ReNew

Technology for a sustainable future

Issue 133

REUSE & RECYCLING SPECIAL

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PLUS

Gas vs electric heating

Shipping container converts

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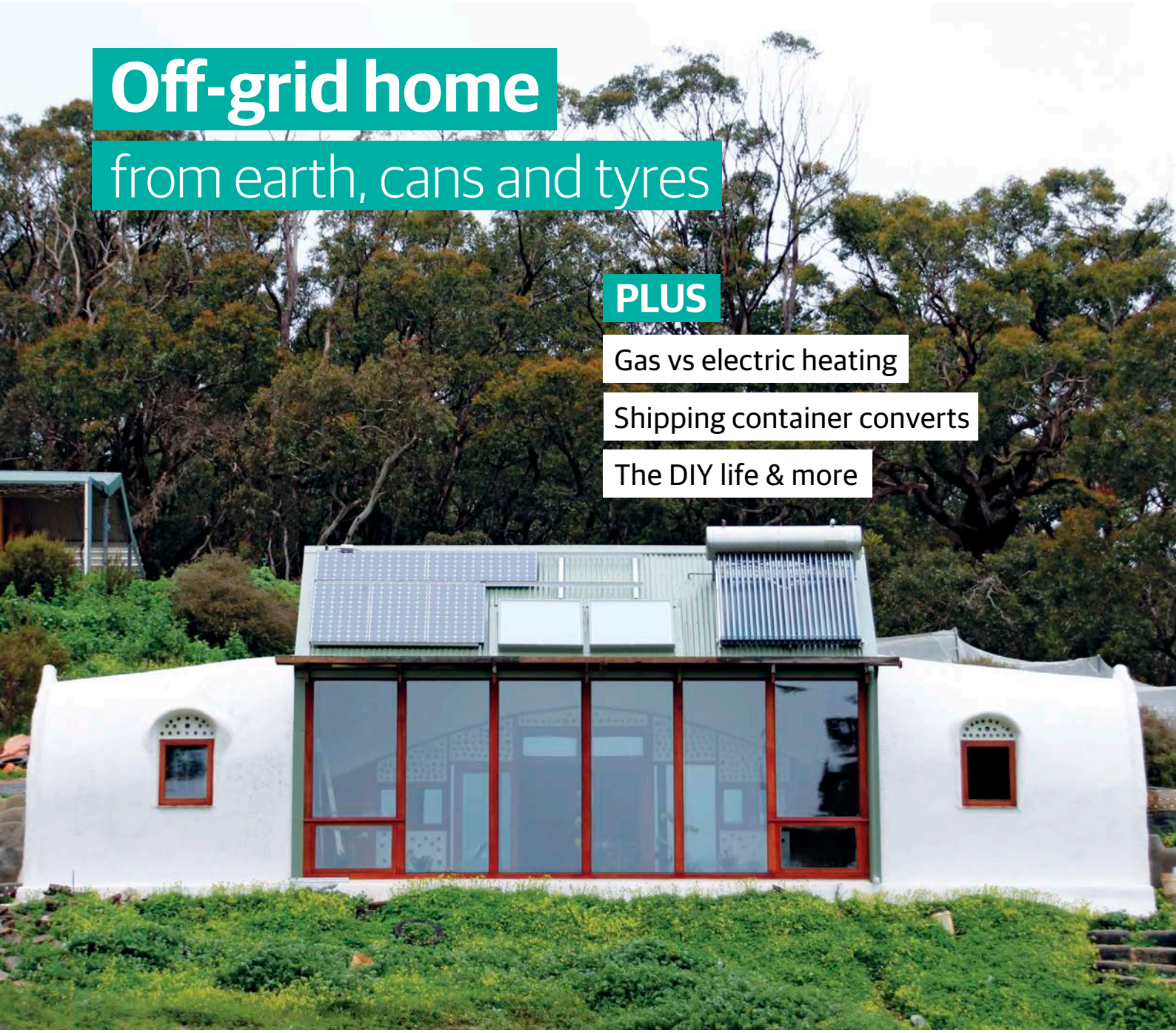

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Waste not, want not: tech recycling
Low-cost owner-build: keeping it simple
Passive House: all sealed up in Canberra

LED lighting
Buyers Guide inside

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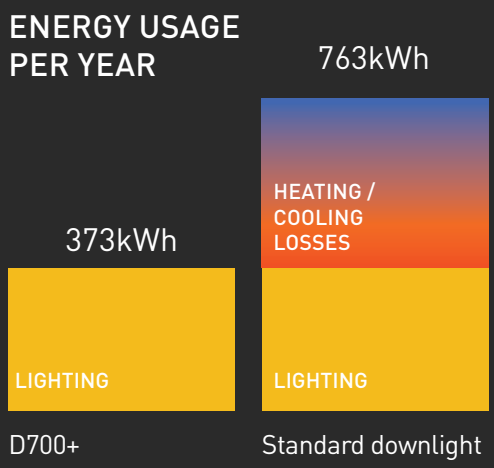

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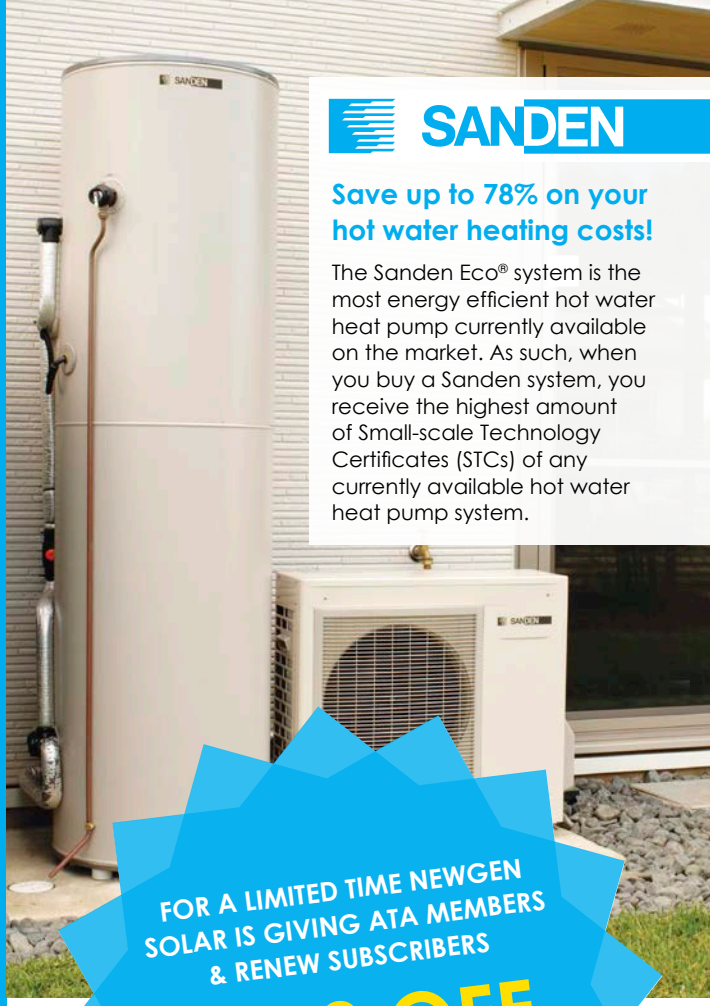

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↑ This Canberra home has met the rigorous standards for Passive House certification. Learn from an owner/designer's experience. Page 34.

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Special feature: reuse & recycling

↑ Experience the joys of a container conversion in Daylesford, central Victoria. Page 48.

↑ Claiming to recycle up to 96% of construction waste from building sites, Mobius is one of a new breed trying to do things differently. Page 44.

↑ Fancy staying in an earthship? One is about to launch in the Adelaide Hills. Page 56.

← **Cover image: Earthship Ironbank, a B&B in the Adelaide Hills. Photo by Philip Glitheroe.** Earthships are constructed from recycled and reused materials. Approximately 800 tyres were reused in the construction of Earthship Ironbank, with another 300 for the rainwater tank. Along with its tyre walls and earth-bermed structures, Earthship Ironbark is wired up to collect data—it has temperature sensors throughout in a bid to better understand the heat flows in an earthship. Earthships were invented in New Mexico, where the climate is very different from the Adelaide Hills, but owner-builder Martin Freney has tweaked the design for local conditions. One of the challenges Martin faced was sourcing bottles and cans for the walls; container deposit legislation in South Australia means used bottles and cans are hard to find! Page 56.

↑ The PET greenhouse. Page 68.

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LED lighting buyers guide

DIY

Regulars

About *ReNew* and the Alternative Technology Association

ReNew magazine

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

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

Sanctuary magazine

The ATA also publishes *Sanctuary: modern green homes*, providing inspiration and practical solutions to make your home or build more sustainable. The current issue looks at heritage renovations, backyard aquaponics and solar and battery storage.
www.sanctuarymagazine.org.au

Advocacy and projects

The ATA conducts research and consulting projects with partners and clients from government, industry and community sectors, as well as advocating on issues of importance to our members.

The ATA has recently upgraded its free solar feasibility calculator, Sunulator, to include analysis of adding batteries to solar systems.

The ATA also recently helped to protect efficiency and labelling standards for appliances, with their recommendations being accepted by the COAG Energy Council.
www.ata.org.au/ata-research/sunulator
www.ata.org.au/wp-content/projects/TheFutureOfGEMS.pdf

Alternative Technology Association

The Alternative Technology Association (ATA) is a not-for-profit organisation that exists to connect, inspire and assist people to make sustainable choices 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 privileges to help you achieve your sustainability dreams. Your ATA membership provides you with benefits such as our free 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

The ATA is escalating its work in East Timor thanks to a $250,000 grant from Google Australia. ATA is currently planning the installation of the first 50 solar lighting systems in October 2015 for homes dependent on kerosene lamps, piloting the latest model of the village lighting system—a 30 W panel, 3x 3 W LEDS, a 1 W night light, a USB phone charger and a 26 Ah battery.
www.ata.org.au/ipg

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Contributions are welcome; guidelines available at www.renew.org.au or on request. Next editorial copy deadline: 20 October 2015.

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Attention residents of Canberra and the surrounding areas

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Editorial

Waste not, want not: a reuse/recycling revolution?

STATISTICS on waste in Australia are disquieting. With construction waste accounting for 30% to 40% of landfill and just 20% of our plastic waste being recycled, it can seem like an intractable problem.

But there are initiatives and groups working to stop the flow at the source. Product stewardship agreements, such as those applied to manufacturers of TVs and computers, are having a measurable effect on the amount of waste ending up in landfill, as Kirsten Tsan reports in our article on e-waste. Construction waste is being minimised through a combination of targets and landfill fees, alongside passionate companies working to find ways to recycle or reuse—and we dig a little into this topic.

We often get asked about solar panel recycling. It's been slow to get started here—a good-news story about panel longevity—but the need is growing. Lance Turner looks at this, along with battery and light recycling.

Alongside a lament for a pre-plastic world, we look at some of the statistics and issues around single-use plastics. Much more plastic is recyclable than currently is recycled, and so much more is produced than we really need—disposable forks, we're looking at you. We spent time looking for the 'gotcha' image of plastic in the ocean garbage patches, only to find that those patches are actually more like plastic soups, with many tiny particles of photodegraded plastics. It's an ecological disaster and we need to find a solution.

On a more positive note, we look at how salvaged materials can become a building. We feature two shipping container homes and we witness the launch of the first permitted earthship in Australia, a home built from reused tyres, earth and bottles. It's a beauty, so why not plan a visit when it opens as a B&B in 2016. And usefulness and reuse intersect in an amazing greenhouse built from PET bottles by primary school students.

As you're probably aware, the ATA (*ReNew*'s publisher) has been involved in investigating whether it can be cheaper and more sustainable to go all-electric at home. One of our members takes that a step further with a practical experiment, comparing gas and electricity for heating. He looks at economics, efficiency and comfort—it's a must-read!

We also get to hear from an owner-builder who applied common-sense principles and went all-electric to build a low-cost net zero energy home. Plus we feature an owner-designed Passive House, one of six now certified in Australia—quite a feat. Our buyers guide is on LED lights, providing guidance on types, efficiency and what to look for. Plus we've got DIYs, the Pears Report and all our regulars! Finally, a big thank you to all those who did our recent survey, see p. 89 for more. If you missed out, we are always pleased to get feedback at renew@ata.org.au.

Robyn Deed
ReNew Editor

In *ReNew 134*, out mid December

Solar panel buyers guide, energy efficiency and energy audits + more.

SINCE Tesla launched its Powerwall this year, the interest in adding batteries to grid-connected solar has increased dramatically. At the ATA we have been receiving queries daily from people looking to add batteries to their solar systems or wanting to know if they should be purchasing battery storage with their new solar system.

That analysis is now easier with the launch of the ATA's battery storage addition to our popular Sunulator tool. Sunulator (www.ata.org.au/ata-research/sunulator) is a freely available detailed feasibility tool that allows analysis of solar-battery system performance. Unlike other solar calculators, it uses half-hourly consumption and generation data over a whole year and calculates project feasibility over a 30-year time frame.

While grid-connected solar battery storage is still somewhat expensive, this is set to change following the lower prices and simpler configuration announced by Tesla. This will no doubt catalyse their competitors to further drive down costs and improve performance. In addition, many solar households are about to lose premium feed-in tariffs, and batteries offer the opportunity to better utilise solar energy that would otherwise be exported to the grid. Battery storage can also provide a source of power during blackouts. For more information on options to add batteries to grid-connected solar, see the article 'Going Hybrid' by the ATA's Andrew Reddaway in *ReNew 132*.

Although Sunulator may be a bit complex for many homeowners or community groups (but maybe not *ReNew* readers), you can always use our paid advice service to have an ATA expert run Sunulator for you. In the next couple of months we will also be adding more state profiles to the data-sets it uses.

A big thank you to the City of Sydney for supporting the development of the storage functionality in Sunulator.

Donna Luckman
CEO, ATA

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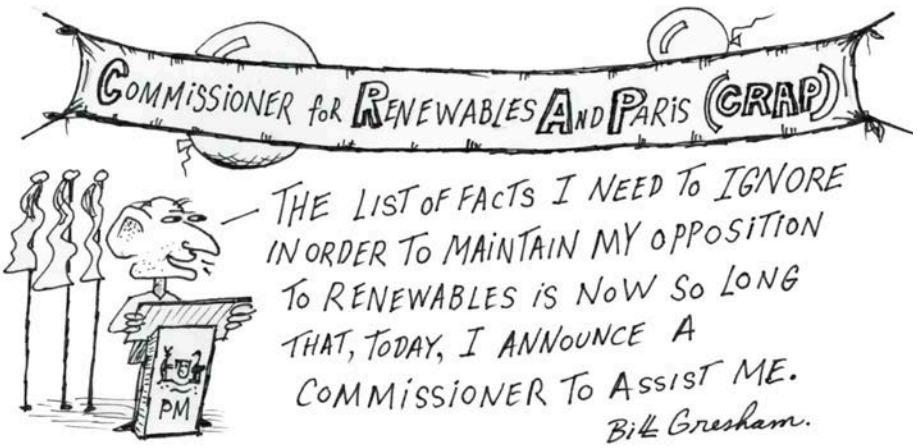
Up front

The City Harvest

Food waste forms a significant proportion of landfill in Australia. The City Harvest aims to tackle restaurant food waste head on with an initiative that combines composting, social enterprise and sustainable agriculture.

They will be using Closed Loop machines, systems capable of transforming large quantities of food waste, including meat scraps, into soil conditioner in a very short time frame. The City Harvest will collect the resulting soil conditioner and mix it with soil to make compost. This compost will be applied to city gardens tended by disadvantaged youths who have undertaken Cert II in Horticulture at CERES Environment Park, with the produce being sold back to the restaurants. The pilot will soon be up and running at King and Godfree in Carlton, Melbourne.

In a country lacking in topsoil it makes sense to make compost, but the amount of electricity the Closed Loop machines use also needs to be considered. The CLO500, the largest and most efficient in the range, uses a maximum of 12,000 kWh a month to compost 1000 kg of food waste per day. Given this amount of energy use, the machines should be run using renewable energy or GreenPower. *ReNew* looks forward to seeing how The City Harvest project evolves.
www.closedloop.com.au



UTS building provides enlightenment for students

Image: Darren Bradley

A new university building inspired by the palette of Austrian painter Gustav Klimt, with concertina-style windows that "swell and billow", has won the City of Sydney Lord Mayor's architecture prize.

The University of Technology Sydney's (UTS) science faculty building seven, designed by Durbach Block Jaggers Architects and BVN Architecture, was recently awarded the prestigious prize.

Mayor Clover Moore said the building on Thomas Street, Ultimo, was an important part of a long-term master plan for UTS and helped to integrate the open space of Alumni Green with the surrounding streetscape.

"This inspiring building, with its curved and billowing facade, helps to soften the landscape, while also maximising winter sunlight on the valuable park space known as Alumni Green, where students and teachers can enjoy their lunch and relax."

The building has a 5 Star Green rating and includes innovative air conditioning, a green roof, and use of recycled materials.

The building contains a range of specialist research facilities, clinical teaching spaces and Australia's largest undergraduate-science teaching space: a 200-seat 'super lab'.

It has a number of innovative features, including a subterranean labyrinth beneath the Alumni Green where air to the building is pre-conditioned, a glass facade made from 97% recycled glass, with 85% from recycled domestic glass; and a green roof that provides insulation and stormwater retention, with all water collected used for irrigation.
www.bit.ly/1L8Ugs8

QLD residential solar pilot project launched

Queensland's regional electricity retailer, Ergon Energy, will be trialling a residential 'Hybrid Energy Service' from this September.

The pilot project, costing about $2.6 million, and supported by a $400,000 grant from ARENA, will determine whether this energy business model, which offers customers a combined package of solar roof panels and battery storage, will be rolled out in regional Queensland in the future.

The 12-month trial will be conducted in 33 high-energy-using (4+ bedroom) homes across Townsville, Cannonvale and Toowoomba. A

Back to the future

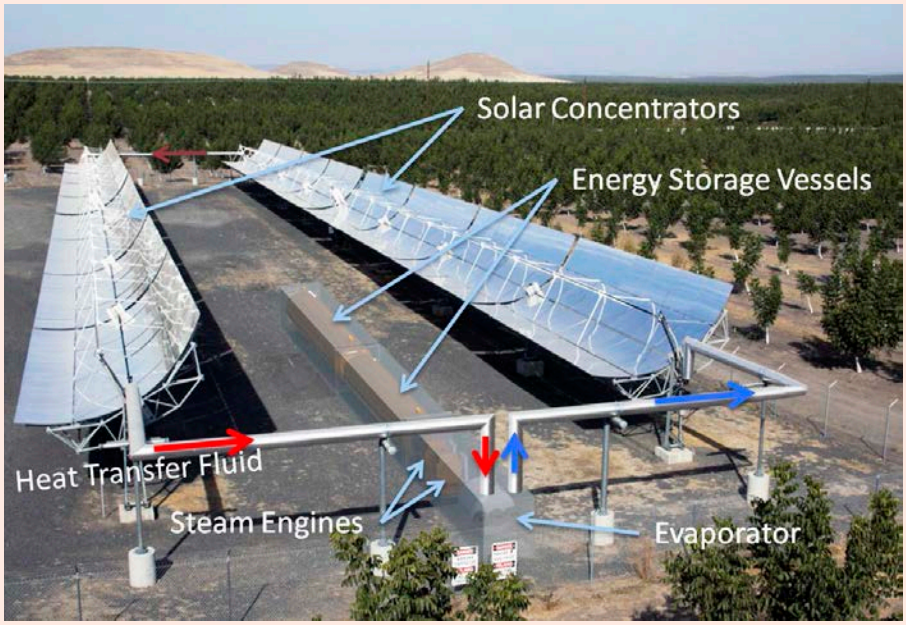
When you think of solar farms you probably think of large arrays of photovoltaic panels connected to grid-interactive inverters. Or maybe you picture a huge solar tower with thousands of heliostats reflecting the sun onto it to produce high temperatures.

