surface damage) the top surface of the cell with oxides and reducing optical losses with double-layer anti-reflection coatings and surface texturing using grooves and inverted pyramids. The first reports of 18% (Blakers 1984), 19% (Green 1984) and 20% (Blakers 1986) efficient solar cells appeared at this time.

The rear surface of these cells comprised alloyed aluminium, which was known to have poor surface passivation and reflectivity. However, the alloy is an outstanding 'gettering' layer (a layer which removes unwanted impurities by providing an alternative material—a 'getter'—where the impurities prefer to reside), capable of removing silicon wafer contamination caused by diffusion and oxidation furnaces. In 1988 the PERC solar cell was developed. In this simple and elegant design, electrical contact to the silicon was achieved via an array of small holes in a rear silicon dioxide layer, spaced about one millimetre apart in order to minimise contact recombination losses (when the electrons and holes recombine before they can be collected and used as current). The front surface had good surface passivation and low metal contact areas to minimise surface recombination, plus surface texturing to maximise light absorption and light trapping. Optical and recombination losses at the rear surface were minimised by using an aluminium reflector atop the rear passivation oxide. Chlorine processing minimised silicon contamination during high temperature steps. Cells with Voc of 705 mV (very high; a typical cell has Voc of 600 to 650 mV) and efficiencies above 22% were reported (Blakers 1989).

Further improvements were made, albeit at the cost of increased complexity, eventually leading to 25% efficiency (Zhao 1999). Better surface coatings and deposition techniques have become available, as has process machinery designed and optimised for PERC.

A tipping point has been reached—the improved efficiency of PERC cells outweighs the slightly higher cost. PERC is becoming the new industry standard cell design, with billions of dollars in annual sales.

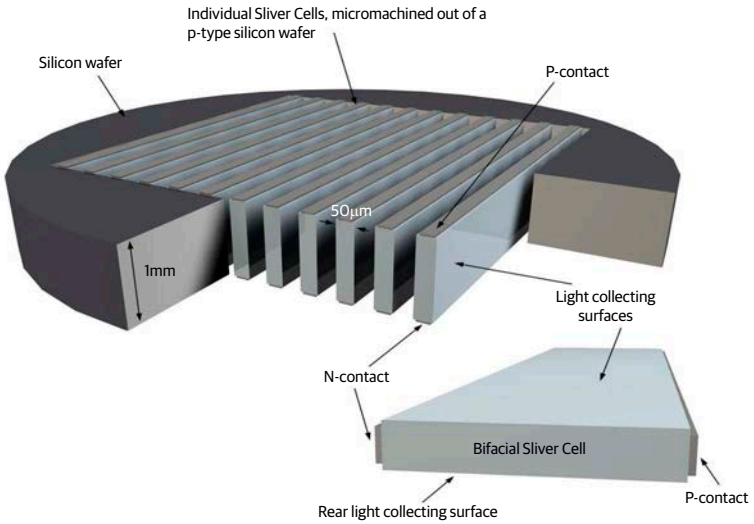


8. TRAINING
A large proportion of Asian technology and business leaders in the PV industry received their undergraduate or postgraduate degrees and technology training in Australia.

Benefits of supporting innovation

Benefits to Australia from these achievements include reduced cost of solar energy, reduced greenhouse gas emissions, royalty payments, investment by foreign companies in Australian R&D and Australian companies, student fees, preferential arrangements by foreign alumni and international prestige at events such as the Paris climate conference.

Since PV now constitutes approximately a quarter of new electricity generation capacity installed worldwide each year (and



← Sliver cells were an interesting technology that showed promise, but the more complex manufacturing couldn't compete with low PV prices and the project was halted in 2012.

rising fast), the benefits—greenhouse and otherwise—are starting to flow in substantial measure.

It's possible to estimate the direct commercial benefit from the efficiency improvements enabled by adoption of the PERC solar cell. For example, a 5% relative efficiency improvement on 50% of Australian photovoltaic systems over the ten-year period 2018 to 2028, with average annual installation rate of 2 gigawatts per year and average area-related costs of $1500 per kilowatt, would translate to savings of $750 million. Worldwide, the savings would be about 50 times larger.

ARENA's role

The government recently announced that it will not abolish the Australian Renewable Energy Agency (ARENA), which is good news. However, it also announced that ARENA's grants function will be severely curtailed, in favour of offering funding in return for equity, with the aim of making a small real rate of return. In short, ARENA will act like the Clean Energy Finance Corporation except with riskier investments and a lower required rate of return on capital. Very few projects that ARENA has funded to-date would have proceeded under this approach and, in fact, universities can't accept equity investments.

Competitive grants are accepted worldwide as a highly effective method of supporting R&D and early-stage commercialisation. Equity returns, as proposed for ARENA, have rarely been effective in Australia at an early stage in the innovation chain. In contrast, sustained provision of grants leads to technology development and education, and substantial benefits flow to Australia.

Grant-supported renewable energy R&D and education is a crucial part of climate change mitigation and will be seriously downgraded by this new policy. Recently, 60 senior solar energy scientists and engineers wrote to the prime minister to urge continuation of ARENA's grant funding role in order to support R&D, early stage commercialisation and education. Hopefully, the government will moderate its policy and restore ARENA support for grants so that we can continue to see successful innovation following on from research and early stage commercialisation in Australia. ✷

Andrew Blakers is professor of engineering at the Australian National University.

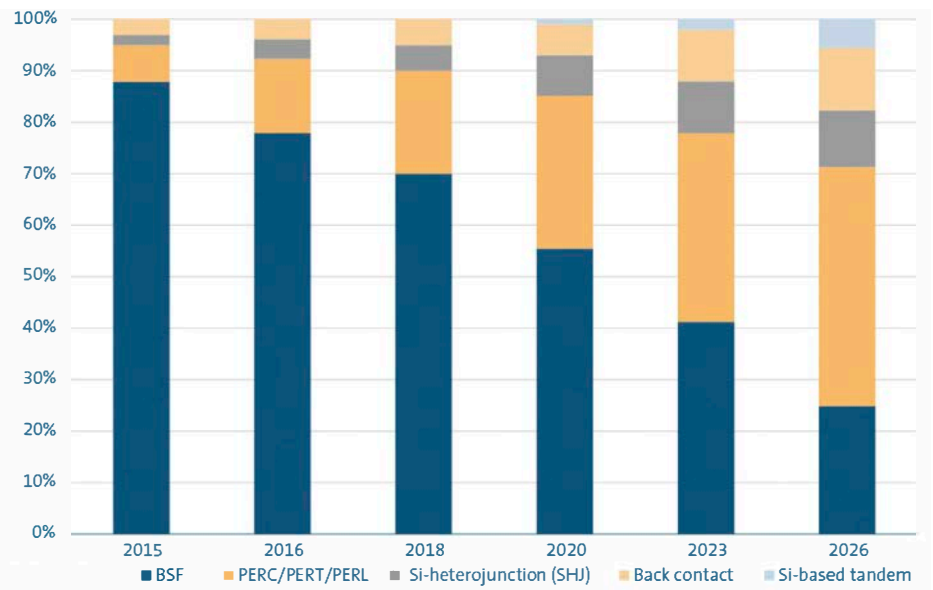


Image: ITRPV, www.itrpv.net

↑ Projected future market share of different PV cell architectures. Cell types are: BSF (back surface field, a cell design used to reduce surface recombination), PERC (passivated emitter and rear cell), Si-heterojunction (cells that use thin amorphous silicon layers on top of monocrystalline silicon, such as the Panasonic HiT cells), back contact (cells that have both the positive and negative contact on the rear surface) and silicon tandem cells (cells of different types are placed one on top of the other, each converting a different part of the light spectrum).

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Making batteries viable
Boosting the value of storage

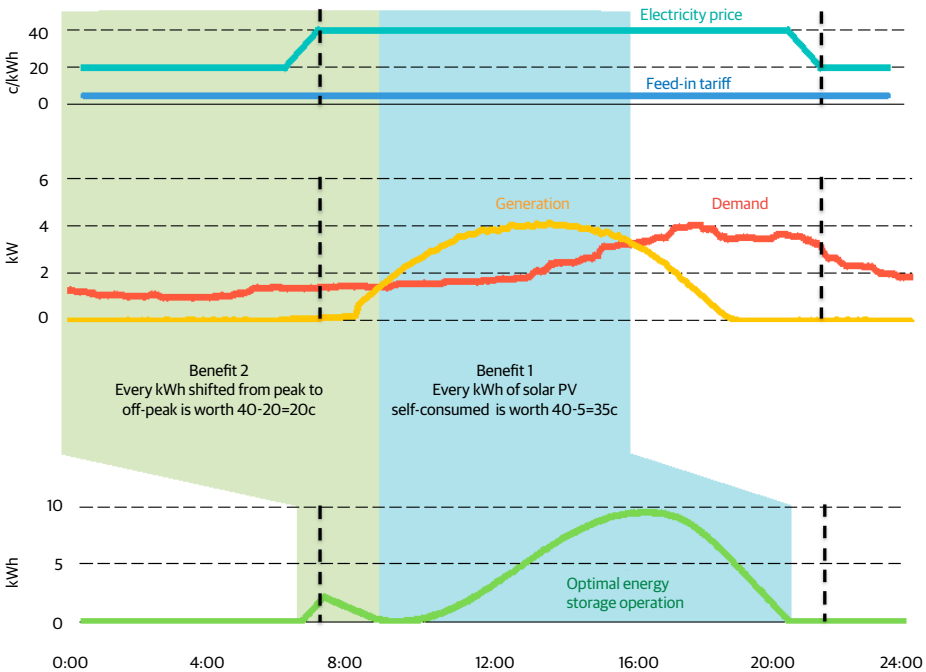
Julian de Hoog and Khalid Abdulla explain how energy consumption and weather forecasting can improve the financial equations for domestic energy storage.

MANY residential householders are now exploring the possibility of installing energy storage in their homes to reduce their electricity bills and better manage their energy needs (see 'Energy Storage Market Heats Up' in *ReNew 135*). This is true in particular for solar PV owners currently benefitting from feed-in tariffs that are due to expire: from January 2017, hundreds of thousands of customers (in particular in Victoria and New South Wales) will receive considerably less for any energy exported to the grid, making the idea of storing excess energy for later use more attractive.

The excitement and interest isn't just limited to residential solar PV owners though—across the energy industry there is an expectation that large batteries and other forms of energy storage will be installed at increasing rates. Many industry analysts predict that the rate at which energy storage is taken up will be greater than the rate at which solar PV was taken up at the same stage of technology maturity, suggesting that an energy storage boom may be imminent.

However, energy storage still remains a fairly expensive proposition and householders looking to install a battery can expect to spend $10,000 or more, even for relatively small systems. As with solar PV, these costs will come down with increasing uptake and technology developments, but for at least a couple of years the cost of a battery will be hard to justify in most cases. The same is true for many utility-level and large-scale energy storage projects.

However, the economic case for batteries may be improved significantly using 'value stacking'—in other words, using the battery for as many different benefits as possible. At the utility level, this means that the cost of a battery may be justified if it can be used for several of the following: shifting peak load, regulating frequency, managing voltage, and deferring network investment—all of which basically mean reducing the cost or improving the reliability of the network.

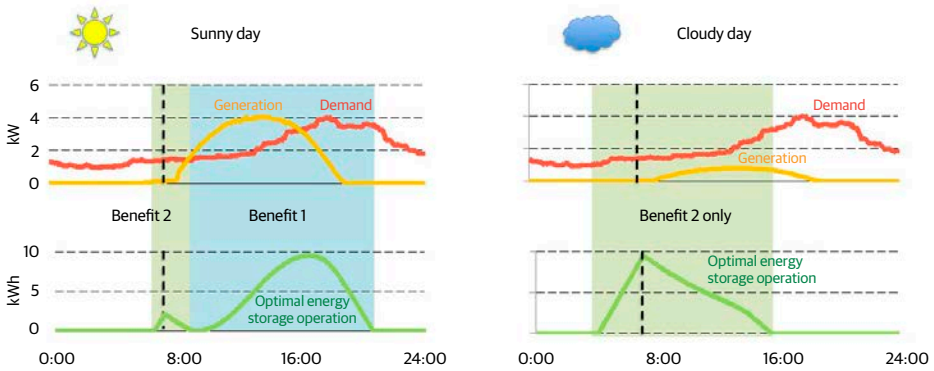


↑ Figure 1. A common tariff structure (top) and averaged demand and solar generation (middle) for a typical customer in NSW. The best way to operate a battery (bottom) is to mainly take advantage of solar self-consumption (Benefit 1), while adding just a little bit of tariff optimisation (Benefit 2).

At the residential level, value stacking is typically simpler: batteries can help you save on your bills by (1) allowing you to 'self-consume' any solar energy you generate, (2) conducting tariff optimisation (charging when the price of electricity is low, discharging when it is high), and (3) in more advanced scenarios, trading energy on the wholesale market (an area in which Australian company Reposit Power is a global pioneer). There are other benefits too, of course, such as having backup power or a measure of independence from the grid, but these are more difficult to quantify.

Let's look at what this really means for a householder: Figure 1 shows the example of a possible NSW customer. This customer pays a peak electricity price, per kilowatt-

"The economic case for batteries may be improved significantly using 'value stacking'—in other words, using the battery for as many different benefits as possible."



↑ Figure 2. The best way to operate your battery depends very much on the weather and your demand patterns. Forecasting becomes essential to get as much value from your battery as possible.

hour (kWh), of 40 cents from 7am to 10pm, and 20 cents at all other times. Assuming no generous feed-in tariff, this customer only receives about five cents for any electricity exported to the grid. The demand and generation profiles shown here are idealised (a real demand profile will jump up and down much more), but only because this helps to illustrate the concepts.

The first benefit this home owner can receive from a battery is solar self-consumption. For every kWh that their solar PV system generates, if this is used to offset peak electricity rather than being exported to the grid, five cents are lost but 40 cents are gained, for a net value of 35 cents. The second benefit this home owner can receive from a battery is tariff optimisation. For every kWh imported from the grid at night-time, instead of during the day, only 20 cents are paid instead of 40 cents, for a net value of 20 cents.

These two benefits can sometimes compete: if we charge the battery fully overnight to take advantage of low prices, then it might still be full (or close to full) the next morning when the sun starts to shine, meaning we can't capture all the available solar energy. Weather forecasting becomes very important, as shown in Figure 2. On a sunny day, this householder wants their battery to be empty in the morning (to be able to soak up excess solar), but on a cloudy day, they want it to be full (to have charged from low-cost electricity overnight).

We conducted a preliminary study to understand just how important forecasting is, using a full year dataset from 16 customers in NSW. We compared the methods used by many systems today (most of which do not take into account any forecasts at all) with some simple forecast-based methods. The benefits vary from one customer to the next, depending on demand and generation patterns, solar PV system size, battery size, and so on—but in general the use of simple forecasts boosted the savings on the annual electricity bill by between 30% and 100%, significantly improving the economic case for energy storage.

Another important aspect of managing a battery well and ensuring it returns its maximum possible value is to understand its degradation. Batteries will degrade at very different rates depending on average state of charge, charge/discharge currents, depth of discharge and number of cycles (among other factors). In some cases it is advantageous to sacrifice some short-term benefit in order to be able to operate the battery for longer. When we took into account the impact of operation on battery degradation, we found that we could significantly improve the amount of time that a battery can be used (in some cases doubling their lifespan). Again, this is a key consideration in finding ways to make batteries return their maximum possible value (we hope to follow up on this research, and what's possible now, in a later *ReNew*).

Improvements in technology will surely lead to cheaper, more efficient and more compact batteries in the coming years—but it will also be essential to operate them as intelligently as possible, taking into account weather, data analytics and a deep understanding of battery degradation. ✱

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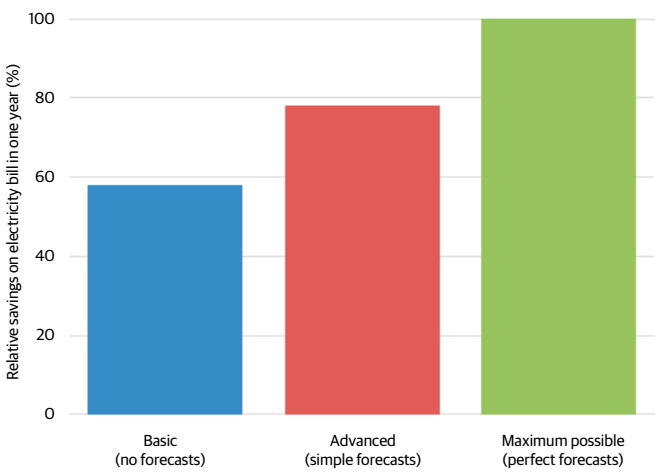
→ Figure 3. Relative savings on a residential electricity bill over the course of a year. The green bar (right) represents the maximum possible savings you would achieve with perfect forecasts (which are of course never possible). However, even simple forecasts can boost savings on your bill from about 60% (achieved by many systems today) to about 80%.



Agents of change
Making batteries go the extra mile

Taking distributed generation a step further, household battery systems will become active network agents in a world-first trial happening now on Bruny Island in Tasmania. ANU's Evan Franklin explains.

THE buzz surrounding on-grid residential battery storage systems has been deafening of late. In fact some market analysts, notably among them Bloomberg New Energy Finance (BNEF), predict Australia to become a global leader in battery storage deployment. BNEF forecasts the majority market-share to be residential 'behind-the-meter' storage, with an installed storage capacity of about 20 GWh expected by 2040. This will equate to around 2.5 million homes—about one in five—being equipped with batteries. Battery deployment is very much in its infancy, but there seems little doubt that battery storage is set to become a key feature of our energy system.

Battery storage, if deployed and managed appropriately, can present a win-win scenario for battery system owners (householders), network service providers (the 'poles and wires' guys), renewable energy developers, power system operators and the Australian community at large.

This is because batteries can take on many important roles—time-shifting to balance behind-the-meter generation and demand being just the tip of the iceberg. Batteries can help network operators to do their job by providing improved network visibility, improved reliability and up-time, and managing voltage levels and load flows across the network—and by doing so deferring or avoiding costly network upgrades. Batteries can also help power system operators (in Australia this is AEMO) and transmission network operators by strategically charging or discharging to help regulate system frequency, rapidly responding to system disturbances and helping guarantee stability given increasing generation from renewables.