One old but proven design for collecting solar energy is the parabolic trough. Light is reflected onto a pipe running along the focal line of the trough. Water flowing through the pipe is heated to produce steam, but using that steam has proved less simple. For large systems, steam turbines work well, but for smaller systems (sub-megawatt), steam turbines are not as suitable as another even older design, the reciprocating steam engine.

Terrajoule Corp in the USA has developed a system using just such engines to turn solar-produced steam into electricity. The system has an overall efficiency of around 20%—comparable to PV systems.

However, they have also developed energy storage to allow the system to keep running through the night or on cloudy days. The storage is amazingly simple—it's just a large insulated pressure vessel used to store hot water under pressure. When steam is drawn off, more of the water in the tank instantly flashes to hot steam due to the slight drop in pressure in the tank. Steam can be extracted until the tank is virtually empty.

One insulated tank the size of a 40-foot shipping container can store around 600 kWh of net electricity storage capacity.



Because the system uses storage vessel pressures similar to those used for LPG, the pressure vessels are low cost compared to higher pressure rated vessels, reducing the system cost considerably.

Terrajoule Corp states that they can produce storage systems at around $100/kWh, with no cycle limits, no capacity degradation and a rated life of up to 25 years. Price per peak watt is estimated to be in the range of US$1.50 to $2.00/W at a 20% capacity factor, depending on system size, insolation levels and other factors.
www.terrajoulecorp.com

4.9 kW SunPower PV array and a 12 kWh/5 kW Sunverge battery storage and control system—which will be owned and maintained by Ergon—will be installed at each home.

With 400,000 homes in Queensland sporting solar panels on their roof, and with a Labor government target of 1 million by 2020, it is hoped this trial will confirm the possibility of delivering reliable, cost-effective renewable energy to more homes in the future.
www.arena.gov.au, www.ergon.com.au

Oceans to get more say in climate change debate

With 2009 negotiations in Copenhagen having underestimated the likely impact of climate change on the world's oceans, leading international ocean scientists are seeking to redress the balance ahead of November's 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in Paris.

In July, Global Change Institute Director at the University of Queensland, Professor Ove Hoegh-Guldberg, with a team of international colleagues collectively calling themselves the Oceans 2015 Initiative, published a paper in *Science* which warned that any new global climate agreement must begin to minimise the mounting toll on the world's oceans to prevent irreversible damage.

The paper draws on an extensive scientific assessment of the impact of climate change on the world's oceans completed last year for the Intergovernmental Panel on Climate Change (IPCC), and aims to provide COP21 negotiators with key information on what future oceans will look like.

Professor Hoegh-Guldberg said the chemical and physical conditions of the ocean were changing at rates that were, in some cases, faster than any seen over the past 65 million years. He further noted that many marine organisms and ecosystems are fundamentally changing as the oceans warm, acidify and lose oxygen. "This is posing growing risks to human wellbeing as well as threatening key industries. However, solutions are still possible if we act decisively in Paris."

As well as further cutting greenhouse gas emissions globally, he said these measures must be accompanied by the rebuilding of the resilience of ecosystems and people against the rising tide of change; for example, adapting to rapid sea level rises, transforming fisheries and the impacts of increasingly volatile storms.
www.bit.ly/1JGgyk6

Up front

Australia's first 'electric highway'

Western Australia's RAC (Royal Automobile Club) has funded Australia's first extended EV charge point network. The first charging station located at Margaret River was opened on 22 June. Four others in the south-west tourist region have opened since, with six more to be completed by the end of the year. RAC's own existing charging station in Perth has also been recently upgraded to be a fast-charger.

Running between Perth and Augusta, the RAC Electric Highway™ comprises 12 stations offering the public both AC and DC fast-charging, which can fully charge an electric vehicle in as little as 30 minutes. Locations and progress can be viewed at www.rac.com.au.

Local councils have provided the charging station sites. WA-based company E-Station, set up in 2009 to facilitate early adoption of charge point infrastructure, was chosen by RAC WA to supply the hardware (manufactured by US company Circontrol) and network/driver management software for the highway. Drivers register with ChargeStar, which offers a web-based portal and an app for billing. The app also enables drivers to locate charging stations and check (and reserve) their availability, and view charging history and energy usage.

Currently, there are only around 250 EVs in WA, and only around 2000 Australia-wide, but, hopefully, with continued investment in infrastructure like this, we will see the network of electric highways (and uptake of EVs) expand in the years to come. www.chargestar.com.au, www.e-station.com.au

← The WA Electric Highway includes 12 fast charging points.

China leads the transport charge

Utilising supercapacitor technology, the Chinese city of Ningbo is now operating the world's fastest-charging electric bus. The bus, manufactured by CSR Zhuzhou Electric Locomotive Company (CSR ZELC), runs along a 24-stop, 11 km route. Although the charge only powers the bus for around 5 km, the bus takes only 10 seconds to recharge, which is done at the normal bus stops along the route.

In addition to its rapid charging ability, the bus also uses around 30% to 50% less electricity than its conventional peers, and about 10% of the energy of a standard diesel bus. The supercapacitors are capable of over a million charges/discharges, giving them a service life of around 12 years, making the buses very cost-effective over the long term. Ningbo plans to add 1200 more buses to its fleet over the next three years.

In December 2014, CSR ZELC also launched a 7.7 km, 11-station demonstration line in Guangzhou for the first low-floor supercapacitor tram. It has been carrying 10,000 people per day, taking only 20 to 30 seconds to charge at the stations along the route.

And China has also reached a milestone in air transport, with a world-first airworthiness certification of an electric two-seater plane, the RX1E. www.csrgc.com.cn/g1689.aspx, www.bit.ly/1JvK5zM

Renewables set to 'megashift'

A recent report published by the Australian Renewable Energy Authority (ARENA) forecasts a boost to the renewables sector as battery prices fall by 40% to 60% in the next five years. The reported 'megashift' to adoption of energy storage will be driven by demand from both the supply side—as networks continue to adapt to and increase distributed and renewable energy capacity—and from consumers wishing to store their solar energy, as a fall in battery costs makes this more financially viable for both.

The report notes that one of the largest markets for energy storage systems will be the end-user market looking to pair storage systems with rooftop solar PV and maximise behind-the-meter usage, so that consumers make the most of the energy they generate before any excess gets diverted to the grid. The next-biggest potential market in Australia for energy storage would be the off-grid market, which has been forecast to grow to over 1 GW in the longer term. www.bit.ly/1Fb6Gha

Letters

Air conditioner standby power

In response to Dale Siver's letter in *ReNew 132*, Dale's situation is, unfortunately, one I have expected to see. When the air conditioner labels were revised in 2010, the standby power use of air conditioners was included in the rated energy consumption and star rating. However, the consumption was based on Sydney's climate.

It's pretty obvious that thermostatically controlled crankcase heating elements won't use a lot of electricity in Sydney, but may in colder places. Unfortunately the energy regulators don't require manufacturers to publicly state what the standby energy use would be in colder climates, even in the downloadable database. So it's a case of 'uninformed buyer beware'.

As Dale pointed out, this can be a significant amount of energy use, so it should be included prominently in public information. I hope someone in Canberra reads *ReNew* and does something to fix this very significant anomaly. Even if the information can be added to the database it would be a help, as advisers could at least warn people which units use a lot of standby power in cold places.

Alan Pears

Timber floor hydronics

After reading Lance Turner's reply to a reader in *ReNew 132*, I thought I would pass on our experience of hydronic heating under timber floors.

Our house is on a steep slope, so is mostly high-set (one room is on a slab, with heating in it, but the balance of the house is up to three metres above ground level). There are I-beams on top of the bearers and a ply subfloor under the timber floors. The heating tubes go through aluminium 'fins', which sit directly below the ply. We then have rockwool insulation below that, fitted inside the edges of the I-beams and held in place with 5mm ply strips. We couldn't find anyone in Queensland who would install hydronic heating under a timber floor, so the fins and heating tubes were supplied and installed by Maas Products from Victoria. There are several zones which can be independently turned on and off.

The initial work of the fins and piping was done when we started building in 2009. However, as we were owner-builders, the whole build took some considerable time, and during that period Maas Products went out of business. So we then had to get someone else to actually install the Accent Air heat pump and fit it up to the water pipes and zone controls—not easy in Queensland where no one uses this system!

Despite the hassles of getting it installed, we are absolutely delighted with the finished system. After several years of use I can say we have had no problems at all with the timber floor shrinking or cracking. We have a fairly wide temperature and humidity range here—we are in rainforest, and at 650 metres we get quite cold winters and warm wet summers. The heating works brilliantly, and while it is not cheap to run, we also have fires and good insulation, so it works fairly efficiently.

In our experience at least, hydronic underfloor heating is fine with timber floors.

Rose and Russell Cuthbertson

The forgotten engineer

I have been reading *ReNew 132* and wish to point out an oversight in the article 'Go With the Flow—a Micro-hydro Buyers Guide'.

On page 76 you have an illustration of six different types of hydro turbine runners. You refer to one as a crossflow when technically you should have referred to it as a Michell runner!

Anthony Maldon Michell was an Australian engineer who received a patent for this style of turbine runner in 1903. Michell was one very talented Australian engineer who invented numerous mechanical items that we still use in this age.

So keep up the good magazine but please give credit where it is due, as Anthony Michell's input to water turbines is often sadly overlooked.

Matthew Thomas

More on air con standby power

I was alarmed to read the letter in *ReNew 132* alerting readers to the potential standby power use of reverse-cycle air conditioners.

We have the exceptional Ururu Sarara 7 from Daikin installed and can't recommend it highly enough for efficiency and sophistication. However, as a further energy saving measure I was in the habit of turning it off at the mains so as to further reduce usage. Now I fear that it is best left alone. At the very least the instruction manual refers to the fact that it may engage the fan even when in standby mode as a means of protecting the machine in hot weather.

The whole issue opens up a can of worms as to what are the consequences if these machines are left without standby power for any length of time in a power failure, or simply at a disconnected property.

Patrick Hockey

Super-insulated walls

In *ReNew 132* you featured and compared a number of wall building systems available in Australia today.

Included in your article was the Green Energy Brick super-insulated wall system which was developed and patented by my company. We have now identified a series of improvements for the Green Energy Brick including a more sustainable insulating core. These improvements will also enable the new improved Green Energy Brick to compete on cost with poorly insulated brick veneer walls. We have worked tirelessly for five years, but without success, to locate the investment/funding necessary to fully commercialise the improved product in Australia.

Despite the successful construction of 30 new homes using our Green Energy Brick, Australian investors are not interested in proven innovative

Making biochar

I have followed the instructions given in *ReNew 124* to build a biochar TLUD burner from a 200 litre drum. However, I find that the article didn't give me enough information to actually produce biochar. I've done two burns and, both times I've ended up with just a little bit of ash in the bottom of the drum.

The article seemed to assume I knew how a TLUD burner worked, but I didn't. I think I need to damp down the fire, but when? And how? Do I just block off the bottom air holes? What about the top air holes? When should I douse the fire? Should I ensure that it is completely out?

Some specific guidelines about the process would be very helpful.

Rob Phillips

Rob, it's great to hear about *ReNew* readers taking up the backyard production of this wonderful product. Your problem is an easy one to solve. You simply need to put out the glowing coals before they turn into ash, which is what will happen in any type of biochar making retort, if left for too long. Keep in mind though, that the retort needs to be starved of oxygen as much as possible, but still be able to maintain a minimal smoke burn. This is what stops the char from turning to ash during the burn process, and maximises the final fuel-to-char ratio.

You may need to make an appropriate peephole in the lid, to observe the state of burn. Then when there is approximately a quarter of the volume left, quench it thoroughly with a hose and tip it out. Or, if the site and weather conditions are right, you can use a rake to pull the drum upside down, to burn off the last remaining volatiles, then quench it. Always have that hose ready with a valve at the end of the hose.

Also, be aware that since the publication of my biochar article, the Australian authorative researcher on biochar and author of *The Biochar Revolution*, Paul Taylor, has described a simpler and more effective means of producing biochar in small batch quantities using an open-air retort (see 'Kon-Tiki: The Democratization of Biochar Production' at www.biochar-journal.org). However, the sealed drum method that I described, which contains and hides the flames, is likely a safer option, particularly in the drier seasons. **John Hermans**

energy-saving Australian technologies. The attraction and apparent security of investing in real estate has drained dry the investment pool in this country. We have not abandoned Australia yet, but the investment market in many countries overseas is attractive. To keep the technology alive we have now registered a company in the USA. Our plans to manufacture our system there for the US market have so far been well received.

We continue to seek the funds/investment necessary to manufacture in Australia, but with little hope.

Paul F Curtis
Managing Director
T3Energy Pty Ltd

Shade and solar for EVs

Something I have been thinking about for a while is the possibility of approaching the major supermarket players to set up shade areas in their car parks with PV panels. It would seem like a win-win solution for them, helping out with their power use, providing shade for their customers' vehicles, and possibly have some charging facilities for EVs as well. And it would add to their green image and so add to their appeal in a very competitive environment.

Our local supermarkets in Seymour have been removing what shade trees were originally in their car parks for years now and it's obvious that the few remaining shady spots are in demand. The rest of the cars just cook in the sun and become dangerous to get back into. I've seen large shade sails used in Mildura for this, but they could just as easily be flexible PVs or fixed panels. There's a lot of great tech out there: we just need to inspire the companies to get on board—or make them more responsible for what happens in their car parks.

There's probably a good economic case to be made for just protecting the very expensive asphalt from too much heat.

Brian Bowring

Solar car park systems are available and are starting to get regular use in some countries. It's still a bit slow in Australia, although I know of one system that has been installed in Sydney. One of the better installers of such systems is a company called Schletter, www.schletter.com.au/solar-mount-system/carport.html

Mick Harris

Simple solar PV hot water

I want to give some feedback on the TechLuck solar PV hot water booster that I recently installed.

I was given a working Rheem heat pump water heater that had been replaced with a gas unit by a city-based friend. A week after going to the trouble of getting it installed, the control board failed, so I had to run it on the resistive booster element as a standard electric water heater, with the resulting humungous power bill.

I then bought the solar PV hot water booster and obtained four secondhand 24 V, 200 watt solar panels. I scrounged a couple of old salt-water pool chlorinators of varying types. From these I obtained an outdoor-rated box with an aluminium backplate to use as a heat sink, an analogue ammeter and enough heavy duty cable to connect to the water heater. I mounted the solar panels flat on the roof and the modified chlorinator box on the side of the water heater and adjusted the thermostat up to 60°C.

By 9 am there were 91 volts across the element and 5 amps flowing into it. That is 455 watts even though there was a bit of cloud cover.

I had to go to work so I missed the midday maximum. At 5 pm I checked it and it was still going. While I was checking it, the thermostat reached temperature and turned it off. I felt the tank and it was very warm. It had been full of cold water.

I had a grin you couldn't knock off with a stick.

Chris Ryan

Write to us

We welcome letters on any subject, whether it be something you have read in *ReNew*, a problem you have experienced or a great idea you have had. Please limit letters to 350 words. Due to space restrictions we can't guarantee to publish all letters received, and letters published may be edited for clarity and length. Email letters to renew@ata.org.au or post to ReNew, Level 1, 39 Little Collins St, Melbourne VIC 3000, Australia.

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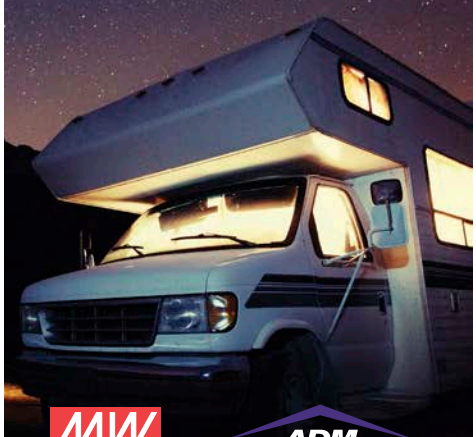

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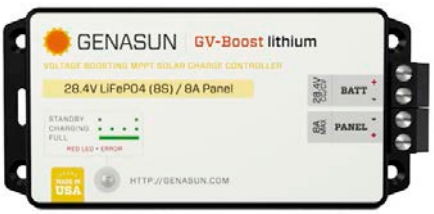
Products

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

Charge your e-bike from solar

Wouldn't it be great if you could charge your electric bike or other lithium battery devices straight from a solar panel? Well, even if your devices use a 24, 36 or 48 volt battery, you can still charge it directly from a 12, 24 or similar voltage solar panel by using the Genasun GV-Boost charge controller.

As its name suggests, the GV-Boost will step the voltage from the solar panel up to a voltage suitable for charging higher voltage lithium batteries (or lead-acid batteries, if you are using them). It can handle solar panels with a maximum output of up to 8 A, and rated output power to 350 W.

The GV-Boost is available for nominal battery bank voltages of 12, 24, 36 and 48 V, features continuous MPPT (maximum power point tracking) to make the most of your solar panel's output, and has a peak efficiency of 99%.

The controller uses multi-stage constant voltage/constant current charging with temperature compensation. They are suitable for marine applications and there's also a fully waterproof version (36 and 48 V battery voltages only). Both types come with a five-year warranty.

RRP: from US$159 for the 12 V model to $239 for the 48 V unit (custom voltage models are available for $320). For more information, contact Genasun LLC, 1035 Cambridge St, Suite 16B, Cambridge MA 02141, USA, www.genasun.com

02

No need to wait for the Powerwall

The Tesla Powerwall made a big splash a few months back, but it won't be available for a while. LG Chem's Residential Energy Storage Unit (RESU 6.4 EX) lithium ion battery system is similar in size, shape and capacity to the Powerwall and is available now.

However, unlike the Powerwall, which fits between the solar array and its grid-connected inverter, the RESU is designed to be used with 48 V off-grid and hybrid inverters, providing a true off-grid or grid-backup system, as well as grid load shifting.

Designed to last more than 10 years, or 6000 cycles, the RESU has a peak output power of 5 kW and a nominal capacity of 6.4 kWh, with additional 3.2 kWh extender modules also available.

Operating temperature range is 0 to 40 °C, so it may not be suitable for installation in some of the hottest parts of Australia unless installed in an air-conditioned environment.

The RESU 6.4 EX measures 406 x 664 x 165 mm and weighs 60 kg, while the extenders measure 230 x 664 x 165 mm and weigh 30 kg, meaning both units are light enough to mount on most walls.

So, if you are looking for long-life storage for a hybrid or off-grid PV system, the RESU 6.4 EX would be a good place to start.

RRP: $6900 (approx). Distributed through Solar Juice, ph: (02) 9725 1111, info@solarjuice.com.au, www.solarjuice.com.au

03

Low-power, low-cost mini PC

With the low-power Bay Trail range of microprocessors from Intel there has been an explosion in low-cost, low-power Windows PCs of late. Many are in the 'Compute Stick' form factor and seem to suffer from connectivity and overheating issues due to their tiny size.

Chinese company MeLE has addressed these issues with their mini desktop PCs, the PCG03 and PCG09 (the same as the PCG03, except with the option to fit a 2.5" SATA hard drive or solid state drive).

The PCG03 uses the quad-core Z3735F Atom processor (designed for use in tablets, but it's a very capable processor with a maximum power consumption of 2 W), with 2 GB DDR3 1600 MHz RAM and 32GB of eMMC storage. Other connectivity includes HDMI and VGA outputs, wi-fi, ethernet, Bluetooth, full size SD card slot and three USB 2.0 ports. Maximum power consumption is just 12 watts, while fanless cooling uses the metal baseplate as a heatsink.

The PCG03 comes with a licensed version of Windows and is capable of most day-to-day tasks (we bought one and it's remarkably fast for its specs). It's ideal to replace your old energy-sucking PC or to make use of that spare monitor that's been sitting in the garage.

RRP: US$199 with free shipping, although we picked up one on sale for US$149. For more information, see en.mele.cn. Available to buy directly from the MeLE Aliexpress store at www.aliexpress.com/store/715968.

04

Aussie-made battery monitor

Battery voltage can only give you a very rough idea of a battery's state of charge, especially if the battery is being charged or discharged. To really know what's going on you need a battery monitor that measures the energy going into and out of the battery.

The Mkove MK70 battery monitor suits 12 V and 24 V lead-acid battery systems and is ideal for monitoring battery banks in off-grid homes, boats, caravans or anywhere a lead-acid battery bank is used. It works with all types of lead-acid batteries including AGM and Gel sealed lead-acids as well as flooded-cell batteries.

The MK70 displays the state of charge of your battery as well as the current flowing into and out of the system, and the current battery voltage. Historical data about the utilisation and performance of the system is also available.

Unlike most battery monitors that use a long cable between the monitor and the battery shunt, the MK70 uses a two module system to sense the voltage and current close to the battery. It then uses a digital signal, which is immune to interference, to send the data to the display unit. The result is more accurate information about your batteries.

The MK70 is designed and made in Australia and comes with a two-year warranty.

RRP: $179 including shipping in Australia. For more information, contact Mkove, sales@mkove.com, www.mkove.com or see the Mkove ebay store at stores.ebay.com.au/mkoveau.

05

Ditch the plastic pegs

Clothes pegs are not the most exciting things, but literally millions of plastic and wooden pegs are discarded every year due to breakage caused by weathering of the wood and plastic. While there are some stronger, more eco-friendly options such as bamboo pegs, ultimately they all break and get thrown away.

Wire Pegs are clothes pegs made of a single piece of grade 201 stainless steel wire (similar to grade 301, but with more spring), so there are no separate pieces to fall apart or break. They won't rust or degrade in the sun and are stated to hold clothes even in strong winds. There's also a marine-grade version, although they are more expensive.

We were sent a sample pack of the standard Wire Pegs and they work quite well, although we did lose a sheet from the line during high winds—but we are in north-west Tasmania and the winds are considerable.

The elimination of plastic alone is a big incentive to buy these pegs instead of plastic pegs from the local supermarket, given that the lifespan of the latter seems to be in the order of a year or two at best. And if your clothes line is relatively protected from high winds, then Wire Pegs are really worth considering.

RRP: $12 for 24 pegs through to $30 for 60 pegs, inc postage (marine-grade pegs are twice the price, e.g. $12 for 12 pegs). For more information, contact Wire Pegs, 1106 Wimborne Road, Manilla NSW 2346, www.wirepegs.com.

06

Biodegradable coffee capsules

Love them or hate them, coffee machines that use disposable capsules are a popular kitchen item. They use aluminium or plastic capsules, both of which are not really easily recycled as they are full of coffee grounds and are difficult to empty.

The Ethical Coffee Company has developed fully biodegradable coffee capsules for use in popular coffee machines such as those from Nespresso, although they can also be used with some other brands. The capsules are available in Australia in a wide range of flavours, including Fair Trade coffee, from Ecocaffe.

The capsules are made from a biodegradable plastic, primarily from vegetable fibre and starch, and will degrade fully in domestic compost in less than six months, faster in commercial composting systems. They are rated as fully biodegradable according to the EN13432 standard. Even the packaging is eco-friendly—the flow-wrap packaging is fully biodegradable to EN13432 standard and the cardboard box is made from 100% recycled content.

RRP: From $6.90 for a pack of 10 capsules. For more information and to buy, contact Ecocaffe, ph: 1300 756 604, www.ecocaffe.com.au. Also see www.ethicalcoffeecompany.com.

Products

07

Sit on it!

EVs are cool, being clean, quiet and efficient, but the Fonzarelli 125 from Fonzarelli Electric Moto has that extra bit of cool.

The scooter has a top speed of 65 km/h, or 75 km/h when you press the 'F', or Forzo, button (a short-term boost button). The 3 kW electric motor pushes the scooter to 60 km/h in six seconds, and range on a single battery can reach up to 75 km (the average is around 50 km), or twice that using two batteries.

With the battery being easily removable, there's no need for a charging station or power outlet where you park your scooter—just take the battery with you indoors and charge it there—this also prevents anyone stealing your scooter, or at least riding off on it.

Charge time is around three to five hours, and an 80% charge of the 72 V, 24 Ah lithium ion battery can be had in just one hour.

The scooter features regenerative braking, both when coasting and actively braking. It comes with a 24-month battery and major component parts warranty and 12-month warranty for other parts.

RRP: $4490 inc GST. For more information contact Electric Moto, L4, 53-55 Liverpool St, Sydney NSW 2000, ph: (02) 8283 5467, electric@fonzarelli.co, www.fonzarelli.co. Also available from Positronic Solar, 2/214 Leitchs Road Brendale QLD 4500, ph: (07) 3103 6018, admin@positronicsolar.com.au, www.positronicsolar.com.

08

Flexible energy storage

Energy storage is set to be the next big thing in residential renewable energy systems, and there's a steadily growing range of smart energy storage systems designed to be added to existing solar energy systems.

The Magellan Residential Energy Storage units combine an Australian-made bidirectional inverter with lithium iron phosphate batteries to provide a flexible energy storage solution. The RES units feature time-of-day programmability, including night tariff charging, integrated data logging, emergency power mode, and are designed to be used with existing solar infrastructure.

The RES1 and RES3 models are single and three-phase models respectively. The RES1 has an output range of 5 to 10 kVA while the RES3 can produce up to 30 kVA. Battery capacity is 9.2 kWh or 13.8 kWh and they are rated from 2000 to 5000 cycles, depending on depth of discharge.

Operating temperature range is a huge 0 °C to 50 °C due to the use of temperature-controlled fans. The units have isolated USB, ethernet and RS485 connectivity for communicating with PCs, and include an inbuilt web server, so they can be accessed with just a web browser.

RRP: from $14,900 (ex GST) for the 5 kVA/9.2 kWh model. For more information, contact Magellan Powertronics Pty Ltd, 64 Bushland Ridge, Bibra Lake WA 6163, ph: (08) 9434 6621, onlineenquiry@magellanpower.com.au, www.magellanpower.com.au.

09

Get those vegies going

Growing your own food is a rewarding experience, not to mention a lot more sustainable than buying from the local supermarket!

The 2016 Permaculture Calendar with moon planting guide helps you create successful crops by planting and tending them at the right time. The 12 basic permaculture principles are covered, with one discussed each month, and the calendar now includes a rainfall/temperature chart.

The calendar is produced in Australia on 100% post-consumer recycled paper using vegetable-based inks and printed using renewable energy. Net proceeds are donated to Permafund, a public fund that makes grants available for activities that demonstrate the ethics and application of the principles of permaculture. Calendar size is standard A4 (210 mm x 297 mm) and opens to A3.

RRP: $14, bulk discounts apply. Available directly from Permaculture Principles, www.permacultureprinciples.com.

10

Vortex power

In the hydro buyers guide in the last issue of *ReNew* we looked at the Zotlöterer turbine, which works using the rotational vortex created as a large volume of water flows down through the turbine unit. We lamented its unavailability here, not realising that a local company has developed a similar turbine designed for high-flow, low-head situations.

The Australian-invented Kouris Centri Turbine Generator from Kouris Power features an elongated cylindrical turbine mounted vertically in a close-fitting vortex chamber. The turbine shaft has top and bottom end-plate/bearing assemblies for reliability and ease of maintenance.

The unit requires a fall of just one to two metres, or even less, so it is ideal for run-of-river or in-dam power generation. The pilot plant in Marysville, Victoria, using a fall of only 0.6m and a flow of 110L/s can produce over 500W, or 12kWh per day—more than enough for a modern energy-efficient home. However, models are available with outputs up to 5, 10, 20 or even 50kW with sufficient flow.

RRP: dependent on site. For more information contact Kouris Power, Suite 618 Owen Dixon Chambers (West), 205 William St, Melbourne VIC 3000, ph: (03) 9225 7212, kourispower@gmail.com, www.kourispower.com. Available in Australia through Vortex Earth Energy P/L, 3C The Crossway, Campbellfield VIC 3061. Contact Rohan Searle, ph: (03) 9357 6579, rohan.searle@jbtooltech.com.au, www.jbtooltech.com.au.

11

Fire-resistant decking

We looked at Modwood decking some years back, and since then quite a few other wood/plastic composite decking materials have entered the market. However, none of them has the fire resistance of the latest Modwood product, Modwood Flame Shield.

Flame Shield incorporates a flame retardant into the composite material and is rated for use in bushfire zones of up to BAL 40, making it suitable for the vast majority of bushfire-prone homes.

Flame Shield is available in four colours—Sahara, Black Bean, Jarrah and Silver Gum—and two finishes, smooth and brushed. The decking has a deeply embossed woodgrain pattern, giving it greater slip resistance than smooth boards, and comes in 137mm wide x 23mm thick boards, in 5.4 metre lengths.

Flame Shield is designed to be fixed on joist centres up to 450mm and weighs 3.7kg per lineal metre (25kg/m²). It can be fastened using either screws or nails, and supports secret fixing. It is Global Green Tag certified and is designed and manufactured in Australia.

For more information, contact ModWood Technologies, ph: (03) 9357 8866, info@modwood.com.au, www.modwood.com.au.

12

Recycling for difficult waste

While we all try to recycle common waste like paper, glass and plastic containers, there are many other products that normally go to landfill as there is just no simple way to recycle them.

Terracycle provides a service whereby you ship these materials to them and they take care of the processing and recycling, turning them into useful things such as recycled plastic timber substitutes. You purchase a Zero Waste Box from Australia Post or Officeworks outlets and the cost of return shipping and recycling is included in the price of the box.

Items that can be recycled using Zero Waste Boxes include coffee capsules, snack wrappers, beard and hair nets, pens and markers, plastic gloves, office supplies and storage media, including CDs, DVDs, records, cassette tapes, floppy disks, memory sticks and even external hard drives.

The boxes are sized to suit businesses rather than individual households, although communities could also make use of this service, given enough waste material.

RRP: from $129 to $219 through Australia Post, depending on box size and targeted waste. A more limited range is available from Office Works at slightly lower prices. For more information contact Terracycle, ph: 1800 983 324, customersupport@terracycle.com.au, www.terracycle.com.au. Also see shop.auspost.com.au/pack-post/recycling-boxes and www.officeworks.com.au.

Comfortably ahead
A tale of two heaters

Turn on your air conditioner—and knock hundreds of dollars off your heating bill. Tim Forcey describes the learnings (and savings) gained from his experiment with reverse-cycle electric heating.

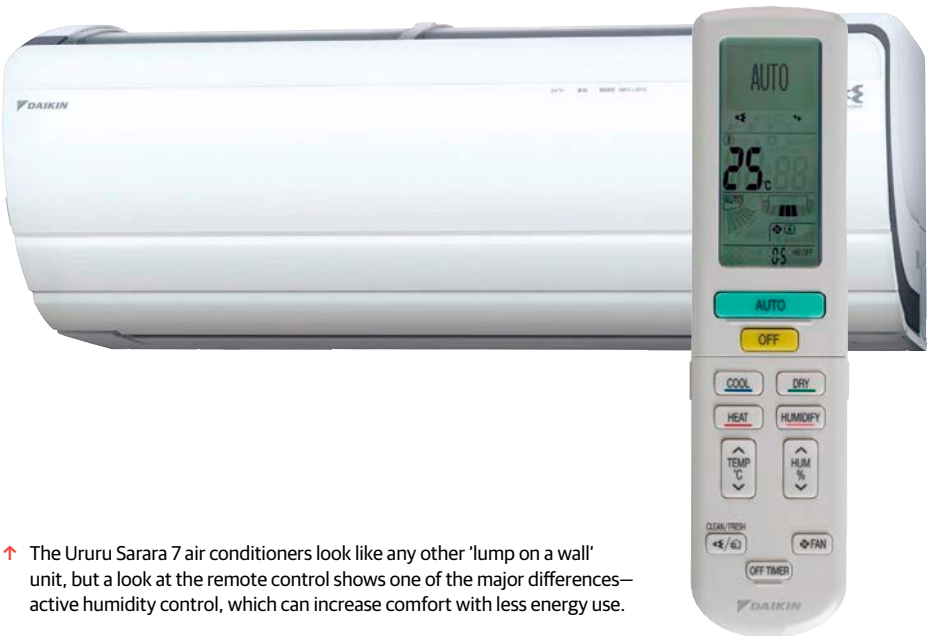
OVER the last 20 years my wife and I have raised a family in our 100-year-old Melbourne bayside weatherboard home. Last spring, following our third partial renovation, we installed two air conditioners in preparation for the hot summers to come—particularly so my wife and I could stay comfortable when working at home.

The two air conditioners we chose did just that, easily cooling our full ground-floor living space (128 m² consisting of seven rooms and a hallway). Based on advice from Matthew Wright (founder of www.pure-electric.com.au), we opted for two top-of-the-line Ururu Sararas (US7s) manufactured by Daikin: one small wall-mounted unit in our front bedroom (2.5 kW rated for cooling) and one medium unit (3.5 kW) in the lounge room.

The total US7 rated cooling capacity of 6 kW contrasts with a 14 kW multi-headed unit that the salesperson said we would need. So lesson number one: avoid the up-sell if your house is reasonably well-shaded and insulated (see box for more on sizing).

Come winter, I was keen to learn how these reverse-cycle units would compare with our 20-year-old ducted gas heater in terms of health, comfort, convenience and operating cost, particularly following on from research by Beyond Zero Emissions and the ATA (*ReNew*'s publisher) into the potential for economic and environmental benefits from going off gas.

My findings? There were pluses and minuses when comparing the two heating methods on comfort and convenience. But when it comes to cost, the reverse-cycle air conditioners beat ducted gas hands down—not only for our home, but possibly for hundreds of thousands of homes around Australia.



↑ The Ururu Sarara 7 air conditioners look like any other 'lump on a wall' unit, but a look at the remote control shows one of the major differences—active humidity control, which can increase comfort with less energy use.

Science—sort of—in the home

Starting in late June 2015 (mid-winter), I sought to heat our home on alternate days using the US7s and then ducted gas.

The US7s are heavily instrumented and can tell you the outdoor temperature, the indoor temperature, the indoor humidity and how much electrical energy they have consumed since you turned them on today, or since you installed them last year! Adding to this, I spread thermometers throughout our living areas. I also referred to our in-home electricity display that relays instantaneous electricity-use figures for our whole house from our smart electricity meter.

And for the first time in my life, often wearing a bathrobe and head torch, I journeyed out behind the bushes to the not-so-smart gas meter to diligently record gas usage.

I will not claim that this exercise was the best example of the scientific method we have seen. Variables and shortcomings had to be managed, such as failure to focus on the task-at-hand at 5.30 am before the morning coffee, Daikin's less-than-fully-illuminating owner's manual, and my co-occupants.

Ducted gas: reliable for years, but now at its use-by date

Our ducted gas system has served us reliably for 21 years. What Star rating our heater could have scored in the mid-1990s is unknown. Using figures taken from the owner's manual plus further measurements and calculations, I learned the unit might be 75% efficient at getting 18.8 kW of gas-combustion heat into

our under-floor ductwork. More efficient ducted gas heaters are on the market today such as those that use condensing technology.

Getting heat into the ductwork and then getting it into the house are two different things. Unfortunately, I can't readily inspect our underfloor ducting because of the tight crawl space, but our ducts are known to have been damaged by animals seeking a warm winter resting place. We managed to patch one hole when access was possible during a renovation. How well the ducts were insulated at day one and are now still insulated at day 7600 is probably summed up by the technical term "not that great". Still, hot air does emanate from each of the eight registers, so that is a plus. I can say as a part-time home energy consultant that this isn't true at every home!

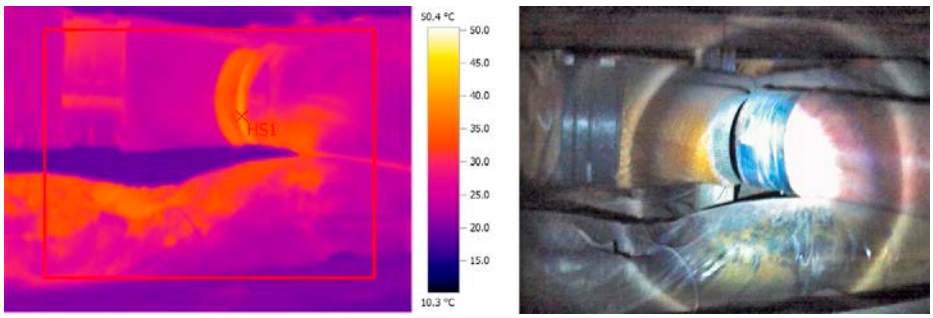
Our ground-floor living spaces are quite zone-able thanks to renovation features such as cavity sliding doors. However, the ducted gas system is designed to heat all 128 m² of our ground floor, whereas often my wife and I spend our waking at-home hours in the 52 m² represented by the kitchen, eating area and lounge room. Later in the evening, this is often reduced to the 18 m² of the lounge room.

So there are losses and inefficiencies all along the way with ducted gas. Only some of the heat of gas combustion makes it into the ducts. Only some of that heat makes it into the house and only some of that makes it to the vicinity of our bodies. It might be optimistic to assume that we only throw away only half of the gas we buy for space heating.

Fortunately our last two renovations included an emphasis on insulation, draughtproofing, double-glazing and thermal window treatments. In mid-winter, most days we use heating for three hours, and never after bedtime (though our usage can extend out to nine hours on days my wife and I work from home). This means we pay only about $500 per year for the gas energy used for space heating.

Still, throwing away half of the gas we purchase seems like a waste. And it's interesting to note that a ducted gas heating system also uses a significant amount of electricity, with our heater using a 300 watt blower to circulate air.

Thankfully, technology and changing economics mean that many Australians can now do better, especially if we happen to have a reverse-cycle air conditioner there on the wall, waiting to be used.



↑ The problem with ducts: Thermal and visual images of a client's crushed and separated underfloor gas heating ducts.

Goodbye gas, welcome to the era of electricity

You might think that Australia entered the era of electricity in the early 1900s. Well, we ain't seen nothing yet! Conversion to an all-electric home and transport is not only being practised by enthusiasts but may well be the cheapest way to go for many of us.

One of Daikin's contributions to this new electric era is the Ururu Sarara, or US7. The '7' refers to the fact that the 2.5 kW model is 7 Star, currently the only 7 Star air conditioner on the Australian market. The words Ururu ('wet' in Japanese) and Sarara ('dry') refer to the way that the US7 employs not only a refrigerant cycle (as do all heat pumps), but possibly the first residential use of a desiccant wheel.