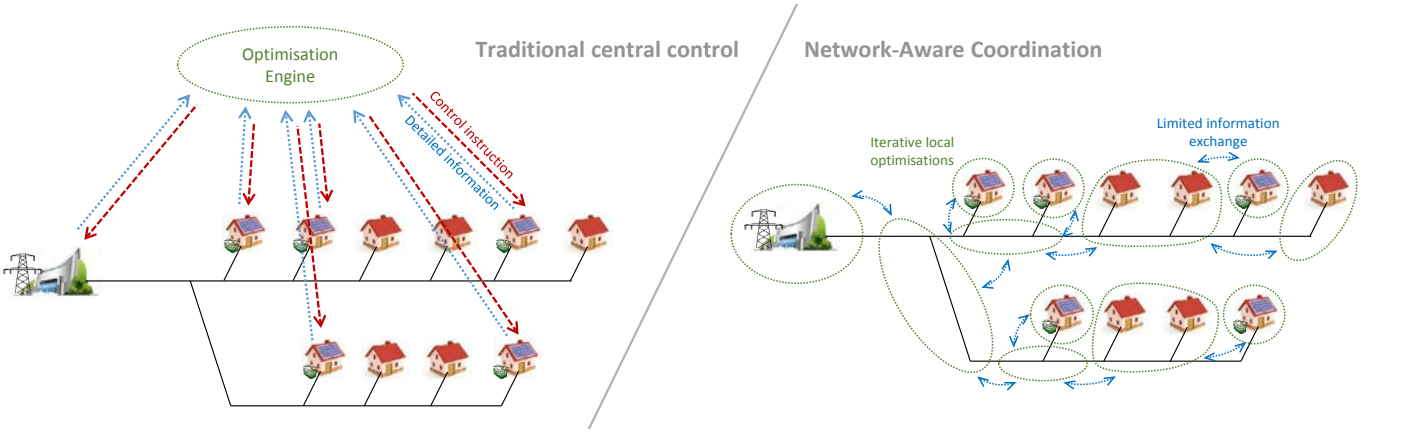
Image: www.flickr.com/photos/gun254

↑ Bruny Island's undersea cable connection to Tasmania's main grid gets overloaded at peak times, such as summer holidays, leading to a reliance on diesel generation. In a world-first trial, household battery systems will be used as mini power stations to reduce diesel use and avoid costly cable upgrades. The project uses sophisticated distributed optimisation software to balance household and network benefits.

Optimal ways to deploy batteries

To date, the different services that battery systems can offer have largely been viewed separately and independently—homeowners install batteries for time-shifting and self-consumption only, while utilities install them for a specific network or power system purpose (South Korea for example is installing 500 MW for the express purpose of frequency regulation). But they can and should be viewed together. Understanding how to optimally coordinate the various roles across thousands or millions of battery installations in the grid will be challenging to say the least. However, this will be the key to unlocking the full potential of battery storage.

This challenge, coordinating millions of small on-grid battery systems to achieve optimal outcomes, points us then to where the next wave of innovation is required and where research and development dollars can yield the 'best bang for the buck'. And this is precisely where part of a recent ARENA funding announcement has been directed. The Australian National University, along with TasNetworks (the network operator in Tasmania), Canberra-based Reposit Power, University of Tasmania and The University of Sydney, has been awarded $2.9 m for a research project which will address how batteries can be used by householders to manage their energy while simultaneously being used to help manage the network. The project also aims to work out exactly how best to reward battery



↑ Instead of traditional centralised network control, the Bruny Island trial will use distributed optimisation software to control power flows and pricing. Network-aware Coordination (NAC) uses negotiation between the local network and neighbouring household battery systems to reach an optimal price/power flow result.

system owners for doing this, thus enabling the batteries to realise extra value for the owner. This will pave the way for maximising the benefits from mass deployment of battery systems Australia-wide.

The Bruny Island trial: householders become mini power stations

Under the ANU-led project, up to 40 battery systems will be installed in homes on Bruny Island in Tasmania's south-east. Bruny Island is connected to Tasmania's main grid via an undersea power cable which, at times of peak demand (typically during summer and holiday periods), becomes overloaded. The only solution at present is to generate power on the island using diesel generators at times when demand exceeds supply capacity; business-as-usual would see an ever-increasing reliance on diesel generation or otherwise the replacement of the sub-sea cable—both expensive and undesirable options. The installation of battery systems on the other hand, if appropriately managed, will reduce the reliance on diesel generation and eliminate the need to replace the cable. The batteries will also address another problem faced by the network operator—maintaining acceptable voltage at the far ends of the network—thus saving the operator from employing costly alternatives.

Let's consider then how battery owners and the network operator might actually benefit from working together on Bruny Island. At present TasNetworks spends around $15,000 to $25,000 per annum on diesel generation for the sole purpose of relieving cable overloading. With an undersea cable costing in the order of a million dollars per kilometre, the alternative of replacing the constrained feeder cable would equate to a cost of well over $100,000 per year. But things really needn't pan out like this: a large fraction of these costs could be avoided by intelligent, automated operation of distributed battery systems.

Allowing part of these network cost savings to be available as an additional income stream, via time-varying price signals, will enable each battery system to decide upon the most cost-beneficial course of action for both the battery system owner and the network. For example, for a particular set of network pricing signals, electricity pricing, anticipated PV generation and household demand, a battery system might decide to store all excess solar generation during the middle of the day, and may even decide to import additional electricity from the grid to charge batteries completely, so that at critical times later in the day it can be paid a premium to export to the grid and reduce load on the island's feeder cable. Add to this mix the possibility, via Reposit's GridCredits platform, of being rewarded for exporting at times when wholesale electricity prices are high and you're starting to get close to unlocking the full value of distributed battery systems.

At the centre of the project is the sophisticated, distributed 'Network-Aware Coordination' (NAC) software developed by researchers at ANU (see next page for more on NAC). Each battery system receives forward pricing and demand signals from this control software, continuously optimised according to the conditions on the grid and based on electricity demand/pricing information.

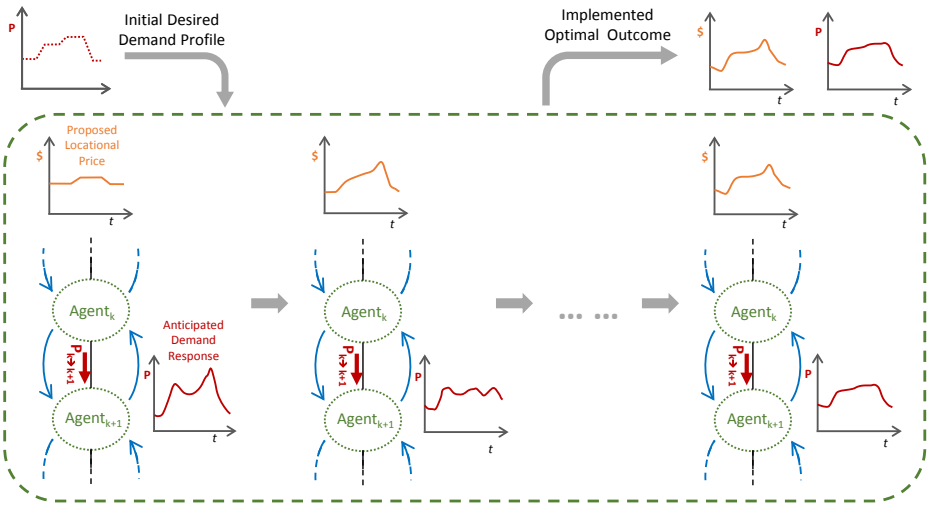
At the heart of each battery system will sit the innovative battery control hardware and software developed by Reposit Power. The Reposit system monitors live data on customer energy usage, household PV generation and weather forecasts, using that data to predict how much energy will be generated and consumed by the household over the next 24 hours. Based on the external pricing signals provided by NAC, each battery control system then determines how to manage that energy to maximise economic benefit to the customer.

For the example described previously, each battery system decides first to charge and then later discharge based on the high future export prices supplied by the NAC algorithm. The NAC algorithm meanwhile has determined the best price signals for all systems across the network so as to ensure the undersea cable capacity constraints and network voltage requirements are met at minimum net cost.

The approach taken by this project—distributed but coordinated control of multiple, customer-owned battery systems which allows customers to optimise their own energy use while also rewarding them for participating in 'the bigger picture'—is a world-first and a great example of Australian innovation and collaboration. The development of innovative reward mechanisms for customers plus the assessment of their responses to and interactions with the technology—research being led by the University of Sydney and the University of Tasmania respectively—add critical dimensions to the project that will ensure the outcomes are transferrable to the wider Australian context. ✸

The Bruny Island battery storage trial will commence with community consultation in the second half of 2016. Interested parties can contact TasNetworks on 1300 13 7008.

"Initial price signals are based on the cost of delivering power to and around the island for each time interval in a particular period (say 24 hours). The NAC negotiation process is iterative to yield final prices/power flows to ensure charge/discharge behaviour of battery systems is coordinated—with the aim being to avoid feeder constraints, minimise on-island diesel generation and manage voltages within acceptable levels across the network."



↑ A closer look at the NAC algorithm for distributed optimisation of network power flows and prices. Agents (generators, controllable loads and battery storage systems) negotiate iteratively with neighbouring agents to determine price and the final demand profile based on initial proposed pricing and a desired demand profile.

The NAC algorithm for distributed optimisation of price and power flow

The coordination of multiple market-participating agents (for example, generators, controllable loads such as controllable air conditioners and battery storage systems) distributed throughout a large electrical network in a way that provides energy services at lowest economic cost is a complex and challenging task. This is especially complicated by the numerous physical and financial constraints in the network which must be respected by any solution.

Traditionally power systems have taken a centralised control approach where decisions for all controllable agents are made based on a single optimisation engine that has access to all relevant system information. However, as the number of agents in the system grows (increasing numbers of battery systems, for example), the complexity of the problem increases rapidly and the ability to centrally find an optimal power flow solution in a reasonable timeframe becomes extremely challenging. In addition, the centralised approach fails to cater well to agents wishing to participate in the market while also maintaining a high degree of autonomy and privacy.

An alternative is a distributed optimisation algorithm, such as the Network-Aware Coordination (NAC) software that Paul Scott and Professor Sylvie Thiebaux from ANU have developed, which offers a scalable optimisation process and retains the independence and privacy of each individual agent in the system.

The NAC approach decomposes the very large and complex 'centralised problem' into a number of much smaller and simpler 'distributed sub-problems', each representing a particular agent or small section of the network.

By iteratively solving the local optimisation sub-problems, agents essentially 'negotiate' the amount and price of power that they exchange with each of their immediately connected neighbours (for example, between a battery storage system and a section of the network).

The local optimisation sub-problem calculates the best response of agents (each acting in its own best interest), to the currently standing prices, which are updated between iterations until connected agents agree on the amount of power that they exchange.

These sub-problems are solved in parallel to speed up the computation and, once the negotiated power and prices converge, an optimal power flow solution for the entire network has been reached. The solution includes network status (power flow and voltage at each node), power/energy produced or consumed by each agent in the network and power/energy prices charged or paid for by each element in the network.

Because of the iterative nature of the distributed optimisation technique, the NAC software provides a market mechanism for ensuring lowest overall cost of meeting energy demands within constraints while also ensuring, via the creation of locational pricing, that individual agents are fairly compensated for their role in meeting those constraints.

For a multiple time-step distributed optimisation, which is certainly required to satisfy the time-dependent behaviour of electrical loads, an optimal solution is computed for every time-step (for example, five minutes) over a defined forward period (for example 24 hours). Optimal solutions for the entire forward period are re-computed in real time as every time-step passes.

On Bruny Island the price signals will be based initially on the cost of delivering power to and around the island for each time interval, with the NAC negotiation process yielding final locational prices that will ensure charge/discharge behaviour of all battery systems is coordinated to avoid feeder constraints, to minimise on-island diesel generation and to manage voltages within acceptable levels across the network.

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Community energy steps up
Decarbonising at the local level

Community energy is growing fast! Jarra Hicks and Franziska Mey of Community Power Agency report on the many projects taking off and some of the remaining barriers under investigation.

SINCE Australia's first community-owned renewable energy project, Hepburn Wind, started generating in mid-2011, many projects have followed to create a small, but rapidly growing movement.

Integral to that growth has been the Coalition for Community Energy (C4CE), a loose coalition of organisations working to promote and foster community energy projects. C4CE reports that there are now 73 groups developing community energy of all different kinds across all states and territories in Australia—from solar and battery storage projects to replace diesel in remote communities in WA, to bioenergy projects using town and agricultural waste, to partnerships with larger wind and solar developers.

In C4CE's first assessment of community energy in Australia in 2015, groups reported on 23 operating projects, accounting for more than 9 MW of installed wind or solar capacity. Together they involve over 21,000 people and produce 50,000 MWh of electricity per year, avoiding 43,000 tonnes of carbon dioxide emissions. Since then, at least eight more projects have begun operating.

Image courtesy Community Power Agency

↑ The world's largest community-owned solar farm is in the UK, the Westmill Solar Coop near Oxford, where 5000 local people own £16 million of solar PV, equating to 5 MW spread over a 12 hectare site.

What's driving community renewables?

The number one driver is that people care about climate change. A 2014 survey found that reducing carbon emissions to address climate change was the leading motivation for most groups (89%). In fact, almost half of all projects have grown out of climate action groups in communities. In a context where the effects of climate change are being felt more and more each year and our government continues to take a weak and changeable stance on climate policy, this is likely to keep driving communities to pursue their own local source of clean energy.

Also, we are starting to see links with the anti-coal and gas movements, as communities threatened with new fossil fuel developments want to pursue safer and less disruptive means of generating energy. This is especially the case in the Northern Rivers in NSW, where there has been an explosion of activity in the past four years, alongside a successful campaign to boot out coal seam gas.

But community energy is also about social benefits. In the same survey, the next most cited motivations were the more social aspects of 'community self-sufficiency and resilience' (80%) and 'engagement and empowerment' (74%). People involved really value the social-focused aspects—like making sure there are opportunities for community participation, ownership and benefit. People also value the local dimension—coming together with other people in their local area to collectively act on issues of concern. Interestingly, economic motivations (such as getting a return on your investment or generating income for the community) which have driven development in other countries (e.g. Scotland) were slightly less important to the surveyed groups (71%).

What's holding community renewable energy back?

Let's face it, the national electricity market wasn't set up for small-scale distributed

Image: Clear Sky Solar

↑ This 70 kW solar PV array is powering the massive cool rooms of Murray River Organics in a community energy project funded via Clear Sky Solar investment. Clear Sky Solar has invested $160,000 in 11 community energy projects to date.

Image: Eneractive Solutions

↑ Farming the Sun is planning an innovative floating solar project for the East Lismore Sewage Treatment Plant, similar to this 112 kW example in Canoe Brook, NJ, USA. The Farming the Sun project will be the first council/community solar farm collaboration and only the second floating solar system in Australia. www.farmingthesun.net/Lismore

energy generation. However, although groups face a complex regulatory environment and a number of institutional barriers, they have found innovative ways to implement renewable energy projects and introduce new opportunities for energy generation in their communities. As small and unknown actors operating in an unstable renewable energy policy environment, it is often particularly challenging for community-owned projects to interact and negotiate beneficial arrangements with energy retailers, financiers and grid operators. One of the biggest challenges is being able to sell the electricity generated at a fair price. At present, the options are either to sell the electricity generated on the site where it is generated—aka 'behind the meter'—or to sell it to an energy retailer.

Ideally, a project would be able to sell its electricity to its members or people in its neighbourhood, but this is currently not possible without first going through the arduous and expensive process of becoming your own energy retailer (not recommended). Two exciting developments that could help change this are the new citizen-owned energy retailer, Enova (www.enovaenergy.com.au), and various trials of 'local electricity trading', such as those in Byron Shire and Willoughby (see box over page).

What's really working?

Solar, solar, solar! Community solar is really kicking some goals and two main models work effectively in the current Australian context. In response to the challenges mentioned above, both models involve a so-called 'behind the meter, below the load' approach, where a host building (a large energy user) agrees to purchase all the electricity produced from a solar PV array installed on their roof by the community group. This avoids the issue of selling the energy into the energy market. The two main models for delivering 'behind the meter' solar are donation-based and investment-based.

1. DONATION-BASED

The Citizens Own Renewable Energy Network Australia (CORENA) started operating in 2013 and has already completed 12 solar PV projects ranging in size from 3 to 10 kW. CORENA uses donations from the community to build up a revolving fund mechanism. They offer interest-free loans to non-profit community organisations in all parts of Australia to install solar on their roof combined with energy efficiency measures. As of April 2016, more than $120,000 had been donated by CORENA's supporters, enabling the installation of 12 solar projects with a total capacity of 74 kW. The not-for-profit beneficiary of the solar repays the loan and the money goes back into the revolving fund. The main goal of CORENA's 'Quick Win Projects' is for them to become self-funding. Eventually, a (donated) funding pool of $210,000 will enable one new community solar project every three months; $630,000 would fund one new project every month, forever.

Repower Shoalhaven started with similar goals but on a somewhat different path.

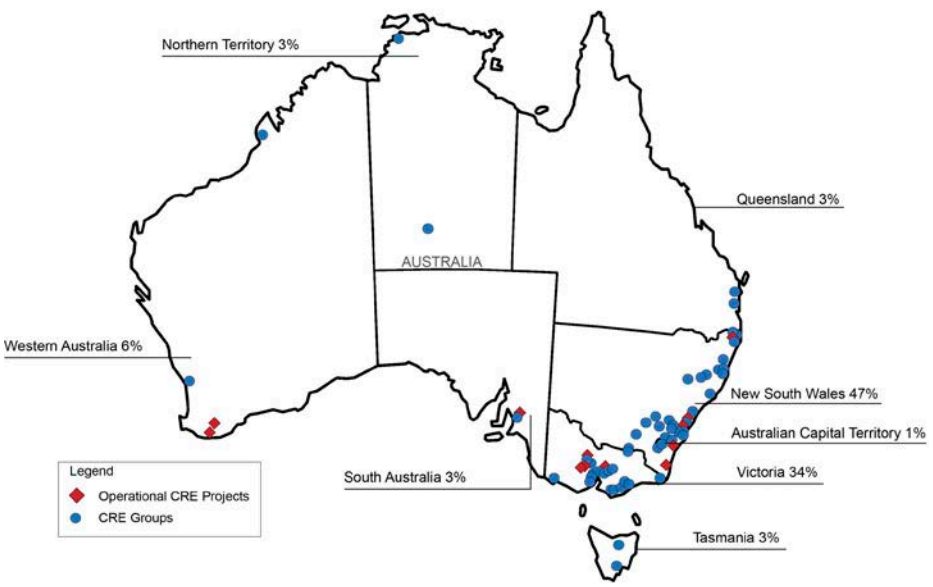


Image: Community Power Agency, 2015.

↑ Figure 1: Community renewable energy groups and operating projects in Australia in October 2015.