A desiccant wheel is a way to add or remove humidity (water) from the circulating air, at low energy cost and independently of the desired room temperature. This is an advantage in summer when we may want to lower air humidity without driving the living space to uncomfortably cold temperatures. In winter, the US7 is able to maintain higher humidity levels than ducted gas can achieve, resulting in health and comfort benefits.

COP that!

As shown at the Australian government appliance rating website www.energyrating.gov.au, in heating mode the 2.5 kW US7 achieves a coefficient of performance (COP) of 5.8. This means that under test conditions, for every one unit of electricity used the device can deliver 5.8 units of heat. The extra 4.8 units of heat are collected as free energy from the air outside your home.

If a ducted gas system is only 50% efficient when it uses one energy unit of gas to deliver half a unit of heat, a 2.5 kW US7 is 580% efficient when it uses one energy unit of electricity to deliver 5.8 units of heat. So at this point in the comparison, the US7 leads ducted gas by a factor of 11.6 (580% vs 50%). Comparing the energy requirements of heat pumps versus ducted gas reminds me of the 'now-a-no-brainer' comparison we often make when considering halogen downlights and LEDs. Truly remarkable!

Note that the larger US7s have lower COPs: the 3.5 kW has a COP for heating of 5.05 and the 5 kW has a COP of 4.6—lower, but still much more efficient than gas. And, should you not own a US7, but rather a reverse-cycle air conditioner with a rating down toward 3 Stars, don't despair! Even a 3 Star unit achieves a COP of around 4 and may be eight times more efficient than ducted gas.

The dark art of sizing an air conditioner

The size of air conditioner you need will depend on your house design, layout and construction. If you have a house with good sealing, shading and insulation, you may find that you can choose a unit smaller than that suggested by installers, although their sizing tools may take insulation into account; for example, see the sizing calculator at www.fairair.com.au. Some experts suggest the standard sizing approach used by installers is based on lower/higher temperatures than needed, while others suggest that larger units may have advantages in faster startup times. If using a unit to cool more than one room, you may need to experiment. Tim Forcey recently found that his US7 was shutting down if they weren't in the room housing the system as it had a motion sensor, but he was able to fix that by increasing the timeout to three hours.

In fact, test-condition COPs may not fully express a heat pump's capabilities. Test conditions specify an outside air temperature of 7°C, so any time the outside air temperature is greater than 7°C, a heat pump may perform better than its rating. Likewise, when the outside air temperature is less than 7°C, it may do worse. During my testing, the outside temperature rarely reached as low as 7°C when heating was required. Further, if at any time a heat pump is not required to operate at its full output, the heat exchangers in the unit will essentially be oversized and COPs higher than the rated figure can be achieved.

It is also worth noting that our wall-mounted US7s involve no air-transporting ductwork. Refrigerant moves between the indoor and outdoor parts of the heat pumps by short lengths of small-diameter and well-insulated piping, thus minimising energy losses.

Comparing the power

As listed on the US7 specification sheet, at full power our US7s can deliver about twice as much heat as their rated capacities, for a total of about 16.5 kW (heating). This means that our two US7s can deliver almost as much heat as our ducted gas heater, and possibly more heat than comes out of our gas ducts into our living spaces.

Because of their heating capacity, our US7s quickly warm the rooms in which they are installed. However, it takes more time if we are trying to also heat adjoining rooms.

The price of energy

Historically in Australia, if one wanted to buy one unit of energy (e.g. a kilowatt hour or kWh), gas was far cheaper than electricity. That is changing as eastern Australia has joined the ranks of regions that export gas to Asia. Our wholesale gas prices are rising towards international benchmarks. The cheapest block of gas on our bill costs 1.61 cents per megajoule (MJ) or the equivalent of 5.8 c/kWh (including GST).

On the electricity side, under the Victorian flexible pricing scheme, Powershop sells me (not-green) electricity at prices ranging from 25 c/kWh during defined peak times (3 pm to 11 pm weekdays), 10 c/kWh for off-peak (11 pm to 7 am), and 14 c/kWh for shoulder (all other times). (Note: These gas and electricity prices are for energy only and exclude fixed or network delivery charges, but include GST.) To sum up, the electrical energy we buy from Powershop remains more expensive than gas, but only by factors ranging from 1.8 (using off-peak electricity) to 4.3 (peak).

People exporting excess solar power to the grid may have to consider an even greater range of electricity prices before turning on an electric heater. These might range from 'opportunity-lost-because-I'm-not-exporting' costs of 66 c/kWh for those on the Victorian premium feed-in tariff, to only 5 c/kWh for a very un-premium tariff. If 5 c/kWh is all you are paid for selling electricity into the grid, that electricity has become less valuable than gas and is very ripe for you to use in gas-displacing ways.

As it happens, our house faces north and winter solar heat is trapped by double-glazed windows. Thus, we never have to activate our heating system when the sun is shining and therefore our heating demands don't compete with our solar exports.

Combining the price disadvantage of electricity with the 11.6-times heat-pump efficiency advantage means that it is theoretically possible for me to use the smaller US7 at one-third to one-sixth the cost of ducted gas, depending on the time of day. For homeowners on the low solar feed-in tariffs, an efficient heat pump can possibly be operated at one-tenth the cost of gas.

Factors that might influence this equation are your geographical location and whether

Refrigerants and efficiency

There is a slow but steady move towards more eco-friendly refrigerants, ones with lower global warming potential (GWP). The Daikin US7 uses a hydrofluorocarbon (HFC) known as R32, with a GWP of 675. Compare that to the common older refrigerant R12, which was both ozone destroying and had a GWP of 10,900! Another common synthetic refrigerant, R410a (a mixture of R32 and R125) has a GWP of over 1700, so of the synthetics commonly used for domestic systems, R32 is a reasonable option.

The most efficient refrigerants theoretically are the natural refrigerants, including CO_2 and hydrocarbon mixes, and these also have much lower GWPs; for example, CO_2 has a GWP of 1. However, we are yet to see any domestic air conditioners that use CO_2 and the few that use hydrocarbons have efficiencies no better than HFC refrigerant models.

While you might think that the change to less destructive refrigerants might have a detrimental effect on heat pump efficiency, the opposite has in fact been the case. That's not because modern refrigerants are particularly more efficient, but rather because the type of refrigerant has less effect on efficiency than other aspects of system design.

For example, the move to variable-speed compressor motors, driven by computer-controlled inverter drives, has greatly improved the efficiency of the average heat pump. Indeed, electronic control of heat pump refrigeration systems is the single biggest efficiency improvement implemented in recent years. The use of electronic controls has also allowed for the use of electronic expansion valves, which can increase system efficiency several percent; they have a wider adjustment range than mechanical valves, so can operate over the wider range required by variable-speed compressors.

Electronic controls have also made heat pumps smarter, allowing them to throttle back when the unit has sensed that there is no one in the room, thus reducing energy consumption, ramping back up when people are again detected.

The design of the heat exchangers (called the evaporator and condenser) is also very important to heat pump system efficiency. The heat exchange surface areas and the resulting temperature differential between the refrigerant and the airflow directly affects the refrigerant operating pressures and hence the work required of the compressor in order to provide the required heating or cooling effect. The larger the heat exchanger, the lower the temperature differential and the greater the system efficiency.

Other factors that affect heat pump efficiency include the temperature differential between the heat source (outside air) and heat sink (inside air), as well as the suitability of the system and its refrigerant for the environmental conditions. Heat pumps required to work in very cold environments must be designed to operate in such conditions. If you live in Tasmania, for example, you would not buy a heat pump that can't operate below an outdoor temperature of 0 °C.

"Conversion to an all-electric home and transport is not only being practised by enthusiasts but may well be the cheapest way to go for many of us."

your system uses a crankcase heater; see box below. The US7 automatically turns off power to the outdoor unit when not in use, greatly reducing standby energy consumption.

The financial, comfort and convenience triple-bottom line

So with all my data recording, spreadsheeting, and generally making a nuisance of myself with fellow occupants, what did I discover?

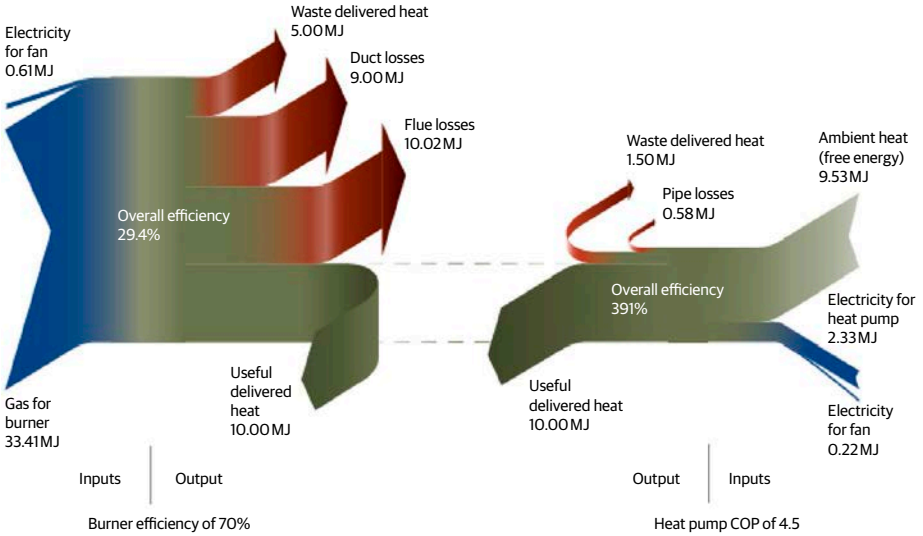
The mid-winter 'heat-up in the morning while getting ready to leave for work' operation can be done with the US7s for around an average of $0.30 (including GST). This varies with different overnight weather conditions and whether off-peak or shoulder electricity tariffs apply. Using ducted gas to heat up the house costs more than four times as much at around an average of $1.30. Across a full day, heating with the US7 costs around an average of $1.50 whereas ducted gas costs $4.80. Heating with electricity during the peak tariff hours of 3 to 11 pm is more costly than at other times, but still beats ducted gas.

During the trials I was able to achieve a similar level of heating comfort with either method. Regarding convenience, with a flick of the thermostat, the powerful ducted gas system heats up quickly across multiple hot air outlet registers in every room. On the other hand, using the lounge room US7 to warm up the kitchen can be done, but requires a half-hour head start using the in-built timer.

The morning startup of ducted gas sends unwelcome hot dry air whistling into our bedroom where someone might be seeking those last few moments of sleep ("Shut-off the gas!") So there are comfort and convenience trade-offs with either heating method.

I am still learning about all of the features available with the US7s whereas I have had 21 years to optimise the performance of our ducted gas. Features are now available from Daikin that use smartphone wifi/GPS gadgetry to activate your heater when you are travelling home and approach within, say, five kilometres of your house. (Possibly one can also find a way to do the same with a gas heater.)

Regarding humidity, comparing the US7 in heating mode versus in heating/humidity mode, we've found that the latter feels much nicer and warmer. This is something people have traditionally not liked about reverse-cycle heating (or any sort of heating for that matter) and Daikin has addressed this shortcoming.



↑ The Beyond Zero Emissions Zero Carbon Australia Buildings Plan comparison of the effectiveness of delivering 10 megajoules (MJ) of useful heat from an ageing ducted gas space-heating system (left) versus a modern wall-mounted (non-ducted) reverse-cycle heat pump air conditioner (right).

The future is electrified

In the future, we will be heating predominantly with electricity and knocking hundreds of dollars off our annual gas bill. Heat pump hot water is next, so the energy portion of our gas bill will become quite small. Unfortunately the fixed gas connection charge will remain until the day our home is completely gas-free. ✸

Tim Forcey trained as a chemical engineer and worked more than 30 years in the petrochemical, oil and gas industries for companies such as ExxonMobil and BHP Billiton. Tim now works part-time as an energy researcher at the University of Melbourne Energy Institute and also consults with Moreland Energy Foundation via Positive Charge. Tim volunteers with the ATA and other sustainability-focused organisations.

The author recognises the contribution of Alan Pears to this article.

Crankcase heater energy use

The crankcase heater is a small heating element that can draw up to 50 watts. It is used to keep the refrigerant from condensing into a liquid in the compressor and mixing with the crankcase oil, making it 'watery' and an ineffective lubricant.

The heater runs all the time when the unit is off, unless the ambient temperature exceeds a particular setpoint. In warmer climates, the heater may not run most of the time, but in colder climates it may run even during the warmer months. In the worst cases it may add more than 1kWh of daily energy consumption to your air conditioner's energy use—something that should be factored in when comparing costs.

When buying an air conditioner, it is worth finding out whether the proposed unit uses a crankcase heater and, if so, how often it is likely to run—you may have to contact the manufacturer for this information.

If your unit does use a crankcase heater then you can shut off power to the unit when not in use, provided that you turn the power back on at least 24 hours before you start the unit, to give the heater time to do its job and separate the refrigerant from the crankcase oil. Failure to allow adequate time for the heater to work results in damaged compressor bearings, resulting in reduced compressor life or even a burned out compressor. Also see letter this issue by Alan Pears on p. 14.

Small changes, big savings
Low-cost, carbon-neutral housing

You don't have to spend up big to get an environmentally friendly home. Glenn and Lee Robinson show us their clean, green cottage based on common-sense principles.

OUR aim was to build a home that was a lot more environmentally friendly than the average in Australia. So we did a bit of homework and found that it's surprisingly simple and economical to build a carbon-neutral house. This article describes what we learnt, how that information was turned into a building and how the house has performed now that we've lived in it for 12 months.

The most important discovery was that most of the techniques for creating a high-performance house cost little more than standard building practices. There are lots of small things in a building that, when done a bit differently, add up to a big difference in comfort and energy use (see our '20 guidelines' on the last page).

↑ This net-zero carbon cottage in Bundanoon, in the Southern Highlands of NSW, cost just $1480 per m² to build!

Finding the right design

Our goal was to minimise dependence on energy from unsustainable sources and create a comfortable, affordable home suitable for occupancy through all stages of life.

We began the design process by making a list of what did and didn't work in all the buildings we were familiar with, listing the features we would like to incorporate. We set a performance standard of net-zero carbon emissions and a budget of just $250,000 for the complete project, including house, garage and landscaping.

We looked at the options available with local builders, project home companies, prefabs and kit homes but found nothing that came near our specifications. A few prefab companies in Victoria could meet our performance spec but freight costs pushed the price above our budget. The one 'net-zero' project home available fell short in the performance stakes. The options were disappointing, but, in a country with the world's highest per capita carbon emissions, perhaps not surprising.

By default we were left with the only viable option being owner-building, which has ended up working out well. We started out by looking at the history of efficient buildings and which techniques and ideas have stood the test of time, and which haven't. We really wanted to see if we could avoid over-complication in the design so we researched low-tech ideas that have been proven to work.

We found a lot of good ideas in the layouts of Earthship buildings. They often have excellent room arrangements for maximum sun penetration, but we weren't fans of all their design principles as they require huge amounts of labour to construct and can overheat and leak.

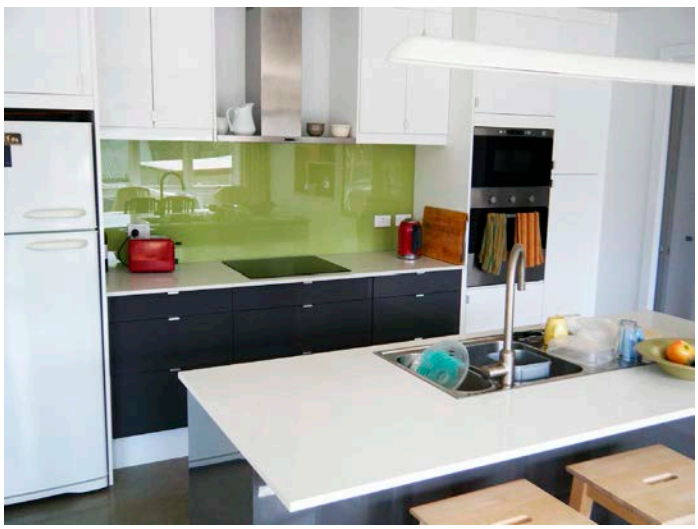
An excellent resource is the website Build It Solar (www.builditsolar.com), where we found the Montague Urban Homestead, winner of the Massachusetts Zero Energy Challenge. We looked far and wide at hundreds of designs and, to us, this was the most elegantly simple, high-performance, economical design. We used this as the basis of our design, but de-tuned it to match our climate and rearranged the layout to suit our needs.

Many building decisions

Our final design was a single-storey detached dwelling of 108 m² with two bedrooms and one bathroom with a separate toilet. There is an adjacent carport/storeroom of 60 m².

"There are lots of small things in a building that when done a bit differently add up to a big difference in comfort and energy use."

↑ Classic passive solar design sees the sun warm the interior during winter but be excluded in summer.



→ The kitchen is a simple, clean ergonomic design, with walkways designed according to liveability guidelines and an induction cooktop for reduced energy use.

Structures were arranged to allow future addition of a 60m² studio/granny flat on the 900m² property (which has since been built).

ROOF

We went with a 25° pitched gable roof. A trussed gable roof was selected as the optimum form as it uses minimal resources (no heavy beams), and provides a dead air space to aid insulation, a service access for the length of the building, a north slope to mount solar collectors and a south slope to stream cold southerlies over the building. It also does not suffer the moisture problems that are common with skillion roofs and allows easy long-term maintenance of the ceiling insulation. Eave overhang means we are not totally reliant on window flashings to shed water. Insulation consists of R1.5 anticon blanket under the metal roofing and R3.5 batts on the ceiling.

A 25° pitch was used as it gives the highest annual output from the photovoltaic array, drains well but is not too steep to walk on and doesn't need raised brackets for solar collectors. The colour is Colorbond Shale Grey which is the lightest colour we were permitted to use in seeking maximum heat reflection. Bargeboards and guttering are all Colorbond-coated to minimise maintenance.

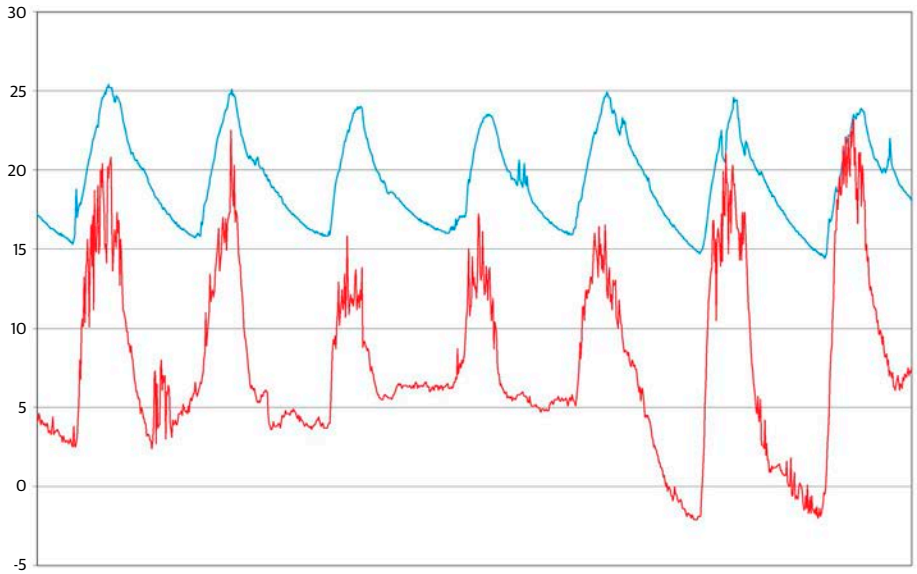
WALLS

We used 90mm stud walling with studs at 600mm centres. We tried to minimise the number of studs as the insulation level drops to R0.5 at each stud. We investigated using the American advanced stud walling technique to further reduce the number of studs, but framing companies here were unfamiliar with the system and it would have added 60% to the frame price. Insulation is R2 batts and reflective breathable sarking.