Image courtesy Community Power Agency

↑ Hepburn Wind is a community-owned two-turbine, 4.1MW wind farm located at Leonards Hill, just south of Daylesford in Victoria, and operating since 2011. A cooperative was established in 2007 to develop the wind farm with community, government and industry support. The coop's members now number 2000, with about half of those from the local community. The coop has recently become B corp-certified, in line with their commitment to social and environmental outcomes.

"In several cases, returns to community investors are done alongside contributing to a community fund. For example, Hepburn Wind contributes $30,000 per year ($7500/MW/year) and Denmark Community Windfarm contributes $10,000 per year ($7100/MW/year) to purpose-built grant funds."

Headed by a dedicated social entrepreneur and economist, Repower Shoalhaven Association aimed to set up clean energy investment opportunities for their local community. One reason for their success was the decision to start small and to keep the momentum by starting with a simpler and easier to deliver donation-based project. Donations from the local community funded a 9 kW solar PV array for the Kangaroo Valley Community Centre and Ambulance Station, just a year after the organisation kicked-off.

2. INVESTMENT-BASED

The next big step for Repower Shoalhaven was to develop an investment project: Repower One. It was financed through raising $120,000 in a community share offer to install and own 80% of a 99 kW PV array on the rooftop of the Bowling and Recreation Club in Shoalhaven Heads in October 2014. The club agreed to purchase all electricity produced for an agreed price with the income received repaid to investors as a dividend. The project was met with great enthusiasm and the next project followed just nine months later, with Repower Two comprising two 15 kW solar systems installed on the roof of two local churches. Since then, the organisation has been busily signing up new host sites, with at least three new projects in the pipeline.

Clear Sky Solar is another successful model with nine projects and a total capacity of 425 kW up and running as of March 2016. This community group emerged as a local chapter of the Clean Energy for Eternity Association, established during the height of the climate movement in 2006. In their model, community investors form a trust which then provides a loan to a solar company that owns and operates the solar PV installation on behalf of the host site (e.g. the Boggabri Pub).

A final example, the partnership between the City of Lismore and Farming the Sun Inc, demonstrates the great potential for local council and community collaboration. Lismore City Council and Farming the Sun have now completed negotiations to build two solar farms, one at the Goonellabah Sports and Aquatic Centre and the other at the East Lismore Sewage Treatment Plant. To overcome limitations at the East Lismore site, a truly innovative solution with a floating solar system was found. Community investment will provide a loan to fund the construction of the solar farms; the farms will be owned by the council and will use all electricity generated on-site.

A bit more on the forms community renewable projects take

As noted, community renewable projects use models that are either donation or investment based, where individuals in the community put money (and effort!) in to make the project happen. They invariably rely on a large amount of voluntary work (both to get them up and keep them running) and often get some grants in the early stages to help them on their way. Large grants were important for getting both Hepburn Wind and Denmark Community Wind (the two existing community wind energy projects) up and running due to the large upfront cost of the many feasibility studies and the planning applications, both of which can take years. Solar PV is proving to be a much more straightforward, scalable and flexible technology for community groups to work with. For this reason, a majority of groups are pursuing solar PV in various forms.

Because a community energy project requires balancing the desire for community ownership with the realities of policy, regulation and financial practicalities, getting the legal structure right is essential. Incorporated associations are often used for donation-based models, whereas cooperatives are favoured for investment-based models. The majority of groups are choosing to employ company structures because they are more commonly used and are better understood by lawyers, potential investors and regulators. But some groups are changing their company constitutions to still be able to have cooperative-style democratic voting rights or place restrictions on shareholdings, for example, requiring people to be local or putting limits on maximum investments, so that groups can still achieve broad local participation.

The financial structures demonstrate commitment to 'purpose over profit', broad community benefit and the value of volunteering. Of the 35 groups surveyed in 2014, a quarter were for-profit and the rest were not-for-profit. The for-profit projects expect to offer, or are already offering,

"A local electricity trading arrangement would allow the generation at one site to be 'sold' or assigned to the bill of a nearby site."

community investors a return on their investment. In several cases, this is done alongside contributing to a community fund in order to ensure the financial benefits of the project are also distributed to the broader community. For example, Hepburn Wind contributes $30,000 per year ($7500/MW/year) and Denmark Community Windfarm contributes $10,000 per year ($7100/MW/year) to purpose-built grant funds. In some cases, community fund contributions are prioritised before returns to investor-members, reflecting a strong commitment to sharing the benefits within the community, not just with the shareholders.

However, this is only currently offered by the two established megawatt-scale wind farms, rather than the much smaller, and financially more marginal, community solar projects. However, of the 25 or so not-for-profit groups, five are using the profits generated to establish a revolving fund to go towards future community solar projects.

What does it all add up to?

People plus power is powerful! From the experience of countries such as Germany and Denmark, we know that community-owned renewable energy has the potential to play a driving role in building a movement for a renewable energy transition. In both these countries, community projects have led investment in and installation of renewable energy, and have created a strong base of political support for policies that will push a renewable energy transition at a national level. Although it is premature to know just what the impact might be in Australia, some indications of the change potential can be gleaned from the increasing political support from state governments (ACT Government 2015, NSW Government 2015, Victorian Government 2015), local government (City of Sydney, Lismore City, Byron Bay), political parties (Australian Labor 2015, The Greens Australia 2016) and larger NGOs (e.g. GetUp). These changes are helping projects to progress, with the clear benefits of renewable energy and carbon emissions reductions, as well as advancing community ownership, participation and benefit. ✷

LET's trade electricity with our neighbours

There has been a buzz around virtual net metering (or local electricity trading—LET) in the community energy scene. The concept promises to open up great potential to distribute and sell electricity locally (without being an energy retail company) and hence unlock substantial opportunities for community renewable energy. A local electricity trading arrangement would allow the generation at one site to be 'sold' or assigned to the bill of a nearby site on a time-of-use basis.

In effect, this would allow a community energy generator to provide its electricity to nearby collaborators, increasing the value for its electricity by selling at closer to retail rather than wholesale rates. While this opportunity has contributed to the great success of a community solar program in the USA known as Solar Gardens, it is still largely untested in Australia.

Since June 2015 the Institute of Sustainable Futures has led a consortium of 12 private and public partners (including councils, network and retail energy companies and not-for-profit organisations) to investigate the viability of LET in five virtual trials across eastern Australia. This includes a trial with Moira and Swan Hill shire councils of a community-owned solar farm selling energy to its members.

The project also examines the introduction of local network credits for local generators being used in the local area—reflecting that they are using just part of the electricity network, resulting in lower long-term costs of grid supply in the upstream parts of the network. Both concepts—LET and local network credits—address some of the main regulatory barriers to community renewable energy. Already the preliminary results of the ISF trials show that introducing these arrangements in Australia can contribute to more efficient investment and operational decision-making for community energy projects and electricity grid users more generally.

These investigations came just in time to inform public consultation on a proposal to establish local generation network credits being considered by the Australian Energy Market Commission. Vocal support for careful consideration of the rule change will be crucial in securing a positive outcome. Find out more about the ISF project at www.bit.ly/1TQCTRg, about Solar Gardens at www.bit.ly/2OoEBOj and about the rule change here: www.aemc.gov.au/Rule-Changes/Local-Generation-Network-Credits.

Jarra Hicks and Franziska Mey are directors of the Community Power Agency (cpagency.org.au) a not-for-profit which supports community groups to navigate the complex process of setting up a community-owned renewable energy project. Both are doing PhDs, Jarra in law and Franziska in environmental science.

Jarra and Franziska wish to thank the organisations that participated in the surveys used in this article, the Coalition for Community Energy and the Institution for Sustainable Futures at University of Technology Sydney for providing access to the survey data, and the Cooperative Research Centre on Low Carbon Living for financial support during their PhD studies.

Investing in community
Where solar makes sense

A remote Aboriginal community and investors came together to cut bills, reduce emissions—and generate investment returns. ATA's Andrew Reddaway describes how this innovative project went from proposition to implementation.

Image: © West Australian Newspapers Limited

↑ Pictured are Kurrawang board member Rowena Leslie, Tristan Leslie, 3, and Zasco Solar's Scott Nichol.

THE IDEA for a solar system at Kurrawang Aboriginal Christian Community in Western Australia began with Alternative Technology Association member Robin Gardner (ATA is *ReNew*'s not-for-profit publisher). Over several years he's assisted the Kurrawang community with administration through his involvement in Indigenous Community Volunteers and, in the process, he identified the community's strong potential for solar power.

With the Kurrawang not-for-profit community located between Kalgoorlie and Coolgardie, about 600 km east of Perth, that solar potential is excellent. Until this project, Kurrawang obtained all its electricity from the main Western Australian electricity grid, which is fossil-fuelled and charges relatively high electricity tariffs (around 36 c/kWh peak). The community is billed as a single entity and then recovers costs from its 120 residents through meters on each of the 31 houses.

Robin consulted with Kurrawang's board of directors to gain support for the solar project, particularly Rowena Leslie and Denise Lynch who made the project happen.

Sunny scenarios

The first step was to find out just how much a solar system could benefit the community. Robin sought assistance from the ATA, and we helped model the community's energy use and potential generation using Sunulator, ATA's in-house-developed solar calculator.

After exploring several scenarios, the ideal system size was found to be around a 30 kW system. Such a system would displace about 20% of Kurrawang's grid electricity and is small enough for relatively easy approval by the local electricity distributor. Since all the buildings are billed as a single entity, total demand is quite smooth and it was predicted that exports to the grid would be rare. This helps the economics of the project because the electricity retailer pays little for electricity fed into the grid.

In this sunny location, the solar system is expected to generate an average of about 160 kWh/day and offset about 60 tonnes of CO_2 each year, equivalent to removing about 17 cars from the roads. A workshop and nearby machinery shed were identified as the best locations for mounting solar panels.

Solar system selection

Robin and Andrew helped the Kurrawang board to obtain and evaluate quotes from several installers. Prices varied widely—it was clear that some were merely ambit claims!

Zasco Solar's quote was selected, due to a combination of price, components and Scott Nichol's professional approach with the Kurrawang board.

The final solar system includes:

- 2 x 15 kW SMA Sunny Tripower inverters
- 139 x 260 watt Jinko panels
- racking, cables, isolators etc.

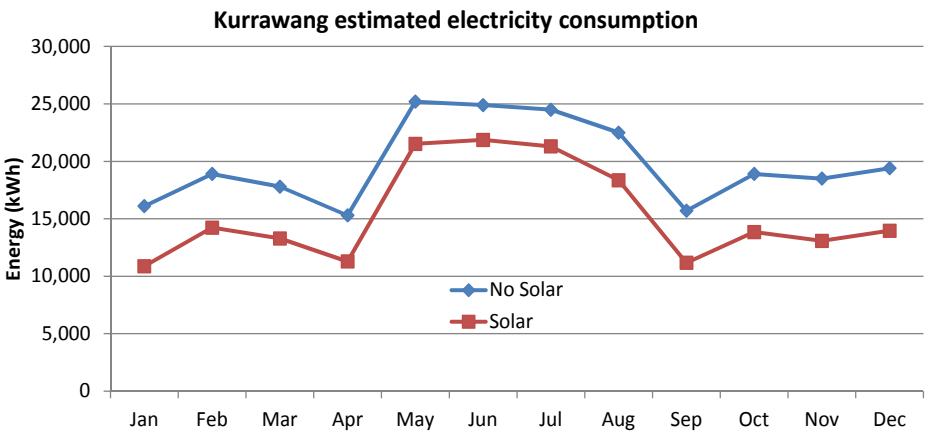
The system is oversized, with 36 kW of panels feeding 30 kW of inverters. This maximises solar generation while staying below the distributor's 30 kW limit for relatively easy grid connection. When solar conditions are excellent some panel generation will be wasted, but such occurrences will be rare.

An innovative finance model

Although Kurrawang is debt free and has many property assets, it holds little cash so finance was required. The ATA introduced the idea of having the project financed by 'impact investors'. With permission from the Kurrawang board the ATA developed a proposed financial model and introduced two investors aiming to

→ The 139 solar panels were installed on a workshop and nearby machinery shed at Kurrawang. They started supplying electricity to the community the same day they were installed!

Images: Scott Nichol, Zasco Solar



↑ Kurrawang's estimated electricity consumption with and without solar was modelled using Sunulator, the ATA's solar calculator. Since all the buildings are metered as a single entity, total demand is quite smooth and it was predicted that exports to the grid would be rare.

generate social and environmental outcomes in addition to financial returns: the McKinnon Family Foundation and CAGES Foundation (advised by Australian Impact Investments). Each investor lent half the total amount of $52,500. Kurrawang preferred this offer to the finance available via the solar installer.

The selected option was a simple five-year loan, with the solar system as collateral. Bill savings were modelled using Sunulator and found to exceed monthly loan repayments. The community would be better off from day one and benefits would increase dramatically once the system was paid off in year five.

Benefits for Kurrawang

In addition to bill savings, Kurrawang expects to benefit socially. Kurrawang board member Rowena Leslie says the community feels empowered by this move towards self sufficiency. "We would like to thank the Lord our God for the lessons learned during the development stage and the added benefits to the environment, our budget and the community spirit," Rowena says.

Installation and community involvement

The solar system was installed on 6 April 2016 and started supplying electricity to Kurrawang the same day. Kurrawang community members contributed labour and equipment to reduce the installation cost, by digging and backfilling trenches for electrical cables, and doing preventive maintenance work on the machinery carport. Free accommodation was also provided for the installers. Community involvement will be ongoing to clean the panels and report on system performance.

Options for the future

The current solar system offsets only a portion of Kurrawang's electricity consumption. The system could be expanded, but this would require more extensive paperwork with the electricity distributor as it would exceed their 30 kW limit. A longer-term option is to install a large off-grid solar system and sever the grid connection entirely. There are also many opportunities to reduce energy consumption.

Model for community energy projects

This project can serve as a model for others. John McKinnon, director of the McKinnon Family Foundation, says he hopes in the future there will be community solar systems throughout outback Australia. "This project is a fine example of what impact investment can achieve in supporting both community needs and renewable energy," says Mr McKinnon.

"We are excited at the potential for replication with other remote communities and the long-term potential to establish a fund of diverse community solar assets," says Kylie Charlton, chief investment officer of Australian Impact Investments.

If you know a passionate person in a similar community, please let *ReNew* know! ✷

Andrew Reddaway is an energy analyst at the Alternative Technology Association.

Design talk
Australian architects at home

ReNew reader Sharon McGann recently interviewed four sustainability-focused architects and building designers in NSW to discover their views on the history and future of sustainable home architecture in Australia.

Caroline Pidcock
Pidcock: Architecture + Sustainability

What are some highlights of where we've come from and where we're going with sustainable home design?
Regulation changes have removed some of the barriers to sustainable design and led to more support for the basics, especially energy efficiency requirements in the building code in New South Wales—but there remains a long way to go. Installing water tanks is becoming easier and more acceptable, and increased energy prices have stretched us to use natural methods to make homes more comfortable.

What do you see are new directions in sustainable home architecture?
There are three major directions I can see: a lot of thought is going into which power sources can replace fossil fuels; there is a strong focus on size, including good quality housing with less space which affects the amount of materials we consume and the costs of heating and cooling; and building communities is seen as important—this is the age of thinking differently about how we live and who we live with, especially with the aging of the population.

Who is doing new things and opening new thought spaces?
For a long time we've been hijacked by the idea we need our own house or apartment. The co-housing movement is a good example of thinking differently, as is Breathe Architecture's The Commons, an apartment building with small living spaces but a community garden on the roof and a shared laundry.

What are you proud of doing new or differently in the past few years?
We want the whole world to embrace prefab. It tends to have a bad name, but you can achieve high quality, it is less impactful than on-site construction and waste can be managed better.

Where are you pushing the boundaries?
We've been following the Living Building Challenge Sustainability Framework. We are bringing the ideas to clients to challenge them to think more ambitiously.

What are you excited about?
We need to be more open to understanding nature, and I am excited about the concept of 'biomimicry' and learning what works. I've also been reading Bill Gammage's *The Biggest Estate on Earth*. It explains how well Australian Indigenous people understand the land, and how over thousands of years they produced, collaborated and worked around the seasons to find abundance—it's incredibly inspiring.

Your hope for the future of sustainable design?
I'd like to see the word 'sustainable' dropped in the future because it will have been proven to be the best way of designing for living.

Image: David Iacono

↑ Caroline renovated her own house to extend the life of this 128-year-old heritage-listed building. Features include 2.4 kW PV, 4000 L water tanks plumbed in, a Sanden heat pump for hot water and hydronic heating, secondary glazing on existing windows and double glazing on new, gaps sealed, recycled materials (bricks, timber and door) and cross and stack ventilation assisted by an openable roof light over the stairs.

"The future of sustainable domestic architecture is to build smaller and get the fundamentals right."

Simon Anderson
Anderson Architecture

What are some highlights of where we've come from and where we're going?
Everybody talks about wanting to include sustainable elements, but it still comes down to cost. However, the general media is starting to talk about sustainable design.

What are you proud of doing new or differently in the past few years?
We entered the Mirvac My Ideal House competition and were shortlisted. We pushed the boundaries with a green roof, which was commended. Our Waverley residence is a house which has created a great deal of attention. We used passive design combined with active systems. It uses computer-controlled thermometers to open and close windows, run from a weather station on the roof. The system currently needs to be wired in; I'm testing a wireless system at home but it's not foolproof. We used C-BUS for this residence, and I'm using ZWave myself, but you have to get an electrician who is interested in the technology!

Where are you pushing the boundaries yourself?
More efficient building practices including panelised prefab systems which lower the on-site labour costs. We are using RITEK prefabricated panels and Boral Green Star concrete, and for 90% of our projects we are thermally modelling our designs to engage clients and give them feedback about heating, cooling, glazing and insulation.

Image: Nick Bowers

↑ Simon Anderson's Waverley house, showing the Fieger thermally broken low-e motorised louvres that are controlled by the home automation/ climate control system.

What technologies are you using?
We are testing virtual reality software, giving clients a 3D model so they can stand in a room and look all around. For example, we can show how winter sunlight travels across the room through the day.

What are you excited about?
I recently visited France and was impressed by how far ahead Europe is. They had electric car charging stations throughout towns and along freeways, and green roofs on bus shelters. The trip reinforced the Scandinavian sensibility of the connection between nature and the built environment, which is what got me into sustainable architecture in the first place. What I'm most angry about is awards for houses with completely glass facades with seemingly little attention to orientation: it's sending the wrong message.

Richard Cole
Richard Cole Architecture

What do you see are new directions in sustainable home architecture?
The new directions in sustainable domestic architecture are a return, in many ways, to old ideas: building houses smaller, better and with a higher quality of natural materials that will endure and weather beautifully.
There are new possibilities for domestic battery storage and interesting opportunities with home automation, paint-on solar photovoltaic systems and nanotechnology. Integrating plants and landscaping into and onto buildings is now well established, with green roofs and walls now commonplace. Pushed further, buildings will become places to grow food.