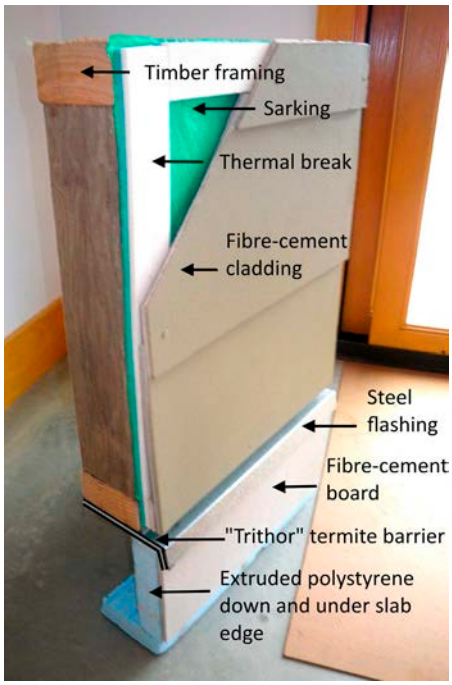
The outer cladding uses HardiePlank weatherboards. We looked at many walling systems and decided that none could compare to the HardiePlank boards for installation speed, cost and durability.

Timber weatherboards require preservative and paint applied to every cut (time consuming) and they are expensive, plus they burn. Mud brick is slow, hard work and offers poor insulation, ditto for stone. Strawbale is labour-intensive and the thick walls limit light penetration, so you need bigger windows. We couldn't see the need for R8 walls as most heat loss is through roof and windows, and you end up using extra roof and floor materials to house the overly thick walls.

Brick veneer needs extra footings to hold up the heavy, high embodied energy walls and, being on the outside, they have limited benefit as thermal mass. Reverse brick veneer was considered but we decided the energy involved in adding vertical thermal mass could not be justified for the small increase in thermal stability it would provide. We also looked at structural insulated panels (SIPs), but planning the services got complicated, and we were concerned that the panels might be hard to match if future modification of the building was required.



↑ Inside versus outside temperatures for a week in July. No auxiliary heating was used as the weather was mostly clear. If you look closely you can see the temperature increase when the owners came home and started cooking.



↑ A mockup of the wall construction materials showing the various components.

The HardiePlank cellulose fibre and cement boards cost just $13.60 per 4.2 metre length, are easy to cut with a hand guillotine and don't rot or burn. Working with an experienced carpenter they go up really fast.

WINDOWS AND DOORS

We used Stegbar Siteline windows, with Auralast non-toxic treated pine frames with an exterior Colorbond-coated aluminium skin. Opening windows have a double rubber seal. Glazing is two layers of 4mm glass with a 12mm argon-charged gap. A low-e coating is applied to the exterior face of the inside pane. The final window specs are U<2.5 and SHGC>0.5.

All windows are casement opening; no sliding or double-hung units were used as, in our experience, they don't seal well as they age. North window area was kept under 20% of the floor area to prevent overheating and reduce night heat loss. There are small openable windows to the south for ventilation, no west glazing and a small amount of fixed glass to the east. No clerestory windows or skylights were employed as night heat loss of these elements exceeds daytime gain.

The window frames are painted a pale colour to maximise the light reflected into the room. All windows are insulated at night with a double layer of curtains. The building design allows curtains to be drawn clear of the windows during the day.

FOOTINGS/FLOOR

The concrete slab is a conventional reinforced raft structure 100mm thick. No fixed internal floor coverings are used so internal air can couple with the thermal mass of the slab. As the slab is exposed, 32MPa grade concrete was used for hardness, and reinforcing mesh bars at 100mm centres were used to minimise cosmetic cracking. A 50mm layer of foam insulation is fitted to the slab perimeter and protected by a metal flashing—this gives an R2 slab. Under-slab insulation was investigated but we decided it was unnecessary in our climate zone (climate zone 7, cool temperate) provided the under-slab area stays dry and can temperature stabilise. This seems to be working as the house is performing even better in its second winter and the only explanation we have is that as time has elapsed since construction the ground under the house is drier and drawing less heat from the house.

ENERGY AND LIVEABILITY SYSTEMS

All lighting is LED and no downlights are used to avoid interruptions to ceiling insulation. Many houses halve the effectiveness of ceiling insulation by the voids created around downlights.

All exhaust systems are shuttered so the building is sealed when fans are off. The ceiling trapdoor is insulated and sealed with a rubber gasket. A maintenance walkway extends for the length of the roof space. The truss bracing was designed for this.

We installed a 22-tube evacuated-tube solar hot water system plumbed to a 250L foam insulated tank centrally located between the bathroom, kitchen and laundry. We avoided a roof-mounted tank as there are losses between the tank and outlets in such systems—we placed the tank indoors as close to outlets as possible. The tank has a mid-level electric booster element so that when we get a few overcast days in a row we only need to warm the top portion of the tank. Interestingly, since we built, the Beyond Zero Emissions study on domestic water heating advises that, over a 12-month cycle, a heat pump water heater would use less electricity.

Space heating is with a Daikin reverse-cycle air conditioner, model RX535LVMA. It's an

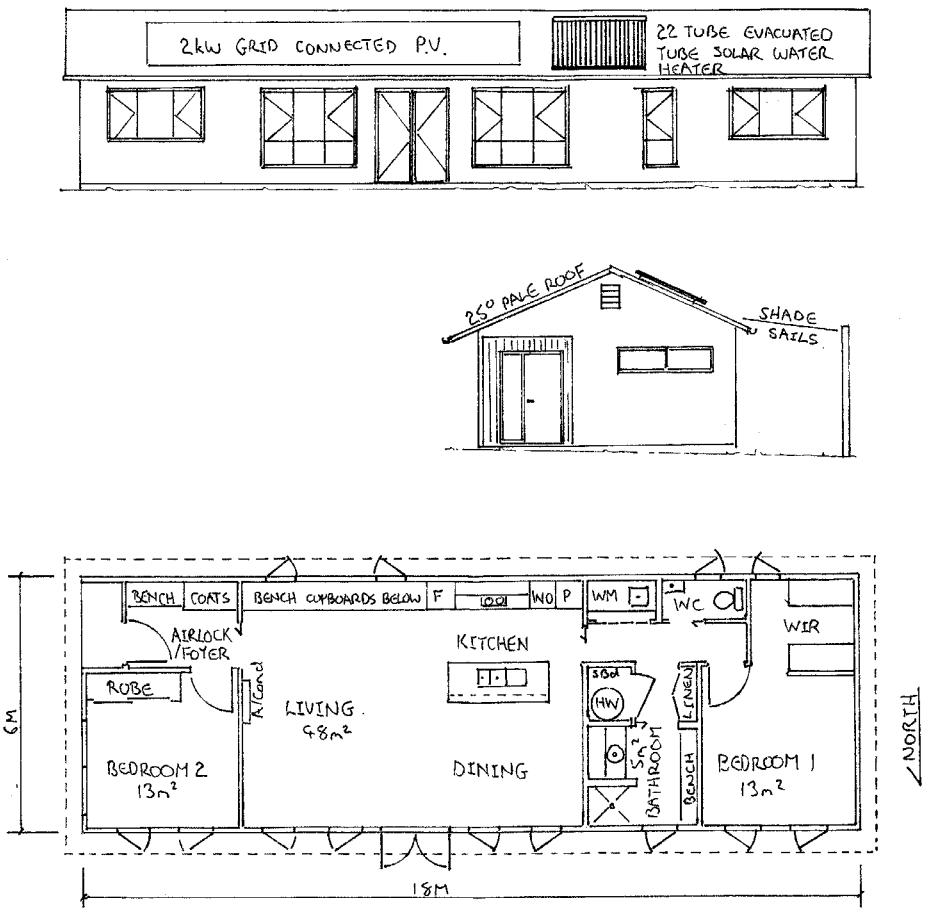
↑ The slab insulation, before pouring of the slab.

"Keeping the ceiling to minimum height has been a great contributor to efficiency, as we don't need to heat air that we aren't actually walking around in."

awesome bit of gear, with a heating coefficient of performance of 4.55. That means for only 0.88 kWh of electrical energy in we get 4 kWh of heat energy out. We located the condenser (outdoor part of the unit) to catch the early morning sun and improve performance early in the day, but as yet we have not needed it in the morning. Keeping the ceiling to minimum height has been a great contributor to efficiency, as we don't need to heat air that we aren't actually walking around in. Getting this wrong, along with poor building sealing, seem to be the most common thermal shortcomings of Australian buildings.

Cooking is with an induction cooktop, which uses considerably less energy than a standard electric cooktop. It also doesn't produce fumes, unlike gas, and it heats up really fast. For oven cooking we generally use a microwave and finish off in our fan-forced electric oven.

Water for the laundry and toilet flushing is from a 10,000 L above-ground rainwater tank. We avoided an automatic rain switch (to change over to town water when the tank is empty) as they don't seem that reliable



↑ The house layout is simple and effective with no wasted space in hallways. There are minimal windows on east, south and west walls. The heavily windowed north wall is designed to make best use of the incoming winter sun.

Lee and Glenn's guidelines

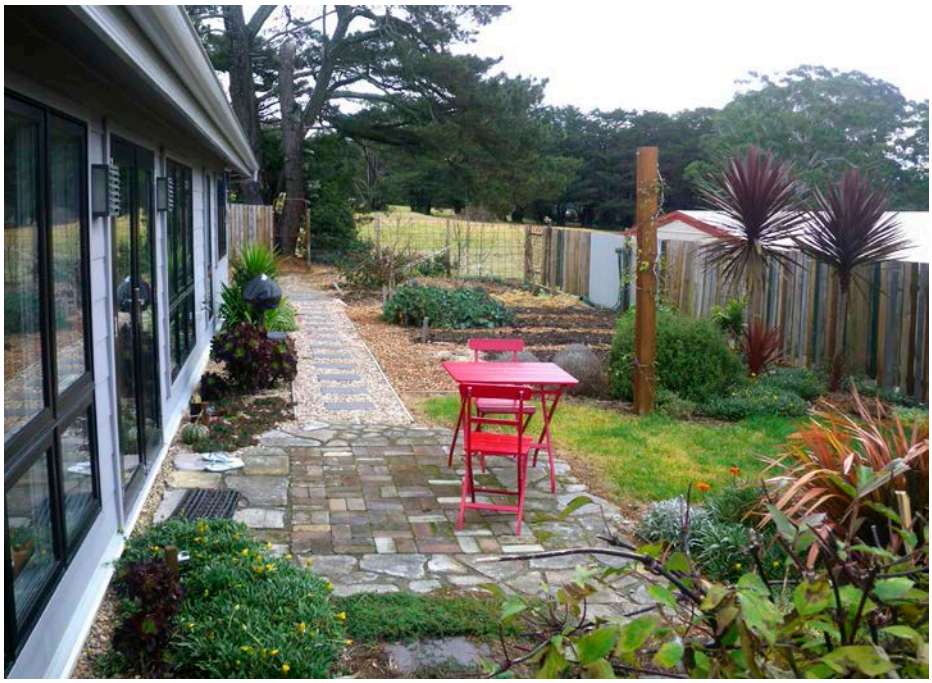
We developed a set of 20 guidelines that we used to design a home to fit our sustainability requirements and budget.

1. Get involved in the design and construction process. We were unable to find off-the-shelf inexpensive options that performed as well as our simple house. Our design cost $1480/m²—to get a similar performance and level of finish from prefabs or specialised builders costs over $3000/m².
2. Use simple, standard, readily available, quickly erected materials.
3. Make your house as small as is practical.
4. Build a simple east-west rectangle.
5. Select a site with all-day solar access.
6. Get winter sun into every habitable room all day.
7. Put most of your glazing on the north.
8. Arrange eaves to shade glazing in summer.
9. Have no west glazing.
10. Use zoned building design, with living areas in the heated zone and thermal isolation from entry and sleeping zones.
11. Keep to one level if possible; it's hard to create even temperatures otherwise.
12. Locate storage along the south wall to act as extra insulation.
13. Keep ceilings as low as is legally allowed so heat is kept where the bodies are.
14. Build on a slab and have no fixed floor coverings.
15. Avoid using sliding windows or exterior sliding doors .
16. Don't use downlights.
17. Seal the house well.
18. Use pale exterior colours, especially for the roof.
19. Face the entrance away from prevailing winds.
20. Design in 600 mm increments to minimise material waste.

Other cost-neutral techniques

We also employed four other approaches that added to our upfront costs but will pay for themselves in the long run.

1. Insulate to suit the climate zone. This allows you to buy smaller heating equipment and use it less often.
2. Use high-performance windows to address the greatest area of heat loss. Standard aluminium sliders would have cost $8000; we chose to pay $19,000 for good quality units to save energy and improve comfort and resale value. Canberra now has energy ratings on house-sale contracts and we believe it will come to NSW soon, impacting property values.
3. Use LED lighting. Watch out, there is a lot of rubbish on the market.
4. Use solar-powered water heating and electricity generation.



↑ North-side patio with vegie gardens in the background.

As-built costing

Preliminaries	$1,489
Labour	$14,545
Excavation	$5,485
Concreting	$7,500
Frame supply	$8,402
Tile work	$4,324
Windows	$19,400
Roofing	$10,973
Lining, insulation	$9,675
Fitout materials	$18,450
Plumbing	$14,000
Water heater	$3,509
Water pump	$569
Electrical	$5,922
Solar PV	$4,185
Air conditioning	$1,975
Miscellaneous	$1,851
Total	**$132,254**
Cost /m² (exc Glenn's labour)	**$1,225**

and we wanted to keep the house simple. We installed a manual mains water filler in case the tanks run low.

All taps, shower and toilet are 4 Star efficiency rated. The dishwasher and washing machine are water- and energy-efficient Asko units, though we mostly wash up by hand unless doing a lot of cooking. The kitchen is located at the centre of the house for best access and is of galley design to eliminate hard-to-access corner cupboards.

We installed a 2 kW grid-connected solar PV array. Over 12 months this has exported almost twice the amount of energy we've imported, even in our all-electric house. We would be interested to know if this has been achieved elsewhere in a house with two occupants—i.e. being carbon neutral with less than 1 kW of PV per person.

The barbecue and lawnmower are both electrically powered. It is nice to mow using sun harnessed off the roof instead of oil transported all the way from the Middle East. It's also much quieter.

Indoor storage cupboards were built along the south wall to add insulation to the coldest face of the building.

The site had a north slope so we sank the building into the ground to reduce wind exposure and provide a level entry to the north. We are also fortunate to have a neighbouring hedge giving extra protection to the south.

The building's wind rating was raised from N1 to N2 to prepare for increased strong winds in the future. Non-combustible exterior materials were also selected in anticipation of increased bushfires in the future.

Low-VOC paints were used throughout, with the exception of the floor as we wanted a super-durable finish.

Project costs

The breakdown of building costs can be seen above. Adding a cost for Glenn's labour brings the house cost to around $160,000, or $1480/m². The land cost $150,000.

The complete project costed after 12 months with garage, fencing, driveway and gardens came to $198,600. This includes about $4000 extra to connect services such as sewer, water, phone and power due to the building's long setback from the street (to leave room for a future granny flat closer to the street, now built).

Things we could have done better

If doing it again we would replace four of the opening windows on the north facade with fixed glass as they are not needed. We'd also use extruded rather than expanded foam for slab insulation as it's tougher, and we'd install a 12 mm synthetic thermal break on the outside of studwork as this is a cheap way to boost wall insulation.

We also have a wishlist of changes to the building industry in general so we can stop being the slackest western nation on earth. The first would be to match England in requiring all new homes to be Net Zero by 2015—fairly simple in our climate. We'd also like to see stronger regulations enforcing legal access to sunlight: currently there is little to deter vegetative shading of PV panels.

As a society, we also need to do more to demonstrate and value the reduction in energy use that comes with sustainable building. One way to do this would be to require that energy bills, perhaps over two years, be attached to house sale contracts. This would include all energy use—electricity, town gas, firewood, BBQ propane, mower petrol etc. That way, prospective purchasers could see the true operational costs of a property. ✸

Lee Robinson is a fitness trainer specialising in helping elderly and disabled clients,which makes her aware of the ways that buildings can help or hinder those with disabilities. Glenn is a non-practising electrician who runs the local YHA hostel. He is passionate about preserving what remains of the earth's resources and creating the best future he can for his grandchild.

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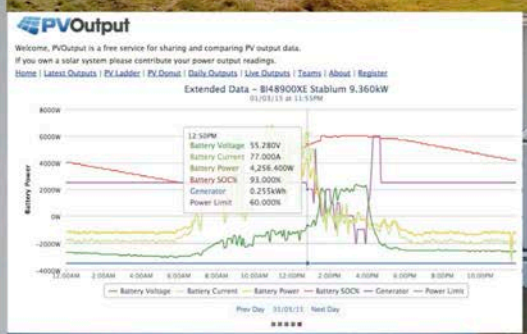

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Up to standard
Passive House in Australia

Designing and building your house to the Passive House Standard in Australia is now a viable option. Architect Fergal White visits a certified Passive House home in Canberra to see the house in action and hear its story from owner and designer Harley Truong.

↑ Harley's Passive House, front (north-facing) elevation. Harley built two almost-identical three-bedroom homes on the 1020 m² site, each optimised for passive solar gains.

Passive House Standard

The Passive House Standard (also known as Passivhaus) is an international energy-use standard that requires a house annually use no more than 46 kWh/m² of electrical energy in total, and have no more than 15 kWh/m² of heating and cooling energy demand, while maintaining a constant temperature of 20 °C in each room. The building must be airtight and have minimal thermal bridges. The energy and performance requirements are the same regardless of climate, but the method to achieve them will differ depending on climate.

I APPROACHED Harley Truong's Passive House in Canberra knowing that this freezing cloudy July day would be a real test of the house's certification. Stepping inside, the building was beautifully warm, with no heating system in use. Truly impressive!

The Passive House Standard dictates (low) maximum energy usage per square metre, both overall and for heating and cooling (see box). It does this by specifying a well-insulated envelope and airtightness that is perhaps unprecedented in Australia, where the building code doesn't stipulate any level at all.

There are now six certified Passive Houses in Australia, with many more under construction. But that wasn't the case in 2013 when Harley Truong embarked on his own build, so he made remarkable use of the internet to find his way to successful certification.

Renovation attempt

His family's journey to find a better way of living began with an attempt to renovate their 40-year-old home in Canberra. The house was draughty with cold floors, constant use of ducted gas heating and mould growing on the windows from condensation, all issues that were affecting the family's health and bills. Winter bills were often as high as $600 per month.