Image: Simon Wood Photography

↑ Richard's Angophora House was designed for his parents to be fully accessible and in tune with its surrounds.

Who is doing new things and opening new thought spaces?
Make Architecture in Melbourne is doing some beautifully crafted little buildings, which are socially and environmentally responsive and give back to neighbouring or public spaces. Room 11 in Tasmania is building small houses that are uncompromising in their architectural response to the site. And Phooey Architects in Melbourne does amazing and quirky designs using predominantly recycled or reclaimed materials. Overseas, Amanda Levete in London is continuing the tradition of her Future Systems architectural practice by pushing the technology of materials such as ceramics or carbon-fibre to create new and exciting works that are environmentally responsible.

What are you proud of doing new or differently in the last few years?
One is a house for my parents, the Angophora House, which was a difficult build on a challenging site. We managed to build an uncompromised and carefully crafted house that is very responsive to the site and is also fully accessible. One innovation was the use of large sliding doors which act as moving walls. They incorporate insulated panels and double-glazed units with retractable blinds between the two sheets of glass; they provide a high level of insulation and sense of enclosure in winter, but can be opened right up in summer. On other projects, we are incorporating a lot of hydronic heating in combination with solar PV and solar hot water systems to really bring energy usage down.

What technologies are you using?
We use BIM (building information modelling) and design everything in three dimensions. BIM is now capable of quick and real-time analysis of design and material options which impact on the energy usage of the building. We are looking forward to greater integration and use of this in our design process.

What are you excited about?
I have been teaching a second-year university course which covers the fundamentals of siting, solar passive design and construction. It is exciting to see the students—these budding architects—coming to the realisation that these factors are fundamental to good design, and that they don't preclude creating beautiful and cutting-edge architecture.

Anything else about the future of sustainable home architecture?
The future of sustainable domestic architecture is to build smaller and get the fundamentals right. Too often we are wooed by new ideas and technology, and overlook the basics of orientation, shading, thermal mass and ventilation that are vital for effective passive solar design.

Dick Clarke
Envirotecture

What do you see are new directions in sustainable home architecture?
Passivhaus is the newest kid on the block for cooler climates. A reverse version might be appropriate in hot climates. This has led to taking 'air tightness' much more seriously; most good builders now do simple things like sealing the clearance gaps around windows and doors. Considering embodied energy when designing a house is also beginning to take hold and manufacturers are taking it seriously, which is really encouraging.

Who is doing new things and opening new thought spaces?
The ATA of course! We are also seriously impressed by some of our collaborative-competitors such as Oliver Steele in Sydney who has recently completed a row of sod-roofed terrace houses in Newtown, and colleague Tracy Graham and builder Nick Sowden who recently built a delightful hemp masonry renovation in Marrickville which won the council's Sustainable House of the Year award.

Where are you pushing the boundaries yourself?
I'm using new eco-modelling software at the concept stage to help steer design and material decisions. We are reducing embodied energy further and further, and improving the condensation performance of the building envelope. We are also dematerialising the applied finishes by reducing the use of paints and renders in preference for raw materials.

What do you wish your clients would let you do?
Get ragged: think about biophilic design and be a bit loose, a bit more naturalistic and respond to the local environment. Edges can be left raw and unfinished. I love that, particularly when it's in contrast to the hard machined surfaces that most of our mass-produced materials come with.

What technologies are you using?
Hemp! It's good in the building and processing, and good for the land and the farmer. And soon we will be working on 'panelising' it. I am also keen on magnesium oxide cement panels—especially the ones that are made with mirror-like surfaces and textured surfaces which can be left 'unfinished'.

What are you excited about?
Seeing BASIX upgraded in NSW to 7.5 Star equivalent.

Your hopes for the future of sustainable home architecture?
I have great hopes for battery storage. I keep playing with designs for nano-houses (micro housing), but the planners in government still need to recognise their value. Finally, I am passionate about 'integrated transport' which ties everything together and is a term that means something holistic and complete—but there is still a long way to go. ✱

↑ Recycled timber cladding was used in Envirotecture's Treehouse project.

Building in a flash
Advantages of prefab

It seems that prefabrication in buildings, whether that's entire buildings or building components, may be about to have its day in Australia. Peter Smyth looks at the advantages of prefab and what's happening in Australia today.

PREFABRICATION of buildings has been attracting more interest in Australia in recent times and is shedding its association with the cheaper end of the industry. However prefabrication accounts for under 5% of housing construction in this country—compared to 9% in Germany, 12% to 15% in Japan and a huge 50% to 90% in Sweden. Although some simple prefabricated components such as roof trusses have become ubiquitous in Australian building, entirely prefabricated buildings or parts of buildings are much less common—although more so in the commercial building sector, where designs are more easily broken into repeating modules.

Prefabrication is being promoted for a few reasons. The construction process is often vastly quicker: a case study looking at the prefabrication system used by the large construction company Hickory found a reduction in project delivery time of 50% to 60%; a smaller construction firm Modscape is able to complete the construction of a whole house in just 12 weeks.

Prefabrication is also more accurate, with factory processes and tolerances being easier to manage and much finer than on-site construction. This accuracy can mean that prefabricated buildings need less maintenance in the longer term and provide a well-sealed, insulative envelope. Builders like the more predictable management of prefabrication as well, with factory processes meaning bad weather and other disruptions are much less of a problem. This environment greatly reduces work at height and increases worker safety.

Waste is also minimised as materials can be ordered more accurately, are more easily stored for later use on future jobs and excess is more easily sorted and recycled. The use of wet trades on site, such as painting and rendering, can be largely eliminated as well, and these can be particularly locally polluting. All of these aspects add up to streamlined design and production processes which increase efficiency and can quickly produce buildings of very high quality. They can also often be cheaper for both the builder and the client.

All of that sounds pretty attractive, so why don't we prefabricate more in Australia? Some of the answer to that lies with a traditionally conservative construction industry that changes only very gradually, and sometimes reluctantly. There are some significant structural impediments in the way as well, with perhaps the most important of these being that the Building Code of Australia (BCA) has generally been written with on-site construction in mind. This means that for a project that uses prefabricated components there are often extra hurdles to clear to ensure the design and construction is compliant with the Australian building regulations. This can be a time-consuming process, can add significant costs and requires more specialised

Image by Craig Moodie, courtesy Hickory

↑ The majority of this nine-storey apartment block, One9, went up in just five days in late 2013 using pre-built modules from the Hickory Group. Hickory uses parallel on/off-site construction to speed and improve the on-site construction process. The resulting building has a 6 Star energy rating and includes double-glazed windows, greywater recycling and solar hot water. www.hickory.com.au/projects/filter-prefabricated

Image: Prebuilt

↑ Construction underway in the Prebuilt factory in Kilsyth. Complete modules are framed and fully finished in the factory and then transported by truck to the site for installation. Construction takes around 12 weeks in the factory followed by a one day installation, followed by a week or so of finishing on-site.

Image by Paul Adams, courtesy Fairweather Homes

↑ Fairweather Homes designs and builds houses that are prefabricated at the component level rather than the entire house being prefab. Their wall panels can include cladding and windows pre-built off-site. Roof structure, insulation and roofing materials are also prepared off-site for quick installation. A recent two-storey build took just three days on-site to build from slab to roof.

professionals. Financing prefabricated construction can also be difficult, as much of the work may be done long before any of it is seen on-site, so banks can be reluctant to be involved in these projects. The cost of transporting large pre-built modules certainly does not help matters either.

To change this situation there is increasing advocacy from the design and building industries and a number of signs of increasing interest from government. In 2013 prefabAUS was created as an industry body, the first in Australia to advocate for prefabrication. Late last year the Victorian government released a 'construction technologies' discussion paper that looked extensively at the potential for prefabricated construction to be a major part of the manufacturing sector; they've recently followed this with a sector strategy that outlines approaches such as calling for prefabricated structures in government specifications and fostering education in the area (see links at end).

On top of this, the Australian Research Council is currently funding four years of research and training on prefab through the Centre for Advanced Manufacturing of Prefabricated Housing, in conjunction with prefabAUS and Melbourne University. As recent changes to the BCA in the area of mid-rise timber construction have shown, the code can change through industry advocacy.

With the design and building industry looking at the benefits, and governments incentivised by the loss of car manufacturing and other factors, it is entirely possible we'll see prefabrication increase its market share.

Prefabrication is not necessarily something the general public is going to be any more aware of in the future—in many cases even people living in prefabricated structures are likely to be unaware of that fact—but it is a technology that's likely to increasingly change both the manufacturing and construction sectors, hopefully to the benefit of all in society. ✷

Peter Smyth is is a Melbourne building designer. He has previously been a site manager and has particular interests in timber and sustainable design.

Useful links and articles on prefab:

prefabAUS: www.prefabaus.org.au

prefabNZ: www.prefabnz.com; They sponsored the HIVE display of sustainable, affordable, architect-designed prefabricated homes, a timely response to the Christchurch earthquake. They are now planning HIVE 2 which will explore higher density approaches to prefabricated housing in Auckland.

Centre for Advanced Manufacturing of Prefabricated Housing: www.camph.org

Victorian government construction technologies discussion paper: www.bit.ly/1WB46xV

AMT magazine 'Prefab: Sustainable Innovation': www.bit.ly/1rQuPtm

Architecture and Design.com: 'Barriers to prefab construction in Australia (and how to break them)': www.bit.ly/1TU1hRM

Architecture and Design.com: 'A model approach to housing: 5 prefab homes in Australia': www.bit.ly/23VAnOT

Sanctuary magazine: 'Twelve of the best modular and prefab creations': www.bit.ly/1OyKKqj

The Conversation: '20 shades of beige: lessons from Japanese prefab housing': www.bit.ly/1TFzoNw

Sourceable: 'Can Australia Finally Develop a Booming Prefab Industry?': www.bit.ly/1VZjUKd

Queensland University of Technology: 'Prefabricated sustainable housing': www.bit.ly/1Nwg60n

Do prefabricated buildings have to be boxy?

Many fully prefabricated modular houses are quite box-like in appearance and, while this is partially a reflection of trends in contemporary architectural design, it is also an outcome of the influence that the need to transport completed modules has on their design. This doesn't always have to be the case though; it is possible to find designs such as the Freedom design from Prebuilt that challenge this. It's also worth remembering that prefabrication is a continuum that starts with small pre-built components like roof trusses and works up to entirely prefabricated buildings—it is always possible to 'prefab' only parts of a building to ensure that the end result is the one desired.

The greening of paint
An eco-paint buyers guide

Paints have become more eco-friendly in recent years, but there are still traps to look out for. Daniel Wurm explains the advantages of using environmentally friendly paints.

THE painting industry has undergone a tremendous transformation over the last 10 years. Back in 2006, I was the only painter in Melbourne to have phased out toxic solvent-based paints. The rest of the industry looked at me as some kind of tree-hugging hippie when I spoke about the dangers of VOCs (volatile organic compounds) to human health and the environment. The last time I wrote for *ReNew* it was still difficult to find low- and zero-VOC paints, and recycling of waste was a massive issue.

Fast forward to 2016, and I am pleased to say that my industry has taken huge strides down the path of sustainability. It's a good news story that I am happy to tell. Green is not just a fashion statement: it's becoming standard practice. Let's look at some of the developments and see how far we've come.

First of all, low-VOC paints now make up the majority of paint sold. Almost all painters have at least tried them and all manufacturers have introduced low-VOC versions of their paints. In many cases, even their cheaper trade lines are now low-VOC. This means that low-VOC paints are available from all paint stores.

In addition, over 500 painters across Australia have been trained to identify and use low-VOC paints, and even apprentices are being taught about them as standard practice. No one argues about the health risks of solvent paints anymore; we all know there are issues and we all want to protect our health.

If any painter tries to tell you that low-VOC or zero-VOC paints will cost more or won't last, simply walk away and find another painter. If they haven't got the message yet, they probably never will! Almost all major projects including schools and hospitals now have low-VOC paints specified.

Image: The Natural Paint Company

↑ Truly natural paints use simple materials from the earth and plants. Here you can see a selection of natural pigments used by The Natural Paint Company in their products. Note that even natural pigments can contain toxic materials (although these don't!). Some natural pigments may contain cadmium (yellow, orange and red) and chromium (dark green), which should be avoided.

Low-VOC paints are categorised according to their use. For example, the Australian Paint Approval Scheme classes low-VOC low-sheen paints as having less than 5 g per litre of VOCs. We could argue about which standard to use when measuring VOCs, but that is about as interesting as watching paint dry, and VOCs are only part of the issue.

More than VOCs

I prefer to look at the whole-of-life cycle perspective. For example, some manufacturers now offer zero-VOC paints across their range and are independently certified by a recognised eco-label. Why not support these manufacturers, who have shown transparency in their manufacturing process? GECA certification (www.geca.org.au) looks at where the raw materials were sourced and what effect the manufacturing process has on the environment. To me, there is little point in choosing a low-VOC paint if the manufacturer is still producing toxic paint; true sustainability can only be achieved when manufacturers look at it holistically.

"I prefer to look at the whole-of-life cycle perspective. For example, some manufacturers now offer zero-VOC paints across their range and are independently certified by a recognised eco-label. Why not support these manufacturers?"

→ Some natural paint systems use liquid pigments instead of powders, such as this selection from Bio Products.

Natural paints

Natural paints are paints that are manufactured using the least amount of processing. All paints are made from chemicals, but we now know that the more humans alter raw materials, the higher risk there is of those chemicals affecting our health and the environment. I like to think of natural paints as the 'bio-dynamic' products of the painting industry; not everyone wants to use them, they cost more, but they minimise exposure to toxic chemicals. Natural paints are made from ingredients such as linseed oil, minerals, earth pigments, lime and beeswax. They may be a good choice for people with allergies. See the table at the end of this article for a condensed list of suppliers of natural and low-toxicity paints. The full table will be available on the *ReNew* website at www.renew.org.au/sustainable-houses/136-paint-guide.

I don't recommend natural paints for exterior applications; the whole point of using paint is to protect a building from premature deterioration and sometimes plastic is the best way to do it!

Exterior painting options

However, if you really desire to use natural paints inside and out, then there are some exterior paint options you may want to consider.

The best natural paints to use outdoors are mineral-based paints, such as Murobond's Cement Paint. Some of these options can be combined with waterproofing undercoats for a longer lasting and more weatherproof result. However, mineral-based paints do not flex and should only be used on masonry surfaces, never on flexible surfaces such as wood.

Although synthetic exterior paints may come with long warranties, even up to 15 years, the expected lifespan of natural mineral-based exterior paints seems to be no more than 10 years, so you should expect to repaint after this time.

A number of manufacturers make natural enamel paints that they rate as suitable for outdoor use. A typical example is the Bio Enamel range from Bio Products, which gives a hard finish suitable for outdoor trims and surfaces. Another exterior enamel is the VINDO Natural Gloss Oil Paint from Livos.

However, while manufacturers state their outdoor suitability, my experience has been that when used outdoors, natural enamels will degrade much faster as they lack the UV inhibitors of synthetic paints. So, I do not recommend natural enamels for outdoor use, but if using them, keep their use to areas which see little sun and weather, or expect to repaint them every few years.

Are all VOCs bad?

Commercial paint manufacturers have worked to reduce the levels of VOCs in their paints as VOCs, regardless of source, are contributors to smog.

Some VOCs are also quite toxic, so the reduction of VOC levels has come with an added bonus of making paints safer to use. Not all VOCs are toxic, and it varies from paint to paint, but the natural paints tend to contain less toxic VOCs than synthetic paints.

For example, one solvent used in some natural paints is citrus oil, and in particular, D-limonene. While it is a VOC, it is also considered generally non-toxic (you eat citrus peel in fruit cake without ill effect, after all), although it can be an eye and skin irritant in concentrated form. So, the lower the VOCs, of any type, the better.

There is, however, a class of synthetic solvents considered safe and to be a better alternative than even citrus-derived solvents—isoaliphates (also known as non-aromatic compounds). These (mostly) petroleum-derived chemicals are extremely pure and quick to evaporate and dissipate, so do not prolong off-gassing. They are also not absorbed by the human body. A number of natural paint manufacturers use these compounds for the solvent as the least toxic solvent available.

Note though that any chemical that individually makes up less than 1% of the total volume of the paint does not have to be listed in the MSDS (materials safety data sheet), and a single paint product may contain multiple chemicals at less than 1% volume each, although the combined volume of them may be a significant percentage of the whole.

We recommend sticking to natural paints for interior use when possible, although ultimately you need to weigh up all sides of the equation, check the contents of each paint option, and select the option that works best for you—a very low VOC synthetic paint might be a better option than a higher VOC natural paint.

Image: iStock: hroe

← If your garage has a pile like this, then you should take advantage of the Paintback scheme, which will recycle your old paint and paint cans. There are similar schemes overseas, such as PaintCare in the US (although it only covers nine US states, not the whole country, see www.paintcare.org), which takes old paint and remixes it for resale in a set range of colours, while recycling unusable paint and cans.

Heat-reflective exterior paints

It's also important to consider the energy efficiency of the building getting painted. Using a heat-reflective paint will not only give greater longevity, it will also cut cooling costs in summer. Only some heat-reflective paints are what they say they are; look for paints that are CodeMark certified.

Some paints are sold as insulating paints, but a layer of material less than 1mm thick can't provide much insulation unless it is reflective. In reality, 'insulating' paints are just heat-reflective paints—beware of any paint that claims to provide conductive insulation.

Natural colours

Natural paint colours are usually a little more subdued than synthetic paints, although quite a broad colour palette can be found from a number of the suppliers listed in this guide—although don't expect to find as extensive a range as with synthetic paints.

Most natural paints are supplied as a white base to which mineral- and plant-based pigments are added, allowing you to produce almost any colour you like, although you generally won't find very bright colours in these ranges.

Paint application

Generally, natural paints are applied in a similar manner to synthetic paints, using brush, roller or even spraying. Like all paints, you follow the instructions to get a good result, so it's worth reading up on the best way to apply the particular paint you have in mind to see if it suits your requirements.

Some paints, such as cement paints, are supplied as a powder that you mix with water. You may need to experiment with small quantities of the mixture to find the best consistency for your use, but be patient, the end result of using a natural paint is well worth a bit of extra effort.

Recycling old paint

One of the biggest stories in the painting industry is the introduction of the new Paintback scheme (www.paintback.com.au). This is a collaboration between paint manufacturers, retailers and state governments to introduce a product stewardship program, and it started this year! Paint manufacturers now charge a small levy on all domestic paint sold and this levy is collected and used to pay for a nation-wide recycling scheme. The scheme will make it free for anyone to dispose of waste paint at a collection point. This waste will be sorted and eventually recycled into useful product, closing the loop in the manufacturing process.