Harley attempted to thermally improve the house but to little effect. Replacing steel-framed single glazing with double-glazed windows (non thermally broken aluminium) and adding curtains made the condensation worse. Locating a whirlybird on the roof pulled heated internal air through the 30 ceiling downlight holes into the attic. Harley says, "I slowly realised that the home was almost the perfect inverse to what a passive solar designed house should be. It had the main glazed living areas facing south, minimal insulation, high air leakage and no thermal mass."

So when a large corner site (1020 m²) with no overshadowing came up for sale just down the road, Harley bought it almost instantly. The decision was also quickly made to knock down the poorly sited house on the block, and build two homes, one to live in, and one as an investment property.

Coming around to Passive House

Harley came around slowly to building to a Passive House design. Initially, as perhaps many people feel, he dismissed it as a European-specific standard, not suitable to Australia's milder climate. However, the targets of low energy use, particularly for heating and cooling, were exactly what he wanted after his family's experience in their previous home.

He became aware that the Passive House standard uses site-specific climate data and so

↑ Avoiding thermal bridges in the roofing panels—roofer pictured inserting sawcut gap between internal ceiling and external soffit to obstruct passage for heat conductance.

↑ Blower door testing ascertains envelope airtightness by sucking internal air out through the door and testing for any air infiltration into the building through gaps.

can work in any location. He also found what he calls a "treasure trove" of freely available information online. "I realised that with all the designs and information available, I could design and build the houses myself," he says.

After coming up with a basic house design, Harley worked with a local architecture firm in Canberra to develop the design for council submission. The two 140 m², three-bedroom houses are mirror images of each other and are deliberately compact to minimise external wall area for heat loss and gain, and reduce material use and waste. Entry is from the north into an open-plan living/dining/kitchen, with an east-west corridor separating north-facing bedrooms from south-facing utility rooms. The majority of glazing is to the north where the higher sun angle is easier to shade. Small windows to the south provide daylight to utility rooms and cross-ventilation for summer cooling. There's just one small window on the east and west sides as the low sun angles are difficult to shade. A mechanical ventilation system pulls in air from the north and exhausts it to the south.

A crash course in construction drawing

Once council permission had been granted, Harley, an electrical/mechanical engineer by training, decided to take over the detailed design himself, including preparing the construction drawings. Harley believed that a clear set of construction drawings that detailed every building junction, especially the non-standard ones, would be key to the project's success. "I found the information to do this on the internet," says Harley, "but it was certainly interesting with no training!"

The first step was to take four months leave from his job to work full-time on the project. He taught himself to use Google Sketchup for drafting, the Passive House Planning Package software for all building calculations and the Therm software package to ensure that building junctions didn't contain any thermal bridging.

It ended up taking a year to complete the documentation—it was a big challenge—but Harley is pleased with the control it gave him over the design and construction details. A further unorthodox step was that Harley completed the construction drawings prior to appointing a structural engineer. But he was lucky: he found an engineer who was interested in the standard and was 'old school', calculating all necessary details to achieve structural strength from first principles.

Harley used the Passive House Planning Package to determine the required insulation levels for the external building envelope, based on local climate data (Passive House verified). He found the requirements were much lower than the classic European Passive House examples he'd seen online.

The Passive House standard also specifies no thermal bridging. Meeting this requirement involves establishing an insulation layer around the building, including the floor slab, so that the interior of the house is completely isolated from the exterior (not unlike in a Thermos flask). It is because of this sealing that a mechanical ventilation system is required (see *ReNew 127* for more on these systems).

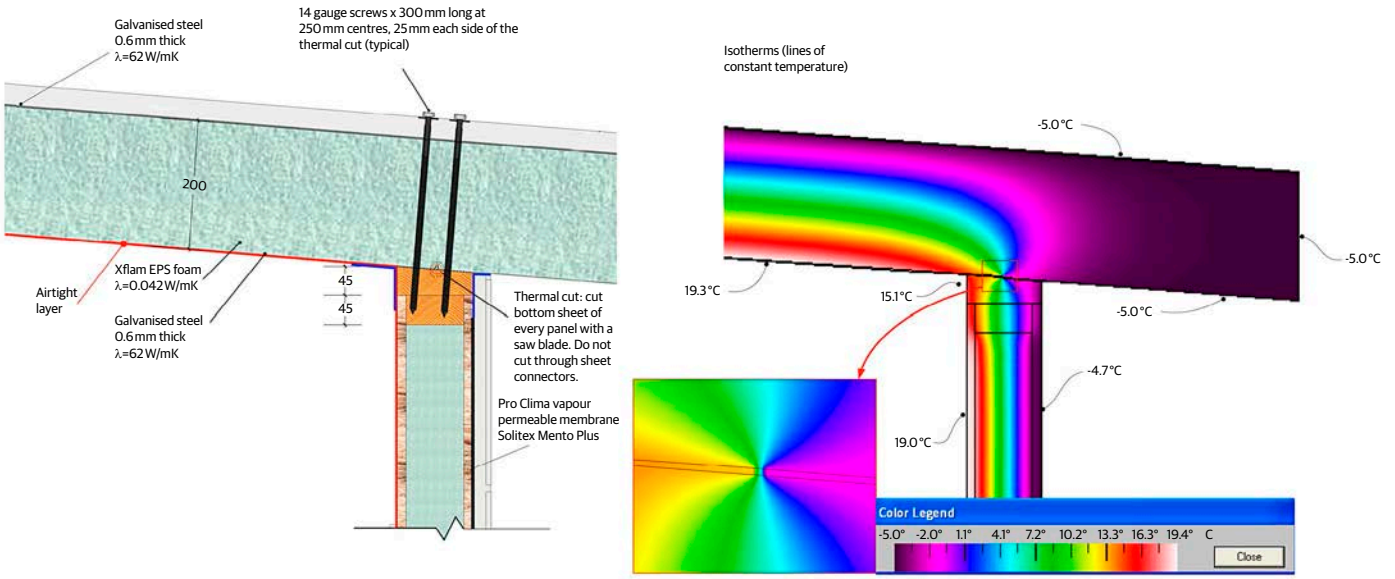
Harley used under-slab insulation, SIPs (structural insulated panels) for his external walls and sandwich roofing panels. As the roof panels have a continuous bottom metal surface that runs from internal (ceiling) to external (soffit), a thermal break, in the form of a continuous sawcut, was required to avoid thermal bridging (a tip Harley picked up from watching roofing videos on YouTube).

Harley made material choices based on thermal values and ease of assembly, with all knowledge gleaned from his research.

He ended up importing German uPVC double-glazed windows which use a double airtight seal, not unlike a car door. "At the time I couldn't find an Australian-designed window or door that would achieve the airtightness required," Harley says. He notes, however, that there are now local window manufacturers making airtight windows in timber and uPVC at competitive prices.

A smooth build

After a year of preparing the construction documents, Harley approached three builders for a fixed price quotation. The response was varied. The first contractor, a high-end builder, had a look but didn't want to make a bid. The second builder, with green building experience, put in a high bid. In the end,



↑ Sample of construction drawings showing instructions and isotherms. It is critical to make sure that no heat is escaping in winter or infiltrating in summer through the continuous insulation layer around the building.

Harley went with a third builder who didn't give a price immediately, but wanted to talk with Harley about every single aspect of the job, including how the contract would be structured. As with the structural engineer, Harley was impressed with the 'Let's see how we can make this work for you' attitude. This builder had also previously worked on a project where airtightness was a critical factor.

Harley ended up taking on much of the risk of meeting Passive House certification. In the three months prior to starting construction, Harley held weekly meetings with the builder to discuss the building details and interview all the tradespeople.

Harley says the eight-month construction went very smoothly. He worked part time during this time (four hours of labouring/resolving issues on-site and four hours at his workplace), and he attributes the project's success to having all the key decision-makers on-site every day in close communication.

Of all the Passive House requirements, Harley found that airtightness was the one least understood by tradespeople and general contractors. The Australian building code does not require a particular performance level, so not many builders know about it or prioritise it. As this is a mandatory Passive House performance requirement, Harley bought his own 'blower door' testing kit and tested both houses three times: when they were first sealed up, prior to plasterboarding and upon completion. "Failing the air-tightness test was my greatest fear," he says. Consequently he "over-engineered", using over one kilometre of airtight tape. Harley found the quickest way to detect an air leak was to use the back of his hand with his eyes closed!

A certified joy to live in

There were no Australian Passive House certifiers available at the time so Harley arranged certification online with a certifier from Canada. Certification relies on performance tests, software calculations and photographic evidence. Without any preliminary checks during the build, certification took four months, longer than Harley had hoped (several weeks would be a more typical length for certification), but was eventually granted in 2015.

The result is a house that's "a joy to live in". Harley says, "We're not the type of people who tough it out when it gets cold or hot—we like to be comfortable without having to rug up—but we have not needed to use heating or cooling during the first 12 months living here."

The whole family has developed a heightened awareness of passive solar design. "It's wonderful," Harley says, "how the moment the low winter sun shines through the windows it's like a heating system being turned on." The ventilation system is completely silent and the air in the house is very still. Harley describes the warmth of the house as "being everywhere" with all surfaces and areas having the same temperature.

On nice spring and autumn days, the family leave the windows open to enjoy the outdoor temperature. Natural night-time ventilation, by opening windows and doors, is the best way to cool the house down in summer in Canberra, where night temperature are much cooler. This concept is encouraged in the Passive House standard and allowed for in the calculations with windows and doors located strategically to maximise cross ventilation.

A testament to the house is the improved health of the family along with their lower annual energy bills, down to around $1000 (from $3500) thanks to their new energy-efficient home. ✱

Fergal White (fergal@pidcock.com.au) is an architect specialising in Passive House and sustainable design. He is an associate director with Pidcock–Architecture + Sustainability and a member of the Australian Passive House Association.

For more details on Passive House, see the Australian Passive House Association at passivehouseaustralia.org.

Lessons learnt

For anyone thinking about building a new Passive House home, these are some pointers from Harley:

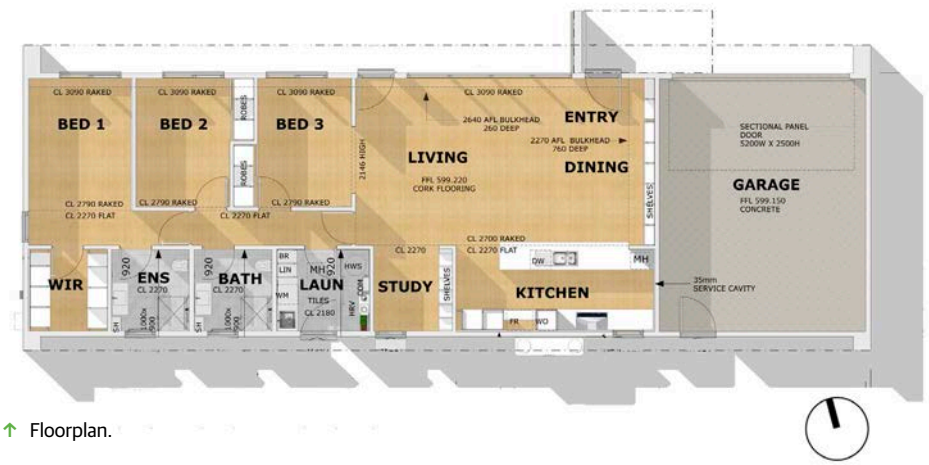
- It is not as expensive as you think: the cost per house was around $460,000, including garages, or $415,000 excluding them, giving around $3000/m² assuming 140 m² size, compared to around $3500–$4500/m² for a standard custom-designed house. This cost doesn't include Harley's labour, but with increasing availability of Passive House products and experienced builders/architects, the cost premium is likely to reduce over time.
- Choose your architect and builder carefully, to ensure they have knowledge of and (preferably) experience with Passive House.
- Appoint a Passive House certifier at the detailed design stage to avoid delays or issues later.
- Use conventional building methods where possible as this will involve less perception of risk for a builder.
- Be mindful of airtightness during construction and perform tests at progressive stages of sealing the house.
- Select materials with independent testing results. The International Passive House Association certifies materials, but most are not available in Australia, so thorough research is needed.
- If you can afford to splash out on just one item, spend your money on high-quality, European-standard windows and doors.
- If the Passive House Planning Package specifies heating/cooling requirements, install inexpensive post-heaters/coolers for the ventilation air; you may not use them but they are a fallback.
- Have fun!

Is Passive House applicable in warmer parts of Australia?

One of the questions that many people ask when considering Passive House is whether it's applicable to the warmer climates in Australia.

Fergal White, the author of this article and a Passive House architect, says the Passive House low-energy standard is achievable in both the warmer and cooler climates of Australia. He says that research has been conducted, based on completed projects, to verify that Passive House buildings can suit a wide range of climates, and that there are many successful Passive Houses in warm climates including Spain, Indonesia and Mexico. Fergal is currently conducting research into what adjustments would be required for Harley's house to meet the standard in Darwin, Alice Springs, Sydney and Melbourne; his preliminary results indicate that the thermal adjustments for the Canberra building envelope are minimal for all locations except the desert climate of Alice Springs which would require higher R-values with this particular design.

Fergal believes a particular strength of the standard is that it is performance-based and covers all operational energy in the house. He says although draught sealing is integral to the standard, the house can still be opened up to allow for cooling breezes. It will be interesting to follow up more on Fergal's research in a later issue.



↑ Floorplan.

House specs

Treated floor area of each house: 127 m² (140 m² using Australian (external) method of measuring).

Passive solar principles: north-facing living areas, south-facing utility rooms with windows/doors positioned for cross-flow ventilation. Tiled on-ground floor slab providing thermal mass.

Passive House data: Airtightness 0.11 ACH @ 50 Pa, annual heating demand 15 kWh/(m²a), heating load 15 W/m².

Insulation: Underslab R 4.7 TYCO extruded polystyrene, wall R 3.4 Ozone SIP panel, roof R 5 Askin sandwich panel with XFlam foam.

Windows and doors: glazing—Saint Gobain Planitherm Climaplus Ultra N 6/16Ar/6LE g-Value 0.61 (similar to SHCG), Ug Value = 1.14 W/(m²K). Frame—Inoutic Elite uPVC.

Mechanical ventilation with heat recovery: Zehnder ComfoAir200.

Hot water system: Sanden Eco heat pump.

Airtightness layer: Pro Clima Intello Plus wrap with Tescon Vana airtightness tape.

Credits

Building designer and Passive House calculations: Harley Truong

Architect: Andrew Verri

Structural engineer: John Skurr Consulting Engineers

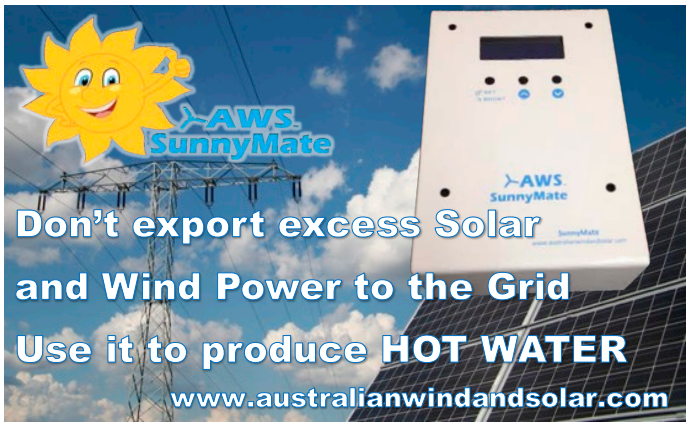
Builder: RJ Building ACT Pty Ltd—Richard Philippa and Jorg Staufenbiel

Mechanical ventilation supplier: Air2Energy.

Window supplier: Sustainable Building Resources

Air pressurisation tester: AJP Engineering

Passive House certifier: Peel Passivhaus Consulting, Canada.



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Waste not, want not
A recycling round-up

Lance Turner considers the evolving recycling options for some of the common technologies in households: solar panels, lights and batteries.

Solar panel recycling

Up until recently there have been no official schemes for recycling solar panels in Australia. However, as the number of broken and otherwise failed panels begins to grow, so has the need for recycling.

But how much solar panel waste is there at present, and what are we looking at down the track when the current explosion of solar panel installations come to the end of their working life?

Although figures are hard to come by, one typical example is that of Japan, which has seen considerable growth in PV installations in recent years. According to the Japanese Ministry of the Environment, by 2040 770,000 tonnes of solar panels will need to be recycled. The ministry has stated that, in conjunction with the Ministry of Economy, Trade and Industry (METI) and industry organisations, it will begin to implement measures for "removal, transportation and processing of solar power generation equipment" before the end of this fiscal year, in March 2016 (from www.bit.ly/1PwRFfC).

In Europe, requirements have already been added to the Waste Electrical and Electronic Equipment (WEEE) directive, bringing in a take-back and recycling scheme to deal with solar panel waste. The program, PV Cycle (www.pvcycle.org), provides fixed collection points, collection services for large quantities, and collection via distributors.

The WEEE directive means that solar panel manufacturers not only have to ensure collection and recycling of their products when they have reached their end of life, they will also be required to ensure the financial future of PV waste management.

Image: pvcycle.org

↑ Old PV panels contain large quantities of valuable materials such as aluminium, silver, tin and glass.

Looking at Australia, there is currently (as of March 2015) 4.1GW of installed capacity of solar PV. Assuming around 250 watts per panel (a common size), that's around 16 million solar panels. With an approximate weight of 18kg per panel, you are looking at 288,000 tonnes of solar panels, or around 11,500 tonnes per year (assuming a lifespan of 25 years) needing to be recycled. Of course, many PV panels will have a greater lifespan, while other, lesser quality panels will die sooner, so these figures are really just ballpark.

Regardless, that's a great deal of materials needing to be recycled, most of which is glass, silicon cells (a glass-like material) and aluminium.

Aluminium framing is easily recycled in existing aluminium smelters. However, without a system of collection, transportation and dismantling of solar panels, these materials are currently going to waste, usually ending up in landfill.

But things are changing, with both Canadian Solar Australia (www.canadiansolar.com/au) and Yingli Solar (www.yinglisolar.com/au) recently announcing that they are teaming up with Reclaim PV Recycling (which started in 2014, see www.reclaimpv.com) to provide solar panel recycling in Australia.

What's interesting about Reclaim's recycling system is that they don't just pull the panels apart and recycle the various materials; instead, they have developed a process that allows them to disassemble panels down

Image: EcoWaste Coalition

→ Compact and strip fluorescent lamps contain small amounts of mercury and other heavy and valuable metals and should be recycled properly, not sent to landfill.

to the cell level, so that individual cells that are still viable can be reused in other solar modules. Being able to do this reduces the overall embodied energy of the new solar modules, while reducing the materials needing to be recycled at a foundry level (i.e. reprocessing the silicon itself or melting down the aluminium frames).

Reclaim aims to provide the infrastructure and networks required to enable large-scale recycling of PV panels, and they already have numerous collection points in operation. As more PV importers/manufacturers sign up to work with them, a steadily increasing number of unusable PV panels will be diverted from landfill into the recycling scheme. Reclaim also states that they are hoping to spawn more PV manufacturing in Australia.

The biggest obstacle may be to have enough recycling collection points to make recycling viable from all parts of the country. But given that there is already in place an extensive distribution network for solar panels, solar panel collection should not pose a significant logistical issue—the distribution network could simply become bidirectional.

What to do with old lights?

As LED lamps take over the lighting market, large quantities of older technology lamps will need to be recycled. The introduction of compact fluorescent lamps happened quite some years ago, so that's meant that recycling for these mercury-containing lamps already exists here in Australia.

There are three companies recycling fluorescent lamps here—CMA Ecocycle, Ecocycle Australia and Toxfree. All three companies are part of the FluoroCycle scheme (www.fluorocycle.org.au), a voluntary product stewardship scheme that seeks to increase the national recycling rate of waste mercury-containing lamps. According to FluoroCycle, an estimated 90% of fluoro and other mercury-containing lamps end up in landfill, adding considerably to the environmental mercury load.

FluoroCycle targets commercial and public lighting, which accounts for the majority of lighting waste. However, any organisation or business can sign up as a signatory to the scheme, with dozens of companies, corporations and even a few councils using the scheme already.

Many councils also already have collection points in place to take small (domestic) quantities of fluorescent lamps, meaning most Australians can simply drop their dead fluoro tubes off at their local council depot. You will need to contact your local council to see if they offer this service—if they do it will most likely be listed on their website.

Even if they don't, there are other options. See if your workplace has signed on to the FluoroCycle scheme, and if they haven't, suggest it. Once in place, see if they will allow workers to bring in their old fluoros for recycling—although this may not be practical or safe for straight tube lamps, compact fluoros travel well.

For those in major cities, another option is IKEA. All stores accept bulbs, including compact fluoros, and household batteries, and some stores even accept mattresses!

If none of these options are available to you, don't give up. Lamp Recyclers (www.lamprecyclers.com.au) offers a postal recycling system. You order the appropriate box kit on their website and once you receive it, fill it up with fluoros and when it's full, seal it up and drop it off at your local post office. Lamp Recyclers will do the rest.

While these options so far only cover fluorescent and similar gas discharge lamps, there's already a need for recycling of LED lamps, as the technology has been around for some years now and early adopters are seeing some lamps come to the end of their useful life (and, of course, some of the low quality lamps had very short lives!). So far, SUEZ Environnement (www.sita.com.au) is the only waste company in Australia to offer recycling for LED lights that we know of.

Halogen and regular incandescents contain only glass and a small quantity of metals, and are generally not recycled. According to Business Recycling (www.businessrecycling.com.au), "Currently there is no national recycling program for halogen light bulbs. There are a number of commercial operators accepting mercury-containing fluorescent lamps and they may also accept halogen. Halogen light bulbs can be safely disposed of in landfill."

While landfilling is not ideal, the materials are generally benign and do not pose a hazard. You should also check locally to see if there are recycling options in your area. For example, in South Australia, incandescent and halogen lamps are accepted through the same recycling collection points as CFLs and fluorescent tubes (Banner Hardware, Mitre 10 and True Value Hardware stores; see www.bit.ly/1V5RLxZ).

Battery recycling

Battery waste falls into two main categories—large format batteries, such as car batteries

and solar system batteries, and small format batteries (common household batteries, also called dry cell batteries), which includes the myriad types of small batteries used in phones, media players, and portable equipment, such as lithium button cells, AA, AAA, 9V, as well as the many sizes and shapes of lithium rechargeables used in mobile devices such as phones and cameras.

Materials that can be recovered include copper, brass (a copper-zinc alloy), lead, tin, zinc, lithium, cadmium, steel, manganese, plastics (from battery cases), sulphur (from sulphuric acid electrolyte of lead-acid batteries) and numerous other valuable materials.

Lead-acid battery recycling has been actively conducted in Australia for decades, with almost all of the material in lead-acid batteries being recycled. Most councils will take old car batteries, and there are numerous scrap metal merchants that will take lead-acid batteries of all sizes—some will even pay you for the lead content.

However, smaller battery recycling is less extensive, with many millions of batteries—mostly single-use disposables—going to landfill each year. To address this, the Australian Battery Recycling Initiative (www.batteryrecycling.org.au), an industry and community working group, was established in 2008 to investigate a coordinated national collection and recycling scheme for batteries. The ABRI website contains basic information on the types of batteries recycled, as well as some of the schemes for collection, but for detailed information on battery recycling and where you can deposit your batteries to be recycled, see the Planet Ark Recycling Near You website at www.recyclingnearyou.com.au.

A number of the schemes are also listed below:

- Residents in Perth (WA) can deposit old household batteries (such as AA, AAA, C, D, 9V and similar batteries) in over 150 battery recycling bins around the city.
- In Melbourne, household batteries can be deposited in participating retail stores.
- Sydney City Council has established a number of drop-off locations to recycle handheld batteries, mobile phones and light bulbs.
- In other urban and regional centres in NSW, Community Recycling Centres are being rolled out to collect batteries and other problem wastes with funding from NSW EPA.
- Battery World stores offer a free battery recycling service for their customers. There are over 70 stores across the country.
- ALDI is the first supermarket to offer a national battery recycling program for customers.
- IKEA takes batteries, light bulbs and some other items in some stores.
- Mobile phones and mobile phone batteries are recycled through the MobileMuster program (www.mobilemuster.com.au). They can be dropped off at over 3500 participating retail stores and local council facilities or returned in a reply paid envelope.
- A pilot project to collect and recycle used power tool batteries commenced on 1 September 2015, with the aim of investigating the feasibility of collecting power tool batteries through hardware stores. Batteries will be collected through selected Bunnings, Masters and Trade Tools stores in the Brisbane City Council area. The project is being managed by ABRI with funding from the Queensland Department of Environment and Heritage. The team responsible for collection and recycling includes Infoactiv Group, MRI (Aust) Pty Ltd and Planet Ark. ✱

↑ Millions of batteries are thrown into landfill each year, yet they all contain valuable metals and other materials.

Resources:

General recycling info and locations
www.recyclingnearyou.com.au

PV recycling
www.reclaimpv.com

Light bulb recycling
www.fluorocycle.org.au
LEDS: www.sita.com.au
South Australian drop-off points: www.bit.ly/1V5RLxZ

Battery recycling
www.batteryrecycling.org.au
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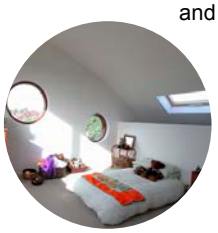

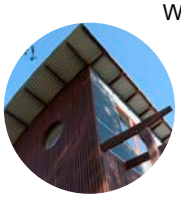

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Construction waste
A reuse/recycling revolution

With around 30% of waste in landfill coming from construction, what can an architect or builder do? Robyn Deed and Emily Braham talk to a few about the practicalities of reducing waste.

IT SEEMS that the problem of construction waste is a difficult one, even for those builders and architects motivated to do something about it. Even when demolition is avoided where possible, a home sized appropriately rather than excessively and the least wasteful approach to materials is used, there will still be waste.

Common building practice has been to use skips on-site to collect the remaining off-cuts, rubbish and discards. Many companies will separate valuable waste, such as bricks or steel, and recycle some materials as well, but it can be difficult to manage, particularly on small sites and for small companies.

For larger companies, recyclers may be willing to pick up the larger quantities of recyclables from building sites, but a lot of waste still makes its way to landfill. The figures vary from year to year and state to state, but in 2010–11 waste from construction and demolition made up around 30% (by weight) of landfill in Australia[1].

Interestingly, in 2010–11 the construction industry had the highest resource recovery rate, at around 66% nationally, compared to the other waste streams of household waste (51%) and commercial/industrial (59%). But it could be higher, with some suggesting that 96% or more could be reused or recycled.

In *ReNew 132*, The Green Swing noted that standard practice for a sustainably minded client is to make waste management part of the build tender documents, but that this may mean very little in practice. The client is generally not on-site to control what actually happens. The Green Swing's approach was to instead choose a builder early on in the design process and work with them collaboratively to ensure sustainable material choices and good waste management.

↑ Recycling facilities tend to be made for big trucks, so are often unsuitable or even dangerous for smaller users, that's if they let you use them at all.

But what does good waste management look like in practice? Below, two building designers discuss the challenges and the effort involved in doing it well.

Case study 1: The realities of waste

Jeremy Spencer from Positive Footprints describes the approaches they've tried, and what's worked and what hasn't.

The first method we tried was to separate recycling as we went along using individual black bins on-site. Although this worked to an extent, it was difficult to get tradespeople to adopt it consistently; you need a really good induction so that everyone understands what you are trying to achieve and why. As our company got bigger, this system became harder to manage. And, once mess starts on-site, it often escalates and is hard to then control.

Even if you've inducted everyone on-site and had the difficult conversations with those that haven't been doing it properly, you then have to physically manage the recycling. Recycling facilities tend to be made for really big trucks so it can be quite dangerous to use them with a trailer—if they let you in at all; sometimes they say you are too small. You end up spending a day going around different recycling facilities for specific materials. This represents significant cost and time expenditure when you have multiple jobs. Steel is really the only one which covers your time; you would get around $150 for a demolished steel roof, which makes it just worthwhile financially.

→ One of the systems tried by Positive Footprints to organise waste. This worked but got difficult to manage as the company got bigger.

→ The sorting line at Mobius Materials Recovery, which claims to recycle up to 96% of waste it collects from building sites. The company does a lot of manual sorting as well as using purpose-built machinery to separate out items that can be recycled or reused, such as soil (for landscaping and infill), concrete, bricks and roof tiles (crushed and fed back into projects), plastic (separated into rigid and film and sent for recycling), polystyrene (taken to a recycling facility from where it's sent overseas), metal (taken to a recycling facility), timber (generally shredded and reused in flooring). Mobius is a new venture, set up two years ago with the aim of both providing a for-profit service to the construction industry and helping to educate about waste. They provide a report to building companies on the quantity of waste generated and recycled per project.

Image: Alistair McCaskill

We now use a firm called Mobius Materials Recovery which does the sorting and recycling of our building site waste. We still reuse materials on-site where we can, but all waste is put into a cage that Mobius provides, which they then collect for recycling and reuse.

The average building job would likely produce at least 20 m³ of waste which would be taken to landfill. Using Mobius costs slightly more than a standard skip, but not a lot more. We've found that, as the cages are kept permanently on-site, it also keeps things clean and is really convenient. The only things that can't go in to the bins are liquids, asbestos, and other hazardous wastes.

For paint wash-up and disposal, we create a wet area away from drains: we dig a pit, line it with paper and then place the liquids in that—once it dries you can put it into the landfill bin.

Case study 2: Recycle what you can

Your Abode has found they can manage the recycling of some but not all materials. Darryn Parkinson describes their approach.

On every project we seek to recycle as much construction waste as possible and limit the amount of material going to landfill. It takes us a lot longer, but we do this because we simply feel it's the right thing.

It's very project-specific, but typically we find 60% to 80% of waste materials can be recycled (by weight that is). Volume-wise it may be less because a lot of the non-recyclable waste, such as foam packaging, is bulky, but weighs very little.

The major issue is the space required. Rather than the old-school idea of having one pile of waste, or one skip with everything going into it, we need to manage up to five separate waste streams on a site, which takes up space.

We typically separate metal, clean timber, cardboard/paper, bricks/concrete and general plastic containers. There are a number of locations around Sydney where we can take these for recycling. The clean timber is chipped into garden mulch, the bricks and concrete are crushed into recycled roadbase, and metal is scrapped into a metal recycling stream.

Generally our trades respond well once they understand what we are doing and why we are doing it. Managing it is sometimes still an issue though, and we find ourselves having to carry out one final re-sort before the waste leaves the site.

Good building waste control and management is still a rare thing. A significant reason for this is that there are so few locations that actually take and recycle waste. Plasterboard waste is fully recyclable but very few locations take it. Similarly with a lot of plastic waste, such as the drums that electrical cables are rolled onto, empty paint containers, offcuts of electrical cabling and plumbing pipework.

At the end of a project, I constantly despair at the waste from packaging. Appliances, fixtures and fittings are all wrapped in an excess of plastics and foam for protection, which should be recyclable but largely ends up in landfill.

One way to motivate more action in this area is to realise that building waste is essentially money being thrown away.

Money and regulation

To what extent can builders save money by reducing waste? There are several aspects to this: the cost of disposing of waste in landfill, the cost of paying for materials that aren't used, and the value of old materials able to be sold. A report by Hyder Consulting in 2011 on waste management in Australia identified that landfill levies on construction waste vary

across jurisdictions (from $42 to $102 per tonne in 2009 according to the Construction and Demolition Waste Guide, 2012[2]), and that the higher these are, the higher the motivation to find recycling and reuse opportunities. State-based waste recovery targets are also driving change with recovery rates improving dramatically over the last 10 years.

The Green Building Council of Australia (GBCA) has seen a reduction from an average of an 80% (by weight) waste recovery rate eight years ago to 95% now for Green Star certified projects (a voluntary scheme that applies to larger multi-residential and commercial projects). Jorge Chapa from GBCA says that building companies have certainly noticed that waste equals money lost, though for some a passion for environmental returns is also a key driver.

Jorge adds that recovery rates, while important, don't tell the full story: "A 90% recovery rate can sound great, but if that's 90% of a tonne/m², that's still 100 kg/m² going to landfill." Green Star now has two ways to qualify for the construction and demolition waste credit: either a maximum of 15 kg/m² of waste sent to landfill, or a 90% target for resource recovery. Jorge says the targets are achievable, and are backed up by international data such as from the UK Smart Waste program that tracked construction waste and recovery rates over a number of years.

Image: Alex Hunt Photography

→ This kitchen is Peter McArdle's own, a compilation of a couple of different but closely matched kitchens from an old unit complex where owners are progressively upgrading. Peter advises that reusing kitchens can be satisfying but tricky due to potential water damage, difficulty in sourcing parts for leaky taps, and fitting old units to new layouts.

Reuse opportunities

To reduce waste, many sustainably minded designers and architects embrace material reuse, both re-purposing demolished materials on a site or passing materials on to another project, rather than sending them for recycling or into landfill.

Reuse provides a lovely intersection between aesthetics and sustainability. Second-life materials can add character and tie a building to its own, or another building's, story. They can also reduce the embodied energy of the build, particularly when items such as bricks are reused, or concrete is made with reclaimed concrete instead of virgin gravel.

However, there are challenges to reuse. It often costs more to reuse a material than to buy it new, because of the labour to make it fit-for-purpose (think removing nails from timber or mortar from bricks). And making it work in its new setting may be tricky—the size may not be quite right or the material may have warped. Plus, there can be hazards such as lead-based paint and asbestos, along with issues around liability when using old materials that may not meet current building code requirements.

Jeremy from Positive Footprints says that timber usually costs more to reuse. "It can be heartbreaking to get rid of it, but when you factor in the labour to take all the nails out, as well as stripping and planing, it is usually much cheaper to buy new." Although Positive Footprints reuses materials wherever they can, they've found they need to be realistic about it, because not all clients are able to cover the extra costs and time involved.

However, Jeremy notes that sometimes building companies will reuse because it makes economic sense—floorboards, tiles in good condition and bricks, especially "nice red bricks", have some value, so they will be taken away and reused.

Geoff Crosby from Crosby Architects makes the point that it's not always as simple as 'reuse is better'. "You have to consider more than just the material's embodied carbon," he says. You've got to consider the energy to transport it, store it and make it reusable."

Geoff is a fan of reuse when it makes sense though. In a current project to build four two-storey terraces in Castlemaine, Crosby Architects retained the original house on the site as part of the development, an example of reuse on a large scale! They did demolish a lean-to that was badly deteriorated, but even then they found homes for most of the materials that came out of it.

"All the materials were separated and stacked and then given away. Practically nothing went to the tip," Geoff says.

Kitchen benches were reused, hardwood studs and flooring were incorporated into new kitchens and the external cladding became someone's garden shed.

Finding new homes for materials can take time, and it seems informal networks are often the most fruitful. "The site is on a corner near the centre of town, the person demolishing was affable and people stopped to talk to him," Geoff says.

Ptma Architects, based in Queensland, has taken a similarly strong reuse stance in a current project. They plan to build a new 'skin' around an old, termite-damaged home rather than knocking it down and starting again. They'll renovate, and retain and re-purpose as much of the original building as they can. For example, they hope to be able to use the old external cladding internally in place of plasterboard.

Peter McArdle from Ptma Architects credits the homeowners with embracing the unusual concept. "Rather than ending up with a large, new home (with all new materials), they'll end

↑ → Crosby Architects carefully pulled apart ('deconstructed') this old lean-to, attached to an old house on a site they are developing in Castlemaine. They retained most of the house, but all the materials and fittings from the lean-to and renovation were sorted for recycling or reuse. Kitchen cupboards ended up in a kitchen over the road, hardwood studs were used in kitchen cupboard doors (top right), and, in another building, lath was used as strip hardwood along the roofline and corrugated iron added character to the side wall (right).

up with a comfortably sized home which feels new and well-designed, but is predominantly a 30-year-old building," he says.

Consider the building's life

A final consideration is to design for a long life, but to also consider the building's end of life. Geoff Crosby says: "When buildings do reach the end of their lives they should be able to be easily separated into the constituent parts. This means, for example, using construction techniques that allow this and avoiding composite materials with glues."

There are companies (including community organisations such as the Resource Work Cooperative in Hobart, Tasmania) that specialise in 'deconstruction', taking a building apart carefully so as to recover as many of the materials as possible for reuse or recycling. It will take longer than just knocking it down, but the end result can mean monetary return for the materials recovered, reduced landfill fees and a win for the environment when those materials are reused or recycled. ✷

Robyn Deed is editor of *ReNew* and Emily Braham is editor of *Sanctuary*, *ReNew*'s sister publication on modern green homes.

References:

1. 2010–2011 waste figures sourced from www.bit.ly/1NVcy6f
2. Hyder Consulting report 2011 can be found at www.bit.ly/1PTqmf1, with the *Construction and Demolition Waste Guide* at www.bit.ly/1Uuk7VU

Resources:

Your Home waste minimisation page: www.yourhome.gov.au/materials/waste-minimisation

Sustainability Victoria has guidelines on waste reduction: www.bit.ly/1JIwcwd

GBCA has produced a discussion paper on waste management: www.bit.ly/GBCACDWM

Master Builders Green Living Builders accreditation covers waste management: www.bit.ly/1g2FhqZ

'Finders Keepers: the hows and whys of reuse' in *ReNew 122*.

Typical breakdown of construction waste (%):

Paper/cardboard	1
Garden/vegetation	3
Wood/timber	10
Textiles/rags	1
Hard plastic	1
Ferrous	2
Soil rubble (<150mm)	34
Soil rubble (>150mm)	2
Concrete-based masonry	16
Clay-based (e.g. bricks, tiles)	16
Plasterboard	2
Other/unknown	11
Total	**100**

Source: *Your Home*, extrapolated from NSW EPA Waste Census Data 1997

Storage, study, sleeping
Container convert

Tammi Jonas is definitely a convert to container homes. Motivated by reuse and sustainability, their light-filled container conversion has also proved a joy to live in. Here she describes the conversion process.

↑ It took just over six months to convert the used container into this well-insulated, light-filled bedroom/farm office, at a cost of around $9000.

IN MAY 2011, we had a moving/storage/accommodation challenge. We needed to move all our material trappings from Melbourne up to our new farm near Daylesford, but store them for four months while we traipsed across America, and then accommodate our growing (vertically, not numerically) family in a small three-bedroom house on the farm. The obvious solution was a shipping container for all three jobs.

That's how we came to buy a used high-top 40-foot (12 m x 2.4 m, 2.9 m high) container (from eBay) rather than simply hiring one to do our move. It cost us $2500, plus $500 to get it delivered to us in the suburbs and then hauled up to Daylesford.

The day the container arrived, we watched in trepidation lest the truck's cranes broke the low wires overhead. Then we filled it up, to the top, grateful we would have an enormous shed at the other end to supplement our new little house.