Paintback is establishing collection points Australia-wide, starting in major population areas and aiming to have 70 permanent sites over the next three years. It gives do-it-yourself and commercial painters a pathway for unwanted architectural and decorative paint and packaging. It is funded through a 15 cents plus GST per litre levy on eligible products, between 1 litre and 20 litres inclusive. The monies collected will go to Paintback Ltd, which is an independent

What's in a paint?

Carrier/solvent/diluent—used to make the paint fluid enough to flow and to carry the other components. It is often a combination of water and solvents.

Pigment—finely ground solid materials (powders) that give the paint its colour. In natural paints, many pigments are metal oxides or plant-derived materials. In synthetic paints, the pigments are often synthetic rather than natural minerals. Note that some pigments can be toxic, such as lead- and cadmium-based pigments. While natural materials, these are most definitely not safe. A type of pigment that is used to provide more bulk and opacity to the paint is called a filler. These include titanium dioxide (common in white paint), although chalk (calcium carbonate), clays and talc are also used.

Resin—also called the binder, this is the acrylic or other material that binds the pigments and other components together to form the paint layer. The binder can be natural or synthetic, and while most household paint binders work by evaporation of the solvents, some rely on chemical reactions from an added catalyst or second paint component. These are most common in industrial use, but may be used in domestic situations on outdoor metalwork or traffic areas.

not-for-profit organisation. Its governing rules ensure that these funds will be used to establish and operate the collection program and research new ways to repurpose unwanted paint materials. Paintback will also fund research to find better uses for unwanted paint.

Waste water from cleaning tools can be a problem when acrylic paints are used. The chemicals in acrylic paints, even zero-VOC brands, are fungicidal and so waste water should not be tipped into stormwater or sewerage systems.

Although the law allows waste water to be discharged on a flat grassy area away from drains, it's best to hire a painter that has a waste-water treatment unit. There are a number of systems available, and reputable painters, such as accredited GreenPainters (see www.greenpainters.org.au), use these systems either on-site or off-site to treat the waste water prior to discharge. This is also better for your garden or vegie patch. No one wants paint chemicals ending up on their organic vegie garden!

Waste water from truly natural paints, on the other hand, is unlikely to contain toxic chemicals and the minerals present might even be good for your garden! Any hardened waste paint can usually be composted. ✱

Daniel Wurm is CEO of the National Institute of Painting and Decorating, the peak professional body for the painting industry, and a trainer with the GreenPainters program, the sustainability initiative for the painting industry.

Image: iStock: YinYang

Types of paints

There are a number of different paint types and each has a different set of characteristics, making it suited for a particular task and not suited to others. Below is a brief rundown of the most common household paints.

Water-borne and water-based

First, a quick explanation of two often interchanged terms, **water-borne** and **water-based**. Paints that dry waterproof but can be washed up in water when still wet are correctly called water-borne paints. They consist of the acrylic (or other resins) that will form the final coating, a solvent and water. Once applied, the water and solvent evaporate, leaving the rest to cure to form the paint layer. Water-based is a misnomer for water-borne; this usage seems to have originated from the paints being water-cleanup, to differentiate them from solvent-cleanup paints. True water-based paints can be redissolved in water once dry—watercolour artist paints are an example of a true water-based paint.

Acrylic latex

These are the commonly available water-borne synthetic paints you will find at your local hardware store. Suitable for both indoor and outdoor use (depending on formula), they are mostly synthetic, and while now often being low VOC, they can still have toxic chemicals, and indeed often do. Water-borne polyurethane paints have similar formulations.

Natural resin based paints

These are natural-ingredient paints that contain natural plant-derived resins, making them similar to synthetic acrylic paints in application and final finish. They also contain various minerals for opacity and colour. They may have a matte finish or a sheen with added linseed oil, or a similar oil. Generally used indoors only, may be washable/lightly scrubbable.

Natural mineral-based

These are usually based on cement, plaster and lime minerals. They mostly have a matte finish but may have a sheen with added oil. There is some cross-over between mineral-based paints and natural resin paints as formulations vary. These can be used indoors or outdoors, depending on formula, and may require the use of a sealer or undercoat. Some are specifically designed for outdoor use and will have long lifetimes. Mineral paints are not flexible compared to latex paints, so substrates must not flex or unduly expand and contract. These types of paints are best used on masonry such as brick, concrete and plasterboard. Many mineral-based paints are washable and even scrubbable.

Natural enamels

These can usually be used either indoors or outdoors (with the caveats mentioned earlier) and may or may not contain water as a carrier (water-borne enamels tend to be indoor use only), and so may be called either water-borne or oil-based enamel. They can have high water resistance and are available in matte, satin and gloss versions. They are more flexible than mineral-based paints, so may be suitable for use on wood. They may need to be used on an undercoat or sealer coat.

Synthetic enamels

These are designed for applications similar to natural enamels—outdoor woodwork, detailing and similar uses. They have high levels of UV resistance for outdoor use. They are also more flexible than natural enamels, but like other synthetic paints they may contain toxic VOCs and other chemicals.

Milk paints/casein paints

As their name implies, milk paints usually contain milk, which provides casein, a natural protein. Some casein paints use plant-derived casein, making them arguably more environmentally friendly and more ethical than milk casein paints.

← Synthetic paint, especially old paint, can contain toxic materials including lead and cadmium. Always wear a good dust mask when sanding old paint. Even natural paints require the use of a dust mask, as the silicate dust can cause lung problems over time.

Table 1: Eco-paints (including interior, exterior and enamels). The table only includes those companies that produce paints using non-toxic or minimal toxicity materials and/or have an environmental certification. Note that a few larger paint manufacturers do have certifications, although they are not included here. The table was prepared by *ReNew* based on information received from suppliers.

Company	Brand/product	Colour range	VOC level	Suitable for use on	Certifications
Bauwerk ph: (08) 9433 3860 info@bauwerk.com.au www.bauwerk.com.au	Mineral paint with soft, chalky appearance		Zero %, independently verified	Most internal and external wall surfaces, especially suited to masonry finishes	
Bio Products Pty Ltd ph: 1800 809 448 bioproducts@bigpond.com www.bioproducts.com.au	Wall paint in both white and deep base, wall primer, water-borne and oil-based enamel and enamel undercoat, thinners and pigments	Can be tinted to a wide range of colours, depending on product	Less than 1g per litre, depending on product	Most interior surfaces, exterior surfaces for some products	German TÜV certified
Ecolour ph: 1300 326 568 info@ecolour.com.au www.ecolour.com.au	Primer Undercoat, Ceiling White, Eco Living Interior, Eco Weather Proof Exterior, Tuscan Flat, Wet Area Satin, Econamel, Polyclear	From white through to fully tintable from any colour chart, depending on product	Zero VOC	Plasterboard, timber, brick, skirting boards, masonry, interior or exterior, depending on product	GECA certified
Livos Australia ph: (03) 9762 9181 info@livos.com.au www.livos.com.au	DUBRON Wall and Ceiling Paint, VINDO Natural Gloss Oil Paint, CANTO Satin Oil Paint, GRAVA Wall Primer Sealer, thinner	Wide range of colours, depending on product	From zero VOC through to containing natural VOCs, depending on product	Plaster, concrete, masonry, brick, oatmeal wallpaper, plasterboard, metal, timber, water-based painted surfaces, depending on product. Interior use, VINDO also for exterior use	Manufactured to strict European regulations & EcoSpecifier verified
The Natural Paint Company ph: (02) 6584 5699 info@naturalpaint.com.au www.naturalpaint.com.au	Vega Wall Paint and Primer, Pure Silicate Paint, Rust Paint, Ceiling Paint, Waterglass, Oil Paint, pigments	Many colours		Plaster, plasterboard, wallpaper, mud brick, renders, wet areas, most surfaces. Interior/sheltered/exterior/full exterior, depending on product.	
Porters Paints ph: 1800 656 664 enquiries@porters.com.au www.porterspaints.com.au	Cement paint, chalkboard paint, interior distemper, lime wash, satin interior, Liquid Iron, Instant Rust, low sheen acrylic, milk paint, Stone Paint, Toughcote			Unpainted bricks, cement render, bagging, off-form concrete, all sound exterior unpainted masonry surfaces, plasterboard, wood, MDF, mud brick, Hebel AAC, most surfaces, depending on product. Exterior/interior, depending on product	
Resene ph: 1800 738 383 advice@resene.com.au www.resene.com.au	Zylone Sheen VOC Free, SpacCote Flat W/B Enamel, Ceiling Flat, SpaceCote Low Sheen W/B Enamel, Lustacryl W/B Enamel Semi Gloss, Enamacryl W/B Enamel Gloss, ClincalCote, Lumbersider W/B Low Sheen, Sonyx 101 W/B Semi Gloss, X-200 Weathertight Membrane, Summit Roof	From whites and off-whites through to Resene Total Colour System, whites, neutrals and Colorbond colours, depending on product		Previously painted or unpainted blockwork, brickwork, concrete and plaster, fibre and particle board, fibre cement, fibrous plaster, plasterboard, timber, wallpaper, wallboards, woven wallcoverings, trims, doors, wet areas, interior or exterior, depending on product	
Rockcote ph: 1300 736 668 sales@rockcote.com.au www.rockcote.com.au	EcoStyle paints, including flat, low sheen, satin, gloss, sealer/undercoat, ceiling white, primer and clear, and Natural Materials by Rockcote in lime wash and clay paint	Depends on product, from white base colours through to any colour.	Zero VOC	Properly prepared substrates such as brick, block, cement render, timber, plasterboard, stone, render, stucco and sandstone, depending on product. Interior/exterior, depending on product	GECA certified
Volvox Amma Earth Products ph: (02) 4788 1117 amma@y7mail.com www.volvoxaustralia.com	Volvox/Clay Décor, Volvox Dispersion, Volvox/proAqua Enamel, Volvox/proAqua Floor Paint	White + over 200 designer colours (clear + 25 colours for floor paint)	Less than 0.01g/L (less than 113g/L for floor paint)	Interior walls, ceilings, furniture, most interior surfaces, depending on product. Exterior (except Volvox Dispersion)	EU EcoLabel licence no. UK/7/1 and independent Frauenhofer Institut Germany, depending on product

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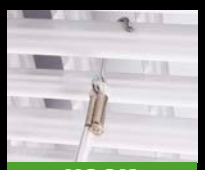

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DAIKIN ReNew Technology for a sustainable future ATA

Less noise, no fumes
Testing cordless leaf blowers

ReNew reader Colin Dedman puts the latest generation of lithium-ion cordless leaf blowers to the test and is blown away by how far they've come, though price and run time can be an issue.

WHY would you buy a cordless leaf blower? Why would you buy a leaf blower at all? For the most sustainable living, shouldn't we rake up all our leaves and debris by hand, and clean out our gutters by crawling around on the roof?

For those of us with rainwater tanks, cleaning the gutters frequently is a necessity rather than a luxury, to ensure that precious rainwater ends up in the tanks rather than spilling out of a blocked gutter. For many years I cleaned up the leaves by hand, while cursing the weekly scream of my neighbour's two-stroke leaf blower. Then my aging back convinced me that if you can't beat them, join them, so I purchased my own screaming $88 petrol blower, that does clean the gutters and patio well. But I hate using it on account of the noise, fumes, hard starting and mixing/storing of two-stroke fuel. There must be a better way.

Corded electric leaf blowers are quieter, always start first time and can potentially use renewable electricity, but the inconvenience of a long extension cord rules them out for me. What about the electric cordless blowers then—are they just 'toys' as many people think?

Here I blow away the myths, by subjecting a variety of cordless blowers to a series of standard tests so you can judge which blower, if any, is suitable for your needs. I've included two mid-range petrol blowers and a corded blower in the tests for comparison.

↑ This elite trio (Stihl, EGO, Redback) of cordless blowers matches petrol performance, but think carefully about what performance you really need.

Measuring blower performance

Some manufacturers would have us believe that the all-important parameter is the air flow rate in cubic metres per hour, while others boast of their impressive discharge velocity in kilometres per hour or metres per second. In reality, both are important.

The most useful single parameter to measure a blower's effectiveness is the blowing power in watts (W), being the power of the moving airstream, as this relates directly to the ability to shift stubborn debris and move a lot of leaves and debris in a short time. The blowing power is less than the input power, due to inefficiencies in the motor and fan.

I've measured the air flow rate, velocity and blowing power according to ANSI Standard B175.2 and tabulated this for all the blowers tested, providing a resource for comparison of blower performance. Manufacturer published values of air flow and velocity have not been included, as they are sometimes incomplete and inconsistent.

The method described in the standard for measuring air velocity is known as the 'Blow Force' method, and involves measuring the blowing force on a 350 mm diameter metal disc placed 125 mm from the blower discharge. It is then relatively easy to calculate the discharge velocity and the air flow rate using the formulas given in the standard.

The table quotes industry-standard nominal (rather than peak) battery voltage for all blowers, again allowing meaningful comparisons to be made. Measured run times are for continuous operation, so expect a little longer for intermittent real-world use. Chargers are characterised by the output power in watts, with greater than 200 watts considered 'fast' charging.

↑ Controlling the power. Speed control is important, and the quality of that control varies greatly.

↑ Lithium-ion batteries have revolutionised portable power tools.

Battery energy

Cordless blowers have notoriously short run times, so battery capacity is important. The stored energy in a battery pack is calculated by multiplying the nominal voltage by the capacity in amp-hours (Ah), with the result in units of watt-hours (Wh). For example, a battery that stores 150 Wh of energy can theoretically produce 150 W of power for a period of 1 hour. The total amount of 'work' that can be done on a single charge is directly related to the stored battery energy in Wh, but a higher power unit will get that work done more quickly.

A better measure of the amount of work that can be done on a single charge is the run energy in Wh, being the run time multiplied by the blowing power in watts. The run energy accounts for both the stored battery energy and the blower efficiency. Buy the largest (highest Wh) battery you can afford and use the blower at the lowest power setting that gets the job done. Avoid blowing leaves over large distances. It is usually more efficient to blow the leaves into small piles, which are then placed into a barrow or bag.

Blower or blower plus battery?

All cordless tools (except the really cheap ones) are sold in two forms. You can buy them with a battery and charger, or just the plain skin (the tool and nothing else). This means you can invest in a particular brand of battery and charger, and add tools as needed, without buying extra batteries and chargers.

Testing results

Let's see how the tested blowers compare, in approximate order of blowing power. Below is a brief summary of pros/cons of the cordless blowers. For a more thorough rundown of each unit, see the full version of this article on the *ReNew* website at www.renew.org.au/renewable-energy/136-cordless-leaf-blowers/

STIHL BGA85
- Equal-best blowing power of 244 W
- 3.2 kg without battery, a heavier option
- Trigger-type speed control
- Expensive.

EGO LB4801E
- Equal-best blowing power of 244 W
- Variable-speed control dial plus turbo switch
- Quietest unit tested for the blowing power
- 2, 4 and 6 Ah battery options
- Five-year warranty.

REDBACK E435C
- 240 W blowing power
- Four speed settings, but no trigger switch
- One of the noisier cordless blowers tested
- 2, 4 and 6 Ah battery options.

RYOBI RBL3650J JET
- 135 W blowing power
- Large 36 V, 5 Ah battery
- Full power run time around 25 minutes
- In common with the RBL1840 and RBL3626, the trigger speed control is excellent, having the best control, right down to zero speed, of any blower tested
- No fast charger supplied
- Noisiest of the Ryobi cordless blowers.

RYOBI RBL1840J JET
- Smaller, lighter 18 V version of RBL3650
- 18 V, 4 Ah battery
- Uses standard Ryobi One+ batteries.

RYOBI RBL3626
- 134 W blowing power
- High discharge velocity, low discharge volume radial fan blower
- Good for gutters and flat areas, okay for small lawn areas
- Full power run time around 25 minutes
- Weighs just 1.8 kg without battery.

RYOBI RBL1850 ONE+
- 18 V version of the RBL3626
- Uses standard Ryobi One+ batteries
- Poor on-off switch (no trigger switch)
- Slow charger.

OZITO PXCBLS-018
- 57 W blowing power
- Good for gutters and small flat areas
- 12 minute run time
- Uses standard Ozito 'Power Xchange' batteries
- No variable speed, but real trigger switch
- Slow charger.

PETROL BLOWERS

Two mid-range petrol blowers have been included as a baseline for comparison. The Stihl BG56 produced a blowing power of 305 W, while the very noisy Homelite Mighty Lite (HBL26YBNC) managed 182 W. The most powerful cordless blowers achieved a blowing power of around 240 W, thus broadly matching the petrol blower performance. When all of the other advantages of cordless blowers are considered, the case for cordless becomes compelling. The petrol options may be cheaper though, at least in initial purchase price.

RYOBI 2400W CORDED BLOWER

The biggest surprise has been saved until last. Weighing in at only 3.6 kg, the Ryobi RBV2400CS effortlessly blows away every other unit tested, including petrol models, and initially had me questioning the calibration of

↑ Master blaster! You may not like the mains lead, but you can't beat the power of 240 V blowers.

↑ This flow-rate testing rig was used as a cross-check to the main testing method.

my measuring equipment. It makes sense when you think about it: with 2400 watts of mains power available, no cordless blower can hope to match this level of blowing power (675 W) and it will also out-blow all but the largest professional petrol backpack blowers, and all for $99! If you don't mind the mains cord, then you can't beat the power of a corded blower, although I did find the two-speed control inadequate in many situations—variable-speed control would be better. It's noisy too.

Care of lithium-ion batteries

Lithium-ion blower batteries are large and expensive, so maximising battery life is important. Avoid deep discharges when possible by recharging before the battery is fully discharged; for example, before the LED 'fuel-gauge' indicator drops to one bar. If the tool won't be used in the next month or so, then store the battery at somewhere between 30% and 50% of full charge, as per the battery fuel gauge. Finally, store the battery in a cool place, certainly not in the average tin shed, where summer temperatures can soar; around 10 °C to 20 °C is ideal. If you are really nuts about battery life, like me, then wrap the battery in a plastic bag and keep it in the fridge (not freezer)!

Conclusion

Lithium-ion batteries and brushless motors have been a game-changer for cordless garden tools, with the high-end cordless blowers giving comparable performance to mid-range petrol blowers, with adequate run time for most situations. Expect to pay upward of $300 for true petrol-equivalent performance. Mains-powered corded blowers are the most powerful of all and are remarkably cheap, but the mains cord and poor speed-control limit their appeal.

The 18 volt cordless garden tools won't match the better 36 V (and above) tools, though 18 V may still make sense if your needs are modest, especially if you already have the battery and charger. Make sure that replacement batteries are available. All of the cordless blowers are significantly quieter than the petrol models, though the results table reveals that some are noisier than others. Hopefully the information presented here will assist in making the right choice. ✱

Colin Dedman is a technical officer in the research school of physics at ANU, with a long interest in DC electric motors and battery technology which underpin the performance of modern portable power tools.

Model	Type	Price full kit	Price blower only	Speed setting	Blowing power (watts)	Air velocity (km/h)	Air flow (m^3/hr)	Blower weight (kg)	Battery voltage (V)	Battery capacity (Ah)	Battery energy (Wh)	Run time (mins)	Run energy (Wh)	Charger power (watts)	Brushless motor	Variable speed	Noise (dBA at 3 m)	Warranty (years)
Stihl BGA85	Cordless	$676	$299	High	244	170	665	3.20	36	4.2	151	15.0	61	272	Yes	Yes	74.5	2+2
				~54%	129	137	538					26.5	57				69.0	
EGO LB4801E	Cordless	$329	$199	Turbo	244	150	860	2.34	50.4	2.0	101	10.4	42	168	Yes	Yes	70.5	5+3
				High	151	127	733					16.5	42				67.0	
				Low	32	76	437					66.0	35				56.5	
Redback E435C	Cordless	$312	$150	Turbo	240	179	589	2.60	36	4.0	144	13.8	55	200	Yes	4 speed	80.0	3+2
				High	136	148	488					22.6	51				76.0	
				Medium	39	98	322					68.0	44				67.3	
Ryobi RBL3650J Jet	Cordless	$359	$199	High	135	155	442	2.48	36	5.0	180	25.4	57	68	No	Yes	79.8	2+2
				~46%	62	120	340					46.7	48				75.5	
Ryobi RBL1840J Jet	Cordless	$229	N/A	High	106	132	476	2.12	18	4.0	72	13.9	25	36	No	Yes	78.8	2+2
				~46%	49	103	369					25.4	21				74.5	
Ryobi RBL3626	Cordless	$269	N/A	High	134	250	169	1.80	36	2.6	94	24.0	54	68	No	Yes	71.5	2+2
				~45%	60	192	129					49.9	50				65.0	
Ryobi RBL1850S one+	Cordless	$199	$99	High	129	247	166	1.50	18	5.0	90	17.0	37	36	No	No	71.6	2+2
Ozito PXCBLS-018	Cordless	$119	$69	High	57	192	122	1.31	18	1.5	27	12.5	12	16	No	No	65.0	5+3
Stihl BG56	Petrol	$269	N/A	High	305	193	645	4.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	82.0	2
Homelite Mightly Lite	Petrol	$88	N/A	High	182	208	332	3.60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	87.0	2
Ryobi RBV2400CS	Corded	$99	N/A	High	675	292	625	3.60	240 VAC	N/A	N/A	N/A	N/A	N/A	No	2 speed	84.0	2
				Low	328	229	491										80.7	

Values of blowing power, air velocity and flow rate are measured rather than manufacturer-supplied, allowing fairer comparison between competing blowers.
Blower weight is without battery, warranty is (blower years + battery years).
Charger power is the kit charger output power, other chargers may be available.
This testing was performed by Colin Dedman, and *ReNew* hasn't verified the results. *ReNew* suggests you use these results as a guide to assist your own research.

Power without waste
Building (or buying) an efficient computer

You don't need to waste energy to get all the computing power you need. Lance Turner surveys the field of energy-efficient computing options.

IN RECENT years there has been a push for reduced computer energy use by both consumers and manufacturers. There are numerous advantages to reducing computer energy use, including reduced running costs, less waste heat and low maintenance through fanless computer designs.

Energy use for a complete computer (including screen etc) can range from just a couple of watts for a tablet or 2-in-1 through to several hundred watts for a high-powered number cruncher, as used for video editing or intense gaming. Typical use of a desktop computer would be under 100 watts for most systems, unless they are particularly old, have a very large screen, or have lots of peripherals (such as printers and the like) running all the time. For laptops, it's much lower of course, with typical usage being 5 to 15 watts, depending on configuration. For tablets and tablet-like devices, energy use is typically 2 to 5 watts.

↑ Mini PCs, like the Intel Compute Stick and NUC (left and top right) and the VOYO V3 can have very low energy consumption while maintaining good performance for general computing.

It may seem that, compared to many other appliances, computer power consumption is quite low. Although that is true, unlike many other appliances, computers run for long periods each day, so their overall energy use can be considerable. For example, a PC averaging around 100 watts (including monitor and peripherals) for 12 hours per day will use 1.2 kWh per day, or 438 kWh per year, which is more than an efficient fridge.

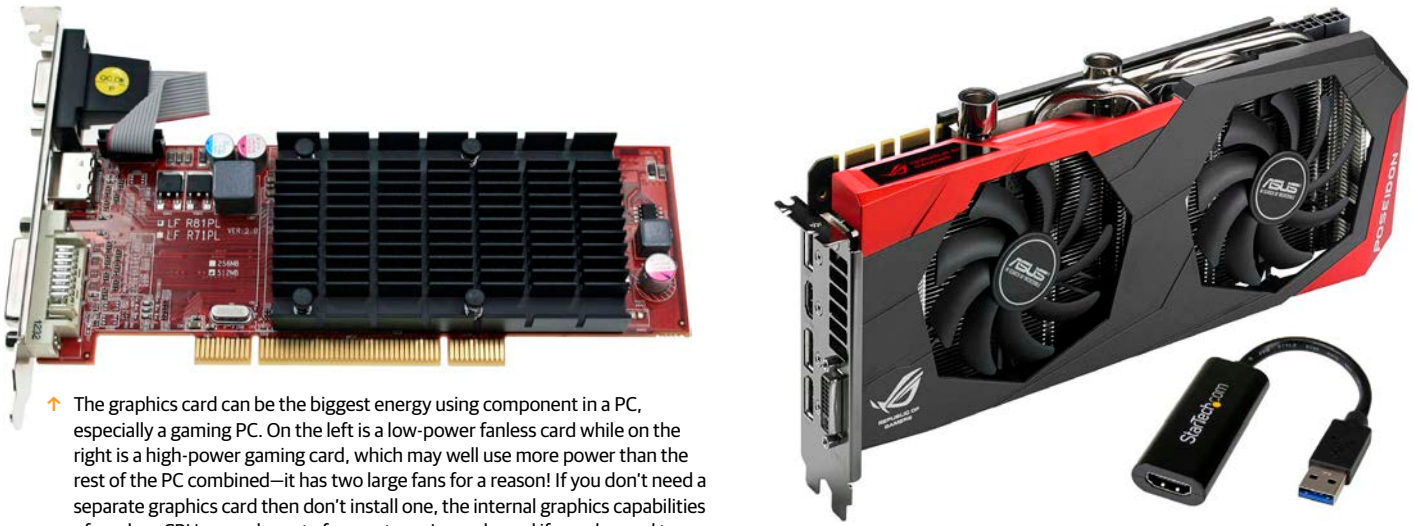
So just what uses so much electricity in the average desktop computer—where does the energy go? To find out, we need to understand the basic internal components of a typical computer. Whether it is a desktop, laptop or even a tablet, all PCs have these basic components. While the following overview describes the most common versions of each component type, there are many subtypes used nowadays, so be prepared to do a bit of research.

Firstly, there's the CPU (central processing unit), which is the brain of the PC. Most CPUs have somewhere between two and eight cores, each core effectively being its own independent processing unit. CPUs with more cores tend to use more energy than those with fewer cores of the same architecture (the internal design of the CPU core), so you need to work out how many cores you actually need—don't buy an eight-core PC if a similar machine with a two-core processor will do what you need it to.

However, the number of cores is not the only indicator of energy use in a CPU. There are many types of CPUs, from ultra-low-power devices designed for phones and tablets, such as the Intel Atom x and Core M series and the the ARM (Advanced RISC Machine) range of processors, through to the extreme number crunching CPUs such as the Xeon, which has up to 22 cores, depending on model, and is often found in servers and where CPU-intensive applications are required.

To see just how many different CPUs are available check out Intel's ARK website at ark.intel.com—and this is just one manufacturer, others include ARM, AMD and VIA.

So, how much energy can a CPU use? Well, depending on the series of CPU and how hard it is worked, maximum power use can range



↑ The graphics card can be the biggest energy using component in a PC, especially a gaming PC. On the left is a low-power fanless card while on the right is a high-power gaming card, which may well use more power than the rest of the PC combined—it has two large fans for a reason! If you don't need a separate graphics card then don't install one, the internal graphics capabilities of modern CPUs are adequate for most user's needs, and if you do need to add an extra monitor, consider a simple USB video adaptor (inset).

from less than 2 W through to around 200 W! Obviously, choosing the right CPU can have a big effect on energy use.

While the CPU is the brain of the machine, the RAM (random access memory) is the short-term memory of the PC. This is where software and application data are loaded to be worked on while the PC is running, and is known as volatile memory, as data is lost when the PC is fully shut down.

There have been numerous versions of RAM over the years, with each new generation being faster while running on less power, due to using lower power supply voltages. The latest generation, DDR4 RAM, requires just 1.2 V and so uses very little power indeed. So if you have the option of a PC that uses DDR4, then that may be the best bet, all other things being equal. For more information on RAM types, see www.bit.ly/1rjMdqb and en.wikipedia.org/wiki/DIMM

When deciding on how much RAM to have in your system, remember that a system with inadequate RAM will tend to use the hard drive as temporary memory, and will run slower and use more energy than a system that has more RAM. For most users, 4 GB is probably enough, but 8 GB is better and means your PC should run more smoothly.

While RAM is the short-term memory, the hard disc drive provides the long-term memory. Traditionally, desktop PCs have used 3.5" hard disc drives (HDD), which have one or more spinning magnetic platters (the discs) which are written to and read from by magnetic heads on small moving arms. If this sounds crude, it's because it is; it's the same basic configuration used for decades, although speed and data storage density have improved several orders of magnitude over that same time. A typical 3.5" HDD may use up to 10 watts, while a 2.5" HDD (commonly used in laptops and mini PCs) will use up to three watts or so.

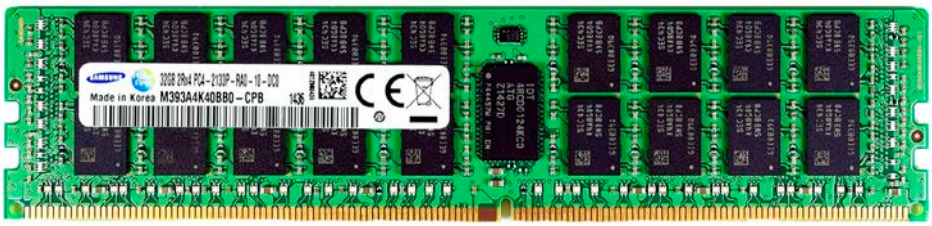
In recent times, HDDs have started to give way to solid state drives (SSD), which are basically a bunch of nonvolatile memory in a box the same size and shape as a 2.5" HDD, and are a simple direct replacement for either size of HDD (there are also mini SSD modules called mSATA drives that plug directly into some mini PC motherboards). Solid state drives have similar power requirements to a 2.5" HDD, but they are much faster than either HDD type, while being more robust. Prices are higher than HDDs, although the gap has shrunk considerably in recent times, to the point that you will most likely consider a SSD when looking for a new drive, unless you need a multi-terabyte drive and have a restricted budget.

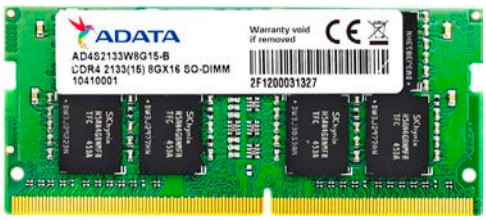
A derivative of SSD storage is embedded storage, which is basically nonvolatile memory fitted permanently to the motherboard of the computer or device. The most common version of this is known as eMMC (embedded MultiMediaCard). Multimedia card (MMC) storage was a type of removable storage like an SD card. While MMC cards have pretty much disappeared, the embedded version of the MMC standard has been developed further and has become the default on-board nonvolatile storage system for low-cost mini PCs and tablets. The main advantages of eMMC storage are low energy use and low cost, but there is a tradeoff in speed—eMMC storage is a lot slower to read from and write to than an SSD or even a HDD. However, for many low-power devices used for basic tasks, this speed deficit is often not noticeable.

One component often forgotten about is the motherboard itself. This holds the CPU and everything else needed to make the PC operate (except the drives), such as the network, USB and other port controllers, slots for add-on cards etc. A motherboard can draw up to 80 watts or more, depending on specifications, so if building a PC yourself, don't forget to check the motherboard's power specs—the lower the power consumption, the better. Look for a motherboard with the specs you require that draws less than 30 watts maximum.

Lastly, we get to what can be the biggest energy user of all—the graphics card. Unless you are a gamer, video editor or similar, the graphics capabilities built into your CPU should be fine—modern CPUs, even low-power units, are often capable of 4K video (the new high definition video standard of 3840 x 2160 pixels), with many CPUs capable of driving up to three separate displays at once, although not always all at 4K resolution and not at very high frame rates. So if you just need screen real estate rather than lots of graphical processing power, then the inbuilt graphics processing unit may well do the trick.

If you add a graphics card for more graphical processing power, you can massively increase the energy use of your PC. Graphics cards can use up to an insane 350





↑ Random access memory (RAM) is the short-term memory of your computer. While not a big energy user, the newer the RAM type, the less energy it uses. Above is a standard DDR4 DIMM (dual inline memory module) while at right is a SO-DIMM (small outline DIMM) as used in laptops and mini PCs.

watts of power when under load, depending on the type of card, so be very careful if choosing to add a graphics card—seriously ponder the question "do I really need this?"

One possible reason you may need to add a separate graphics card is to add an extra monitor, especially if the inbuilt graphics capabilities of the PC only stretch to one or two monitors. However, there's no need for a power-guzzling full graphics card—a low-power alternative is a USB graphics adaptor. These plug into a spare USB port and allow you to add that extra monitor for minimal extra energy consumption (excluding whatever the new monitor itself uses). Such adaptors can be found for under $100 and will usually do at least 1920 x 1080 resolution.

The last few parts inside a PC tend to draw less power, and they include fans (usually just a few watts) and other drives, such as a DVD or Blu-ray optical drive. While optical drives (so called as they use light in the form of lasers to read and write to the disc) can use up to 30 watts or so while running, they are not used much nowadays, and many people simply opt for a PC without them. If you need one later, a slimline USB-powered portable drive is a good solution (I have one that I use for the rare occasions I actually work with optical discs).

There is one last component inside the PC we haven't considered—the power supply. While general efficiency improvements have been seen in this area with most manufacturers, you should look for a desktop PC with a power supply with an '80 Plus' rating—an official rating system that runs from plain 80 Plus through to 80 Plus Titanium. The term 80 Plus refers to the power supply's efficiency of 80% or better—the higher the efficiency rating, the less power is wasted as heat during the power supply's conversion from mains AC to the DC voltages required by the computer.

Note that this rating only applies to integrated desktop PC power supplies. Mini PCs, laptops and tablets etc have separate 'power brick' type supplies, and these can vary quite a bit in efficiency, although more recent power supplies should be MEPS (minimum energy performance standard) rated.

Other energy users

Now that we have looked at the bits inside a PC, there are a couple of other places where more energy is used than you might think. Your PC's monitor can be a real energy hog, and energy use varies enormously. While higher resolution and larger screen size tends to increase energy use, it's possible to find two monitors with similar specs where one uses half the energy of the other. Always check the energy consumption of any proposed monitor; don't make assumptions based purely on screen size or resolution.

Also, don't forget the consumption of peripherals such as printers, scanners and modems—if you are not using it, turn it off. Put all of the occasional-use devices such as printers on a separate power board and switch them using a remote switch such as an EcoSwitch—this is an easy and effective way of eliminating energy use for these devices except when they are actually in use.

If your printer has the ability to go into low-power standby mode, make sure to turn this feature on. We should also mention that power figures, especially for printers, can be misleading. For example, a laser printer might have a rated maximum power of 750 watts, but this doesn't mean it will draw that much all the time, or even most of the time, unless you are printing many pages continuously. If your printer is just printing the occasional page, its average power draw will be much lower, typically less than 100 W, and if it goes into standby it will probably draw less than 10 W.

"If you add a graphics card for more graphical processing power, you can massively increase the energy use of your PC. Graphics cards can use up to an insane 350 watts of power when under load."

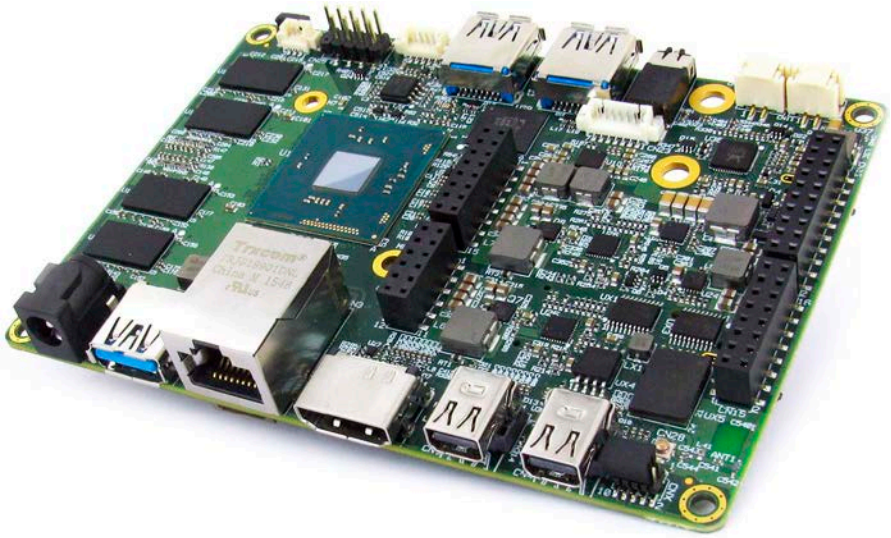
Turning things off when not in use doesn't just apply to peripherals—you should turn your PC off completely when not in use. Don't just let it idle or sit in standby mode, as it will be using energy for no reason. Enable hibernate mode on your PC: this saves the complete machine state when you put the machine in hibernation, allowing it to return to where you left off, even after being powered down.

Off-the-shelf systems

Ok, so we have looked at the components and where the energy actually goes, but what if understanding your PC to that level just doesn't excite you? The obvious solution is to buy a ready-to-go system with as little energy use as your required specifications allow. Fortunately, this is a lot easier than it has been, with a proliferation of mini PCs with surprisingly good specifications and low energy use.

For ultra-low energy use, a good place to start is with a PC using one of the Atom x series of CPUs. These include the x3-Z8300, x5-Z8500 and x7-Z8700 (and more recent and slightly faster x7-Z8750) quad-core

↑ They look incredibly unexciting, but the CPU is the brains of any computing device. Choosing the wrong one can mean you pay more than you need to, while wasting power.



↑ The Udoo X86 is a complete PC plus arduino development board on a single 120 x 85 mm PCB. It can run a full version of Windows, or Linux if you prefer, yet comes with up to 8 GB of RAM and the most powerful version's CPU draws just 6 W (no total consumption is available, but we expect it would be under 10 W). It can even drive three 4K screens at once, and all starting at US$89! www.udoo.org

processors. With these processors, the higher the processor number, the faster the processor can run and the more processing power it has. Even the Z8750 has a maximum power consumption of just 2 watts, yet can operate at up to 2.56 GHz and with up to 8 GB of RAM; it has 16 individual graphics execution units (separate calculation units of the graphics processor core), making it quite a capable processor for general workloads, despite being designed for the tablet/smartphone market. There are a number of mini PCs using this range of processors nowadays, such as the Mele mini and stick PCs and the Voyo mini PCs—particularly the Voyo V3, which comes with 4 GB RAM and a 128 GB SSD (not the slower eMMC storage), all for around US$200.

While the Atom range does provide amazing value for money, unfortunately Intel has recently decided to cease production of most of the Atom-level CPUs, so machines based on these ICs will be harder to find in the future as stocks dwindle, although they are currently readily available.

A step up from the Atom-based units are those based on Intel's Core M processors, which are very capable processors found in higher end tablets, with thermal design powers (TDPs, the maximum total heat, and therefore electrical consumption, that the CPU will generate in normal use) of just 4.5 watts.

Up from these are the mobile Core processors, designed for the laptop market. An example is the i5-6260U, which is a two-core, four-thread, 2.9 GHz processor with a TDP of just 15 watts—far less than its desktop-oriented cousins, but still with good performance. An example of small systems using these and similar processors are the Intel NUCs (new unit of computing)—small PCs that simply need RAM, an SSD and operating system added (some computer stores sell versions all ready to go).

The Atom, Core M and mobile Core processors have quite capable inbuilt graphic processing units (GPUs) and can play basic to medium level games at reasonable framerates (if gaming is your thing), but for better graphics performance while still keeping CPU power down, AMD APUs (accelerated processing unit, AMD's snazzy name for a CPU with high level graphics capability) might be a good option. For example, their 6th generation A-series processors have four CPU cores, six or eight GPU cores and thermal design powers of between 12 and 35 watts, depending on model, making them suitable for low-power yet graphics-intensive processing applications like video editing and gaming.

Really, the options for low-power CPUs with good performance are many, and the range of low-power consuming PCs on the market is vast. Manufacturers including Intel, Acer, ASUS, ASRock, MeLE, Lenovo, HP, Zotac, Gigabyte, VOYO, Apple and many others all produce mini desktop or low-energy use PCs.

"Your PC's monitor can be a real energy hog, and energy use varies enormously."

Really low energy computing

So what if your needs are very modest, such as just surfing the web and doing a few emails? A tablet will suit the needs for some, but the relatively small screens of most tablets can be an issue for many people, especially those with less than perfect vision. In this case, look for larger screen versions, such as the 12.3" Microsoft Surface Pro 4, the 12.9" Apple iPad Pro, or even the 12" Chuwi Hi12 (and there are many others). If you are thinking of buying a tablet, make sure it's a 2-in-1, which is basically a tablet with a keyboard dock or cover that turns it into a laptop. It no longer makes sense to buy just a tablet when a 2-in-1 is around the same price.

Also, some tablets and phones can be connected to HDMI-capable monitors, but most still can't. If you want to use your portable device this way for an ultra-low energy PC, then look for one with Mobile High-Definition Link (MHL) capability, or the wireless version, Intel's WiDi.

Taking this further, some phones can even be used as a full desktop computer, eliminating the need for a separate PC altogether. An example is the new $299 Microsoft Lumia 650, a full Windows 10 phone that includes Microsoft's Continuum connectivity system, allowing you to connect a larger screen (use your TV and eliminate the need for a separate monitor), keyboard, mouse and other devices and use the phone as a full desktop computer. See www.bit.ly/MScontinuum for more information.

Ultra-low budget devices

Most of the options discussed so far will cost you somewhere between $200 and $2000 or more, but for the really budget-conscious, or where an embedded solution might be required, you might want to look at a computer development board such as the Raspberry Pi or the Udoo X86. The latest iteration of the Raspberry Pi is the Raspberry Pi 3. It is a quad-core, 64-bit computer with 1 GB RAM and a micro SD card slot for storage. You can buy the Raspi, as it is known, complete with 16 GB SD card and Raspian OS ready to go for under $70. All it needs is a case (usually well under $10), 5 V, 2.5 A power

supply, a keyboard, mouse and monitor. See au.element14.com

If Linux isn't your thing, then take a look at the latest Udoo board, the X86. It is fully Windows-compatible, has a quad-core processor, up to 8 GB RAM and 8 GB of onboard eMMC storage for basic operating system installs. It is available with a range of upgrades including proper SSD storage and nice little acrylic cases, and even includes an embedded Arduino-compatible secondary processor for the DIY developers out there. Prices start at just US$89, see www.udoo.org

There are numerous other mini and low-cost devices capable of running full operating systems. A more recent example is the Chip, touted as the first $9 computer, an absolutely tiny device with enough capabilities to do general internet, office and old-style ('8-bit') games (www.getchip.com). There are even full Android-based PCs, such as the Remix Mini (www.jide.com/mini), which has a very nice Android skin designed specifically for desktop computer operation.

Other ways to save

Operational energy use is not the only form of energy use—it takes energy to manufacture and recycle electronic devices, so it makes sense to make them last as long as possible. After all, reducing resource use of manufactured goods should be a high priority in a resource-limited world. Electronic device lifetimes are limited by many factors, and devices past a certain age may become unreliable due to degradation of electronic components (especially electrolytic capacitors, which degrade faster than any other component), so you have to put a limit on how old a device can be before it is no longer deemed a worthwhile investment in money and effort. However, any device under five years old is well worth a look, and for the more technically skilled, much older PCs can be worthwhile, and can often be picked up free or at little cost.

For those looking for newer hardware, there are always people and businesses who constantly upgrade, so there is a continual stream of used but good condition devices readily available. EBay and similar websites are great places to look, but it can be safer buying from electronics/computer stores that sell refurbished products, such as Budget PC (www.budgetpc.com.au), GreenPC (www.greenpc.com.au), Recompute (www.recompute.com.au) and Reboot IT (www.reboot-it.com.au).

Software setup

While we have discussed energy use from a hardware perspective, there are also gains to be had by changing or adjusting software and system settings. One of the easier tasks to perform that will reduce CPU load and hence energy use (and also speed up your PC) is to make sure any unnecessary background programs are stopped from running at system startup. In Windows you do this by running the msconfig app, or the more advanced Autoruns (a free download from www.bit.ly/27fkFTm), and deselecting all of those programs and services not needed, then rebooting.

Another simple option is to change the system's energy profile settings (in Control Panel/Power Options), including making sure the monitor turns off when the computer is not used for a set period (10 minutes works for most people). You can also make the PC go into standby or hibernate (deep standby, with power off, yet with the system state saved and able to resume automatically)—ideal if you have a habit of forgetting to turn the PC off when not using it for a while. However, beware of the Windows 'Power Saver' plan as it can tend to reduce system performance. Also, turn off any screen savers, they just keep the monitor on for no reason and are not needed with modern monitors.

Overall, system adjustment is a broad and complex area which we don't have the space to cover further here, but there are some interesting articles and tutorials available that show just how much energy use can be reduced by a bit of tweaking. An excellent example is the article on reducing the energy use of a 4th generation Intel-based system at www.bit.ly/1OcD33n. ✷

References:
Typical power consumption of computer components: www.bit.ly/1WnvL4P
Choosing a PC power supply: www.bit.ly/1sccbwg
80 Plus certification: en.wikipedia.org/wiki/80_Plus
Greener gaming: sites.google.com/site/greeningthebeast

Component or device	Energy consumption (watts)		
	Lowest	Typical	Highest
CPU - desktop	up to 2 (mini PCs)	20 to 80 (typical desktop PC)	up to 200 (server/high-power PC)
CPU - laptop	up to 2 (2-in-1 and similar)	10 to 35 (typical full size laptop)	up to 45+ (high-end laptop)
CPU - mobile	<1	1 to 2	3
Graphics card	2 (USB adaptor)	10 to 80 (typical mid-end card)	up to 350 (top-level gamer card)
Motherboard	up to 5 (mini PC)	20 to 50 (typical full-size desktop)	up to 80+ (server/high-power/gaming PC)
RAM (per stick)	up to 3 (DDR4)	2 to 5 (DDR2, DDR3)	4-5+ (DDR)
Hard drive/SSD	<1 (eMMC)	3 (laptop/SSD)	10 (3.5"HDD)
Fans/cooling	<1	2 to 5	10+ (gaming PC)
Screen	<2 (tablet)	20 to 40 (typical desktop LCD)	up to 100+ (large desktop LCD or multi-screen system)
Optical drive	1 to 5 (CD ROM drive, USB drive)	5 to 25 (DVD burner)	up to 30 (Blu Ray/M-Disc burner)
Power supply (internal losses)	<10% (best 80 Plus supplies)	up to 25% (typical modern supplies)	up to 50% (older power supplies)
Printer	1 to 10 (portable inkjet)	5 to 20 (typical inkjet)	250 to 1000+ (laser printer, when printing)
Scanner	1 to 20 (depending on type, age and light source type)		
Modem	1 to 12 (depending on type, age etc)		

↑ Table 1: Power consumption of various computer components. Each range covers typical consumption for a range of activities, depending on PC load. Figures are quite general, consumption varies with each device, usage patterns, even software setup. All figures are in watts, except for power supply figures, which are percentage losses.

Shop with the ATA

The ATA shop stocks books, kits and energy-efficient devices. Below 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 call the ATA office on 03 9639 1500. **ATA members receive a 15% discount on ATA products, except where noted.**

Luci solar-powered camping lantern

Price: $22.35

Lightweight and collapsible, the Luci Outdoor leaves plenty of room for the rest of your outdoor gear. Great for anything from outdoor lighting, to travel, to patios. Includes 10 LED lights, 50 lumens. Charges in 8 hours direct sunlight and lasts up to 12 hours.

EcoSwitch

Price: $19.95

Standby power accounts for 5 to 10% of all energy. By placing the EcoSwitch in a convenient location you can control power to a device or group of devices (such as your entertainment system) without having to climb under desks or behind cabinets.

Kiri low-flow showerheads

Price: $152.35 (handset)/$132.35 (rose)

The revolutionary Kiri low-flow showerheads provide a great shower at a flow rate of just 5 litres per minute. This saves both water and the energy used to heat it! It comes in either a handset or rose mount. NB: suitable for mains pressure water only.

LED downlight insulating cover

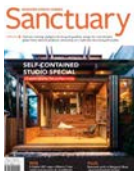
Price: $24

These insulating covers are designed specifically to reinstate the integrity of the insulation in your ceiling that was necessarily compromised after installation of a downlight. They can be used with halogens, but we recommend replacing halogens with LEDs first.

Power-Mate Lite

Price: ~~$125~~ now just $100!

The essential tool for measuring energy use. As well as instantaneous power, it displays energy used and the cost per hour, quarter and year, greenhouse gas production and some more technical figures such as power factor, frequency and VA (volt-amperes).



Sanctuary: modern green homes issue 35

Price: $11.95

Sanctuary 35 investigates sustainable self-contained studios and features 10 green granny flat designs. It also reviews how efficient heating and 'daylighting' technologies can be best used in the home.

Shipping: booklets and magazines – postage $3.50 anywhere in Australia, all other items (books and electronics) $10.

The ATA branches continue to share practical solutions and information on sustainability, renewable energy, building design and energy efficiency. Here's a summary of recent branch events around Australia.

Adelaide: Topics have included, in February, measuring home energy performance, in March, small-scale wastewater treatment/reuse, in April, rebuilding after bushfire and, in May, Finn Peacock of Solar Quotes on battery-ready PV systems.

Brisbane: This year's meetings have included the history of renewables in Queensland, developments in energy ratings labelling, LED lighting, wind energy and, most recently, Energex's experience with solar PV and battery storage trials.

Cairns: The branch runs an ATA stall at local markets (like the Koah market) and, in May, they attended the Cairns EcoFiesta. To assist with local activities, contact doug@ata.org.

Canberra: The Canberra branch started this year with an in-depth look at changes to the ACT House Energy Ratings Scheme. March and May covered measurement of building energy efficiency and temperature.

Geelong EV: Members continue to meet monthly to hear about practical electric vehicle projects, discuss current and emerging EV technologies and plan private workshop projects.

Melbourne: This year started with a great night on the 'demise of Hazelwood'. March was on saving energy through voltage optimisation and, in April, Richard Keech spoke about nine steps to 'energy freedom' in your home. Kate Greenwood spoke in May about ATA's 'Light Up East Timor' project and, most recently, Taryn Lane from Embark lent her experience on community renewable energy projects.

Melbourne EV: The branch began 2016 with a look at the potential of self-driving cars, then, in April, a visit from the Swinburne Formula SAE race car team. Their most recent meeting investigated how home solar and EVs complement each other. The Melbourne EV Expo will be held on Sunday 16 October. See melbevexpo.com.au.

Perth: The branch has surveyed local ATA members about re-launching regular meetings. If you'd like to help the branch develop, contact perthbranch@ata.org.au.

Sydney Central: Their first meeting for the year looked at solar PV including changes in how we generate and use solar energy. Other topics have included ethical investment, timber in home building and battery storage.

Sydney West: In July they are presenting the next Hawkesbury Sustainability Lecture on e-waste. They are also surveying local ATA members about their approach: community.ata.org.au/branches/sydney-west-branch

Tas North: The branch started the year with an ATA stall at the local Chudleigh show and then spent three days on a great stall at Agfest 2016. In May they heard from the local council on their energy-efficient street lighting project.

Toowoomba: In April they held a popular evening on battery technology. In June the guest speaker was award-winning architect and environmental consultant, Mahalath Halperin. The local team is working on the development of an EV expo on 16 October.

For all questions about ATA branch activities you can contact Doug Rolfe, ATA Branch Coordinator, on 03 9631 5407 or doug@ata.org.au or visit the branch webpages at community.ata.org.au/branches.

The Pears Report
Basslink blues, abatement buy-in

Is a second Basslink cable the best solution for Tasmania? And with the UN now trading carbon offsets, how can you become a voluntary abater? Alan Pears reviews the options.

AS A commentator who argued against the construction of the Basslink cable, recent proposals for a second cable between Tasmania and the mainland have led me to review my position—but not necessarily change it.

It's easy to argue that Tasmania needs a backup cable and that this could also provide benefits. But it's not so simple.

The existing cable has brought both benefits and costs. On the one hand, Tasmania could profit from exporting peak power at high prices and from selling renewable electricity when there was a carbon price. It could also import cheap off-peak power from the mainland—increasing its greenhouse gas emissions.

But it costs 2 to 3 cents per kilowatt-hour (kWh), or $20 to $30 per megawatt-hour (MWh), to cover cable costs and energy losses. That's a lot when, due to excess generation capacity, wholesale prices have been depressed to around $40/MWh in 2015–16 in Victoria, where Basslink feeds into the mainland grid. Peak prices have fallen due to renewable generation, energy efficiency, demand management and industry restructuring.

Basslink provided an excuse for Tasmanian governments to continue to ignore energy efficiency improvement. This would have cut consumer bills, made better use of existing generation capacity and provided benefits such as more comfortable homes and more productive offices. Development of new renewable energy generation in Tasmania has not exactly boomed. Tasmanians are also paying a high price for the failure of Basslink.

So it's not clear that Basslink has delivered a benefit relative to other paths. A retrospective study of what could have been done with the Basslink money could be interesting.

The economics of an additional cable are very sensitive to mainland electricity prices and the possible reintroduction of a carbon price. The ability of a second cable to provide useful backup also depends on what happens to Tasmanian electricity demand, investment in new renewable energy generation and rainfall for hydro generation as climate change plays out.

To compete with mainland renewable generation, Tasmanian generators will have to factor in the extra cost and energy losses of using the cable, so they would have to be significantly more productive than mainland generators.

Using the money saved by not building an extra cable (maybe a billion dollars or so) to instead invest in energy efficiency and new renewables, as well as revised dam management practices, could avoid the need for a backup cable and offer other benefits.

Also, instead of exporting to the mainland, it may be more profitable to divert excess electricity to running electric vehicles (or, given Tasmanian conditions, plug-in hybrids), which would offset the much higher cost per unit of energy of petrol and diesel fuel, and use a local resource to avoid import costs. And plug-in hybrids can easily switch to petrol if there is a power shortage.

I don't have the data to make a call on whether or not another cable is a good idea. But I am inclined to be sceptical. Its cost must be compared with alternative options. And the risks of even greater exposure to mainland electricity market vagaries must be carefully weighed up.

Reframing thinking about emerging energy solutions

Recently we have seen intense discussion about the economics of storage and large solar thermal generation relative to other options. Many consider their economics are improving but are not quite there yet. My recent observations of events in Australia and other countries lead me to a different perspective.

Tasmania has been thrown into turmoil by the failure of the Basslink cable—with the low dam levels adding to the pressures and public debate about who to blame. A few years ago, Melbourne faced rolling blackouts as a major powerline to New South Wales was shut down due to a bushfire. And some Queensland power stations had their output limited by lack of cooling water during the last drought.

I've just come back from Japan, where the new green buildings and urban developments I saw are designed to run independently of the electricity grid for at least three days. A combination of on-site generation, storage, extreme energy efficiency and smart management systems deliver this capacity. They have realised that they need to be able to cope with natural disasters and technical failures without disruption of core services.

So the discussion about energy storage, distributed generation and smart management using a lot of data is completely different in Japan. They are simply getting on with a transformation. And, as in other fields, they are finding that lessons from experience allow them to reduce costs, identify benefits they hadn't previously recognised and capture opportunities in new markets.

The contrast with Australia is remarkable. Our energy war, piecemeal approach and

"Voluntary abaters must also buy and cancel offsets to balance the emissions we can't avoid, and to go beyond zero emissions."

focus on narrow short-term costs are seriously undermining our future. Basically, we are being distracted by the detail while others are just shifting to a new paradigm. That's how losers behave.

Climate targets and meeting them

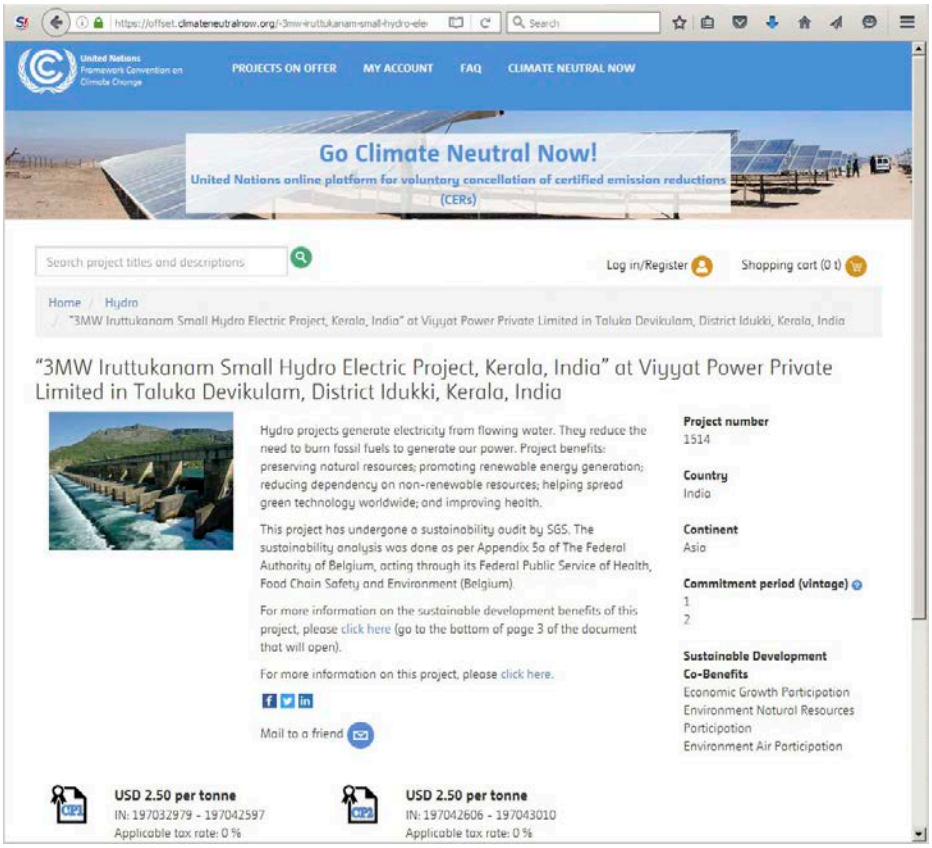
The urgency for action on climate change is building. It now seems to me that responsible businesses, communities and individuals must reframe their targets towards 'beyond zero emissions ASAP', not just gradual reduction or even net zero emissions by 2020 or 2030. The good news is that it's becoming cheaper (or even more profitable) and easier to cut emissions.

This means aggressively cutting our emissions both from our own emission-generating activities and from the inputs to our lives and businesses.

Voluntary abaters must also buy and cancel offsets to balance the emissions we can't avoid and to go beyond zero emissions. An exciting development here is that the United Nations has now set up a carbon offset trading website where individuals can buy and surrender internationally recognised carbon permits (climateneutralnow.org). I found a range of projects with offset costs from US$0.50 to US$5 per tonne of emissions avoided. One project even met the Gold Standard (see www.goldstandard.org, set up by WWF and endorsed by over 80 NGOs) for very high quality credits. You can select the ones you like best, based on the details provided.*

I road-tested the site by buying 100 tonnes of offsets from a small run-of-river hydro plant in India.

So instead of just thinking about donating to worthy international charities, you can now choose to support projects that cut emissions and also deliver worthwhile social, economic and environmental benefits for their host communities—at bargain prices.



↑ The UN's website climateneutralnow.org includes advice on cutting your own personal emissions and carbon offsets to support international projects that individuals can purchase.

Now is a good time to buy quality offsets: they are unlikely to ever be as cheap again. And if we don't buy and surrender them to cut global emissions, high emitters will buy them up at low prices to offset their emissions. If enough people buy up permits to reduce the present glut, prices will increase to a point where high emitters may actually focus on reducing their emissions instead of just buying compliance with cheap permits.

There is debate about the rationale for buying international offsets. The present low prices for offsets are an outcome of a number of factors, including weak targets, over-generous allocations of free permits, poor trading scheme design, lower than expected economic growth since the GFC, declining emission intensity of economies and corruption. However, once they are certified by an approved scheme, they are legal 'currency', regardless of their quality.

Some argue that governments should act to disallow existing poor quality permits. But in my view this is unlikely, despite being desirable. This is effectively retrospective removal of a right to emit and would create a precedent many fear could then be applied in other policy areas. International negotiations are messy enough and, to me, it seems unlikely that agreement would ever be reached to do this. In any case, if you buy offsets you consider to be credible and which deliver additional benefits to communities, they are unlikely to be made invalid and they deliver tangible other benefits beyond emission reduction.

The Australian government could work with the international community to improve the integrity of international carbon certification schemes, as well as its own Emission Reduction Fund rules. ✷

Alan Pears, AM, is one of Australia's best-regarded sustainability experts. He is a Senior Industry Fellow at RMIT University, advises a number of industry and community organisations and works as a consultant.

* Another great option for offsetting emissions is through C3 run by the ATA (*ReNew*'s publisher). This combines offsetting emissions with renewable energy credits and donations to local community groups. www.climatechest.org.au/host/ata.

Q&A

Do you need to know if you can mix old batteries with new ones, whether you can go completely off-grid, how to vent hot air from your home when there's no breeze, or does DIY double glazing really work? Ask *ReNew* your question via renew@ata.org.au.

Renewables or energy efficiency first?

Q —

In 'How green is my solar?' in *ReNew 135*, Andrew Reddaway recommends that solar panels not be considered in isolation. It raises an interesting question: whether to prioritise energy savings or energy production. For example, we have an oversized electric heater which dates from a previous owner of our 1860s cottage. Although it still functions okay, it is very inefficient for our modest needs.

It begs the question: in a bid to reduce our carbon footprint, are we better to scrap the current heater and replace it with an efficient heat pump system first, or is it better to spend money on installing solar panels to generate our own power. It would not be too difficult to make a case for installing solar panels as the last measure after you had attended to all other aspects of establishing an energy-efficient house.

—Patrick

A —

In the USA they used to have a saying, "weatherise before you solarise". I reckon you'd be best with that priority too, especially since you're going to be using that heating a lot during winter evenings and nights when there's not much sun around!

Here's a really good table of reverse-cycle air conditioners (heat pumps) with their energy consumption etc: reg.energyrating.gov.au/comparator/product_types/64/search/

—Andrew Reddaway

DIY double glazing effectiveness

Q —

It was an interesting article about double glazing by Alan Cotterill in *ReNew 135*. However, I am led to believe that double glazing relies on a vacuum between both sheets to be effective. How did Alan achieve this? Was his objective to cut down sound only? Double glazing is certainly a good idea, particularly where I live in the Blue Mountains, but I don't have it because of cost. This is why the article interested me, but I doubt its effectiveness for retaining warmth.

—Rod Marshall

A —

Double glazing doesn't rely on a vacuum, it uses an air gap of a particular width that is wide enough to provide a level of insulation and narrow enough to prevent convective currents in the air between the two panes which would transfer heat from one pane to the other. Many double-glazing units use inert gases such as argon between the panes, as it is a better insulator, but there's not that much difference between argon and air, so DIY double glazing can work quite well compared to single-pane windows.

There are vacuum window units, although I don't know of anyone making them here in Australia; possibly Pilkington has their Spacia units available. You can't produce a vacuum between two unsupported flat panes of glass as external air pressure would press the panes together and possibly shatter them. In vacuum-insulated windows they use many tiny posts between the panes to provide the support for the glass, but obviously this sort of window will not be perfectly clear although it comes close. The space between the panes is much smaller for vacuum glazing than with gas-filled double glazing. For example, Pilkington's Spacia units have a 0.2mm gap compared to at least a 6mm for gas-filled units.

—Lance Turner

Replacing battery cells

Q —

I have a 48V off-grid battery bank made up of 24 x 2V Sonnenschein batteries in series. The system is just over seven years old and is still performing quite well, but during the last year I've felt it has started degrading a little bit. As not all cells are identical, and some will degrade faster than others, is it perhaps a good idea to incrementally (say every two to three years) exchange the most degraded batteries in the bank with new ones in order to extend the life of the other (still good) cells and get the most out of them?

I understand this may lead to a slightly faster degradation of the new cells, but also an extension of the other (still good) cells, instead of say exchanging the whole lot after 10 or 15 years, which is also very expensive.

I know that you're not supposed to mix old and new batteries when putting together a bank of cells, but this is a slightly different scenario, where I know that probably 85% of my cells are still in really good condition and I'm just thinking of exchanging the 'weakest links'.

—Helmut

A —

It's generally best practice not to mix cell ages; it's possible (probable) that doing so will void the warranty on the new cells as well, so is a bit of a risk. I would be talking to the Sonnenschein distributors here (MPower is the one I know of) about what's allowed and what isn't regarding warranty. It's always best to go with what the manufacturer recommends.

When it comes time to replace the bank, you will have a few interesting options to consider, including the Aquion salt water batteries and the new Redflow 10kWh flow cell battery.

—Lance Turner

Far infrared heating

Q —

I have been a subscriber for many years now and love your magazine and the interesting articles and ideas that are discussed.

I have recently heard about far infrared heating panels. Currently we have Nobo panel heaters which although they provide a lovely heat, use a lot of electricity. We don't like the type of heat provided by reverse-cycle air conditioners and hydronic heating isn't viable for us, so we would like some other ideas.

I recently came across far infrared heating panels which seem like a reasonable alternative as they use less energy and they heat objects

not air. I would like to know how much electricity they use compared to other forms of heating.
—Kevin Cato

A —
We have a far infrared heater for our bedroom here in Tassie; it's one of these: www.heat-on.com.au/DIY.asp (there are other, probably cheaper brands around). The panel heater turned out to be the ideal heater in a small space like a bedroom as it is simple to control and takes almost no space, while being completely silent, plus it never gets hot enough to cause a fire—although it must not be covered by towels or clothes etc. It does get hot enough to make you jump if you accidentally touch it.

I was very sceptical when I first trialled it, but I've found it to be the most effective heater in our room at night compared to several other types we'd tried, including the little oil-filled radiant heaters. It is controlled by a small temperature controller I built (you can buy similar units; that supplier has one) and consumes around 2kWh on the coldest (sub-zero) nights here to maintain a temperature of 14°C. Given it is rated at 600 watts, that duty cycle is fairly low. The heat is not a searing heat like high-temperature radiant heaters; it just slowly warms you without you being very aware of it, and we've found it a very comfortable heater to be around.
—Lance Turner

Off-grid community

Q —
My neighbour and I currently have development applications in with the Mareeba shire council in north Queensland. We are splitting off five three-acre rural residential lots between us, with sustainable design overlays on the land. We have also submitted that these properties will all be provided with an off-grid solar system with battery storage (with a plan to make our small village of 80 people 50% solar adopters).

However, the current council planning scheme doesn't have any scope for new rural residential properties to use off-grid solar. A new scheme which is in discussion may do, but we are caught in the middle, and have the opportunity to set a precedent. The planners themselves have admitted to little knowledge in the sector. I have been scouring articles and reports for information on the feasibility of off-grid systems with battery storage, especially in north Queensland. If you have any other reports, guidance or recommendations that may assist us in our negotiations, please send them on through.
—Steve Grist

A —
No one can force you to have a grid connection; it is quite legal to have your own off-grid system. The 240 volt wiring must comply with Australian standards and must be done by a licensed electrician. The solar system may also have to be installed by a licensed electrician, depending on the design. If you claim a rebate for the solar panels (STCs) it will also have to be installed and signed off by a Clean Energy Council (CEC) accredited installer to ensure compliance with a range of solar and battery standards. We recommend that anyone installing an off-grid system use a CEC or Australian Solar Council (ASC) accredited installer. While you may not be claiming the STCs for the off-grid system, given the complexity of system design and the importance of getting it right (with particular regards to winter loads), the safest bet is to use an installer who has completed the CEC or ASC training for off-grid systems.

Some councils insist that properties have power as part of a plan of subdivision, but they cannot force you to connect or to stay connected to the grid. When you wire the house, get the electrician to set it up for an alternative supply like a generator or solar. Then don't ask to get connected, just state "the house is not ready" or, if it does get connected, say "we are moving, can you disconnect us and give us a final bill". Once you are disconnected, switch over to solar.

However, be aware that setting up a house to run 100% off-grid can cost $30,000 to $50,000. Some people may not be able to afford this. Finally, if you can get the development application through with no grid connection it could save thousands of dollars per lot as there will be no costs associated with local electricity infrastructure, but that means all houses would need to be off-grid.
—Mick Harris

A really big fan

Q —
We live in a non-air conditioned two-storey home. It was a passive solar design over 30 years ago and still works pretty well, being warmer in winter and cooler in summer than many other homes we see. Where it has never worked too well are those hot nights where there is no breeze; by morning, it's cooling outside but not inside. As the day warms up, we just get hotter, and after a few nights it can get pretty uncomfortable. If only we could draw all that cooler air into the house overnight! Summers here in Perth will presumably only get worse.

A good exhaust fan should be able to cool the house any summer night when it is hotter in than out, but who installs such things? We have heard of exhaust fans designed to evacuate a whole house, but none of the electricians contacted reply, and no air conditioning people seem interested. I gather that the optimal fan needs a huge diameter turning slowly, so it makes less noise than one (or multiple) small fan(s) turning faster. And since hot air rises, clearly you need to install it/them at a high point in the house and open windows or large vents at the lowest points (and nowhere else) to draw cooler outside air up through the whole house.

We are hoping you can provide some advice. Are there people doing this in Australia? What sort of people should we ask? What questions must we solve? Can it be automated? We don't want a noisy solution that will wake us in the night when it runs, and it would be nice to have it on a timer, or even some clever sort of automation. Please tell us whether this will be cheaper than air conditioning to install!
—Barnard Clarkson

A —
Whole house fans are available, a few suppliers are www.breezepower.com.au, www.lowenergyliving.com.au/whole-house-fan-cooling and www.cardiffair.com.au/domestic. Any of these should be able to give you the details of an electrician to install them as well.

All of the units seem expensive for what they are. There's a useful forum thread on these fans at forums.whirlpool.net.au/archive/1312465.
—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.
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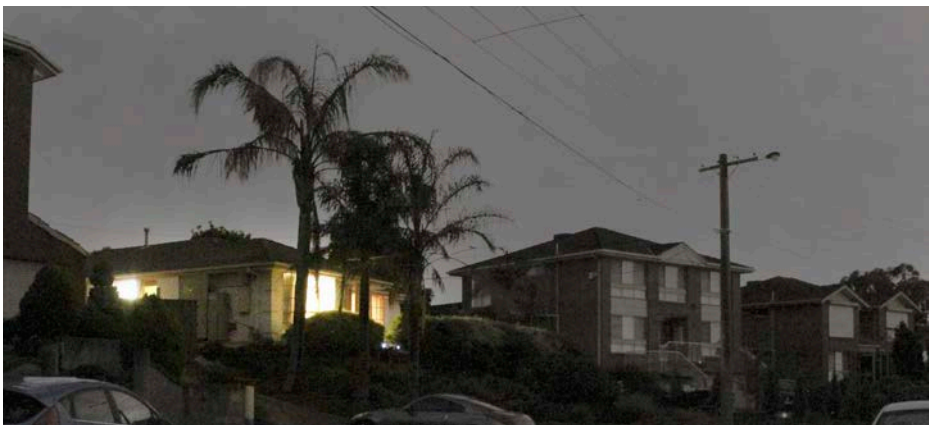
ATA member profile
Making sinewaves in Australia

Long-time ATA member and software engineer Rod Scott continues to expand the work of Selectronic, his family business which 35 years ago created Australia's first inverter. He talks to Kulja Coulston.



↑ Rod's solar hybrid system kept the dinner party going! The guests at Rod's house knew nothing about the power outage until they went outside and noticed the street in darkness. They continued on with lights, music, cooking and a movie, powered by a 5kW Selectronic SP PRO, a 2.5kW PV array and an 180Ah 48V battery system.

THE success of the renewable energy industry has often tracked along a "sinewave sales curve", according to Rod Scott, the products and business manager of inverter manufacturer Selectronic. "It's standing on its own feet more now, but there were times when government program early announcements could dry up business for five months at a time," he says of the 'boom and bust' cycle that has typified the renewable sector in Australia.

Together with his brother Ken, Rod Scott is continuing the work of his pioneering family business which has been part of the local industry from the beginning. Selectronic produced their first inverter in 1981: "It was a 360 watt DC to AC square wave inverter," explains Rod. "We started small and it grew from there." In 1990 Selectronic developed one of the earliest model sinewave inverters.

"It was then that our bigger models started to come out with energy-management functionality. It was all off-grid back then, with Australia being such a sparse country—storage for on-grid systems would have been a very strange concept!" It was in the early 2000s when they developed their first grid-interactive inverter, as that side of the market started to take off.

Rod's parents established Selectronic in 1964 as a contract manufacturing business and ran it out of the Scotts' backyard bungalow in Boronia, Victoria, before moving into a factory. The company cut its teeth custom-making transformers and inductors for the local electronics industry before launching its own electronics products division. Decades later, Selectronic continues to manufacture products locally, when most manufacturing has moved offshore.

"We were one of the first to make inverters in Australia, and we might also be one of the last." Employing around 35 to 40 staff at its Chirnside Park factory in Victoria, Selectronic indirectly employs another 100 people in Australia through its supply chain, and will soon open an international office in Johannesburg. "We can't get everything made here, particularly the specialist electronics, but we support local if we can, as it gives us flexibility and control over the quality of the product."

"We can't get everything made here, particularly the specialist electronics, but we support local if we can, as it gives us flexibility and control over the quality of the product."

Research and development has underpinned the company's success for half a century, explains Rod: "Our future products look like what our customers demand, and it's always been that way. When we developed the SP PRO in 2008, we already had 28 years of off-grid experience." Selectronic's continued commitment to the traditional off-grid market is also paying off, as the flexibility and reliability of those systems is relevant to the growing solar hybrid market. A few years ago a German company, KACO New Energy, rebadged Selectronic's 5kW SP PRO under their own label.

Rod has been an active ATA member and committed advertiser in *ReNew*. He is also personally committed to renewable technology at home, and is running off a 5kW SP PRO with about 2.5kW of solar photovoltaic panels. At a recent party none of his guests noticed the suburb-wide power outage: "I had to take everyone out onto the street before they believed me that we were the only ones still with power." ✱

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