Our intrepid truckie, Bluey, arrived to collect the now-heavy container, and drove it through the rain and up our slippery, narrow driveway onto the farm. I held my breath the entire time, certain there was a very expensive towing bill in our near future. But Bluey was amazing, and our life's treasures were planted carefully in front of the shed to wait out the winter while we gallivanted off to a life-changing northern summer.

A full season later, we returned to commence our new life as farmers. Our design for the interior of the container was inspired by the RockVan (a 1977 GMC motorhome) we'd used on our holiday in the USA. The RockVan has terrarium-like windows that made us feel constantly connected to the outside world. I wanted my bed's placement to replicate the RockVan pleasure of waking to the gentle visage of trees and sky.

I had imagined cranes and costs and the stress of working with contractors to move the container into position as our new bedroom/office with ensuite, but my partner Stuart had better ideas. All we had to buy were some pine fence posts, which we needed anyway for, well, fencing, and borrow Stuart's folks' 4WD.

Stuart dragged the container into place, using eight round fence posts as rollers. In total, he had to move it about 50 metres, and 90 degrees. He then jacked it up and put pad footings with brick piers under each corner.

The building commenced in earnest then, with the roof we pulled off the house's superfluous, low carport becoming a feature on the container—and reducing the heat load on its roof.

Stuart bought double-glazed, aluminium-framed windows and doors direct from China, for both this and a second guest container. The windows in fact arrived in the soon-to-be guest container! The total cost was around $5500, including delivery, of which about $3500 was for the container.

Dealing directly with Chinese suppliers meant the windows were much cheaper, but it can be tricky, as quality can vary and

↑ The container's first use was as a moving van and storage, with all the owners' belongings safe inside while they travelled overseas.

↑ Cranes weren't needed to move the container into position when they returned from holidays. They used fencing posts and a 4WD to shift the container about 50 metres and 90 degrees (to orient it for passive solar).

the logistics require a lot of knowledge and time. However, Stuart already had 10 years experience dealing directly with Chinese companies, so for us this went smoothly.

Stuart cut the door and windows out of the container with an oxy-acetylene torch (nobody mention The Infamous Thumb Injury).

He framed up the inside and we installed the (very heavy) windows, before fully insulating—the roof with reflective AirCell, and the walls with a mixture of secondhand and new recycled pink batts (R2.0). We got an electrician in for the day to wire everything up at a cost of about $1000. Stuart roughed in the plumbing himself for the bathroom.

We then skinned the walls with plasterboard and painted them (with some willing helpers) entirely with paint sourced from the local waste transfer station.

The panelling above our bed came from a discovery underneath one of the houses we used to live in. Because the container is quite narrow, Stuart built a shelf at our head for books and bits. The bed is also intentionally quite high to capture that feeling of sleeping in the garden we had experienced through the glorious state parks of America.

We lined the bathroom with corrugated iron to maintain the industrial/Australian aesthetic, found a pedestal sink at the waste transfer station, and bought a fancy composting toilet for $600.

The shower has exposed copper plumbing (another score from under our old house), a slate floor with stone sourced at the Trentham

↑ → Construction commences in earnest: a roof is added (above), recycled from a rundown carport, window and door holes are cut, an internal frame added, windows installed (top right), insulation added, and plasterboard applied and then painted (bottom right).

Warning

Take extreme care when using an oxy-acetylene torch: they produce very high temperatures that can burn you instantly. We recommend that you take a course on using gas torches safely, such as an introductory welding course at your local TAFE, or find someone experienced who can instruct you on using them safely. Always wear gloves and eye protection to prevent injury from metal splashes, and you should also have a fire extinguisher at hand to put out any accidental fires. Also be very careful when handling windows as glass shards are heavy and will cut you just with their own weight.

← The light-filled study is shown at left. At one end of the container is the shower and at the other, the bedroom.

The completed bathroom (far left) uses corrugated iron lining and a plethora of reused materials in the slate tiles, copper plumbing and tempered glass. There's also a fancy composting toilet.

"All up, our 'parents' retreat' cost us about $9000—that includes purchase, delivery and all building materials—which we reckon is pretty good."

secondhand building supplier for $30, and tempered glass from the same source that cost us $100.

The containers all come with beautiful hardwood floors, durable and useful for their former lives with pallets sliding back and forth. Stuart sealed the hardwood floor in the bathroom, we hung an old mirror we inherited somewhere over the last decade, and we found on old dresser at the tip to use as a bathroom cupboard. A brass towel rail completes the picture.

The container is grid-connected, and has a small Dimplex gas heater that we only really need to use just before going to bed in the icy Daylesford winters. Cross-ventilation from the opening windows keeps us cool in summer, or we use a fan during the day if it's really hot. As we're at nearly 600m, it always cools off at night.

All up, our 'parents' retreat' cost us about $9000—that includes purchase, delivery and all building materials—which we reckon is pretty good, especially since it also bought us four months' storage of all our belongings and our entire move up here!

We've now used the container as our bedroom and office for around three years and we love it. Working in the container is incredibly pleasant, as the room is oriented for passive solar and full of light from so many windows. It's consistently warmer or cooler than the poorly insulated house with its single-glazed windows. It also gives us a genuine retreat from the kids, who, no matter how beloved they may be, are still noisy in the way of children.

The only thing the container can't contain is our joy at being here, on the farm, in such lovely trappings. ✱

Tammi and Stuart Jonas run a farm near Daylesford. They love their container office/bedroom so much that they are planning the eventual rebuild of the main house on their property using eight shipping containers for the bedrooms, office and laundry.

Resources:
'Shipping Container Reuse' in *ReNew 122* covers a bit more about sourcing shipping containers, and another DIY project (see follow-up, right).

'Finders Keepers' in *ReNew 122* gives tips on the whys and hows of reuse, including info on tip shops and national reuse websites.

Tammi and Stuart are great reusers of materials. They ask visitors to their farm to bring something they can reuse (which can range from scraps to add to their compost, to fallen fruit they can feed the pigs, to pieces of timber or items from hard rubbish). Tammi says they scavenge from everywhere: "Stuart loves eBay, we check the tip regularly and Stuart's parents often pick up great stuff from their local hard rubbish collection in Melbourne."

Container advice

Shipping containers are considered by some to be the "democratisation of sustainable building" because they are inexpensive. Empty shipping containers abound; used containers may cost as little as $1500. Whilst inexpensive, they require a fair amount of building know-how and inputs to succeed; for example, additional costs will include windows, insulation, an electrician, a plumber and a metalworker (unless you are a typical *ReNew* reader and can do all of these things!)

Standard shipping containers are designed to carry loads of up to 30 tonnes in harsh environments. They are designed to be stacked up to eight containers high on ships and the walls are usually made of square corrugated steel sheets outside, while the inside lining varies from steel to fibreglass to plywood. Some containers have vertical wall posts which add further strength. The two long walls are load-bearing so if you cut a hole in them this may need to be compensated for—but if you don't compromise the top and bottom longitudinal rails and the corner posts, the container is going to be structurally sound. They are easily stackable for multi-storey builds.

The upside of building with shipping containers is that, provided you are

Coffs harbour container studio follow-up

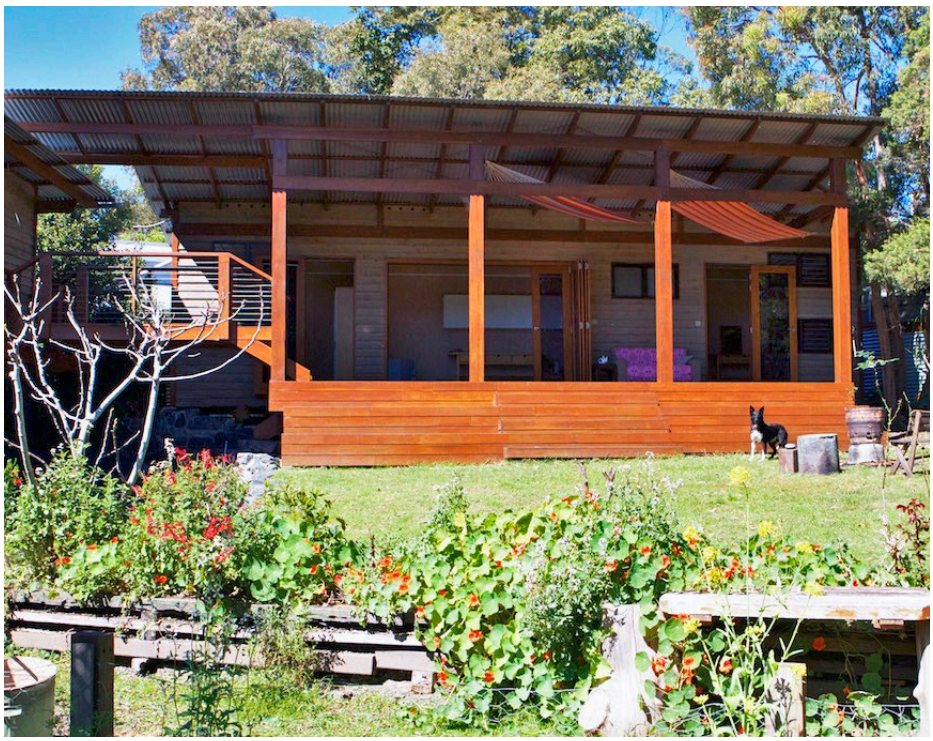
Tony and Karina Rothacker were featured in *ReNew 122*. At the time they were nearing completion of a DIY container project that involved converting a 40-foot 'high cube' shipping container into a two-bedroom unit for their teenage children.

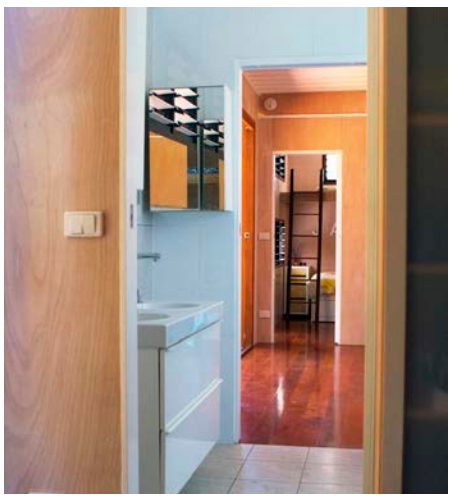
The unit is now complete and contains two bedrooms, a kitchenette and a bathroom. It cost $50,000 in total to build, using local and recycled materials where possible. The Rothackers say they "avoided a claustrophobic feel" by installing bi-fold doors that measure 4.5 by 2.4 metres and an LED strip light which reflects off the white-painted ceiling and adds to the feeling of openness. The shipping container is lined internally in marine ply and painted with lime wash which is hardy and easy to clean. The steel construction means no issues with termites.

The studio is very comfortable: insulation batts are external to the container (under the western red cedar cladding) to avoid condensation issues. Louvre windows are employed for ventilation. For additional natural cooling, ventilation holes have been added between the container and the roof.

The Rothackers say one of the challenges they faced was drilling into the container on the inside to attach the internal lining, as they preferred not to frame the container. A big plus for them is that there is no mobile reception inside the container (perfect for teenagers).

There's a great use of space. Karina says, "When we renovated the main house, our whole family of six lived in the container for months and it was really convenient."





↑ The completed container home in Coffs Harbour (top) is a comfortable two-bedroom unit for the teenage children. The double-bunk bedrooms are at either end. Louvres provide ventilation and light (bottom right).

buying secondhand, you are creating architecture by using a waste material. (There is, however, a trend where people buy them brand new. Containers are being manufactured now specifically for use in building, which cost up to $6000.) Plus, the build can happen in a short space of time.

The downside of building with shipping containers is they require quite a lot of work to change them from a dark, windowless box to a liveable space, particularly in the area of insulation. You need a way to keep the sun off the roof and you need proper insulation to protect against condensation. The walls are rough so the interior will need framing so that the internal walls can be lined. The outside will usually need a new coat of paint to prevent corrosion. Other criticisms include toxicity concerns; the coatings used to ensure the containers survive their time at sea may contain a number of harmful chemicals including chromate, phosphorous and lead. The wood floors that line the majority of shipping containers may contain arsenic and chromium, added to keep pests away.

Every council has its own set of rules about what is allowed. Fire regulations are tricky in Australia. It's best to check regulations before you start bidding on eBay! It's also worth using the right contractor; like most things, it is best approached with a professional design at the outset. For example, figure out where the plumbing is going to go before you lay down the floor. You can enrich shipping container homes with a cleverly designed garden; a rooftop garden is a great addition, or planting perennials to the east and west.

respod.mgarchitecture.com.au
www.fabprefab.com
www.royalwolf.com.au

Bear Grylls with spanners
Making use of urban resources

John Hermans explains how to live, and live well, on minimal income by reusing the vast array of high-quality waste generated by the average suburbanite.

↑ John in his workshop, repairing a commercial induction cooktop. Two drops of vegetable oil on the control dial had rendered this unit (worth a few thousand dollars) almost worthless. A little degreaser and a clean rag soon fixed it. They now cook on solar-powered induction.

IN CASE you haven't noticed, there's been a lot of interest lately around city people's ability to survive away from the world of the supermarket—to survive in the wild like Bear Grylls, for example.

To some this is no more than entertainment, honing a skill set with minuscule probability of any need. I would agree. But I feel some affinity to those taking up this challenge, given my own challenge to live, by choice, with little income.

My daily chores revolve around making, fixing, growing and processing. My wife has paid work two days a week, so we need to get by on an income that could only be described as well below the poverty line. The job title that I've used for the past 10 years is 'Cost of Living Minimisation Worker', unwaged!

Yet we live well, on a large bush property, with an earth-covered home and highly productive garden.

There is so much going on at our place beyond having 100% renewable energy for both home and vehicles, so I thought it might be worthwhile to share some of our tactics for living well without it costing the earth.

An excess of waste

We did not jump into this situation, it evolved over time. The multi-skilling we've needed takes time and determination, but the rewards have been high. Confidence in your skills and ability to learn is essential, but the biggest boon has been living at this time and in this place.

In Australia, we live in a time of unprecedented excess. We have more than we need of all the things necessary for a comfortable life, and a whole lot more that is completely unnecessary. As a consequence, discarded goods are also in excess. It is this 'waste' that makes my family's life so comparatively acceptable on such low income.

Mass production has played a major role, bringing with it the low cost of new goods, making repairs seem unreasonably expensive. With most goods being made overseas in low-income countries, when Australian-waged workers are asked to repair these goods, the economics fail.

Consequently, I just keep getting better at fixing things myself. Many items are now discarded when they have the simplest of faults, even more so than in the past, so the skills needed to fix them are actually decreasing; in years past, goods were treated as repairable when they had much greater levels of 'brokenness'.

Here's a typical example. Ten years ago I purchased a metal cut-off saw (new value $200) at a Sunday market, which was sold as 'not working' for $50. I was fairly sure it would be a loose electrical wire, and it was. Today I would never pay this much because I can easily find one at the scrapyard for much less. I recently did just that, buying an even better one (with the same problem) for just $5.

The vast number of stories I could tell about acquisition of goods with minor faults, for little expense, would fill this magazine.

Another example: have you ever noticed the value of motor vehicles that are advertised as 'not going'? They are devalued by around 75%. I recently purchased a 'not-working' diesel van (for a vegie oil conversion) for under half its value, because there were two faulty capacitors in its computer. Repairs cost $2.50, plus the time of around two days to identify the fault. Money saved—$5000.

Sourcing the goodies

Acquiring and fixing tools, so that I can fix and make more things has been a life-long habit for me. In my teen years I scrounged the local tips to find things that needed fixing. In my 20s it was Sunday markets for used goods, then soon after, it was garage sales. Now the local scrapyard harbours the most amazing treasures. Not to mention eBay!

A good way of life

An all-important bonus to a capable fixer is the grateful response from friends and family who give you things that are 'not quite working properly', as they know they soon will be.

But to be able to live so self sufficiently takes a lot of time. For many full-time workers, even to find time to seek out these devalued goods isn't possible. And with the degree of skill specialisation at work, and the lack of a wider, generalised skill set, the ability for most people to use this waste stream is equally unrealistic.

When I say my skill set evolved, it didn't just happen. I chose to reduce the time spent earning an income and instead follow the philosophy of "when you are not earning you need to be learning, and vegetable gardening and building and..."

I now encourage people to do their best to give up time at paid work and swap it for family, fixing and making. For anyone who can make such a change, I can vouch that it makes for a more satisfying time at home, reduced living costs, and a much more sustainable lifestyle. ✱

John Hermans is a regular contributor to *ReNew*. His primary interests are in low-emission technologies along with local ecological sustainability. John is president of Gippsland Environment Group and holds a BSc in forest ecology.

→ **Bright Sparks** is a new not-for-profit in Melbourne that rescues small appliances to keep them out of landfill. They have a focus on reuse and repair. www.brightsparksaustralia.com

Do-it-yourself resources

The web is a DIY paradise.

iFixit is a global community of people helping each other repair stuff. The website is a resource for people who are on a quest to reuse and repurpose electronics www.ifixit.com

See Jane Drill is an online resource centre that offers free video tutorials on home repair for DIY enthusiasts. seejanedrill.com

Streetbank is a website resource for sharing things (such as expensive tools) with neighbours. www.streetbank.com

Repair Cafes are free meeting places with a focus on repairing things together. You'll find tools and materials to help you make repairs. The Bower in Sydney is a Reuse & Repair co-operative that runs workshops and rents workspaces. www.repaircafe.org, bower.org.au

Local councils are a great place to find DIY workshops. For example, Moreland Energy Foundation runs free workshops for Moreland residents on green renovations.

Laneway Learning hosts informal classes in Melbourne, Sydney, Brisbane, Adelaide, Singapore and Auckland with topics such as how to make recycled furniture and using woolfiller to repair jumpers www.lanewaylearning.com

Fix It! is a community of volunteers in Melbourne who repair and mend things and teach others how to repair things with the aim of keeping stuff out of landfill. www.fixitmelbourne.com

The Simplicity Collective is founded upon the idea that a 'simpler life' of reduced resource and energy consumption is a viable alternative to consumer culture. Practical action plans such as these have DIY at their core. simplicitycollective.com

The **Australian Men's Shed Association** offers a place for people to go and tinker in a workshop. Most of the sheds are also open to women and offer lessons in things such as woodworking and cookery. www.mensshed.org

Open Shed "Why buy when you can share?" is a website where you can rent tools from your fellow members instead of buying. www.openshed.com.au

DIY is a crucial element of the **Transition Movement**. This map gives a good overview, with dozens of projects in Australia. www.transitionnetwork.org/map

Footscray Maker Lab is a community space where members get access to a workshop and tools. Lots of education programs operate out of the space too. footscraymakerlab.com

Instructables is a DIY website where people post instructions complete with photos of how to do *ReNew*-type things, such as create a 2-volt rechargeable battery, repair a toaster or make a wind-powered car. www.instructables.com

Tool libraries enable patrons to use tools without owning them. Google 'tool libraries' to find out more.

A toxic legacy
E-waste recycling in Australia

The mountains of e-waste continue to grow, and much of it is still ending up in landfill. Kirsten Tsan looks at what's happening here to address the problem.

AUSTRALIANS are among the most prolific technology users today—and some of the most wasteful. From 2007 to 2008, an estimated 15.7 million computers reached their 'end-of-life' in Australia, but only 1.5 million were recycled. The rest went to landfill.

E-waste is any electronic equipment that requires electric currents or electromagnetic fields in order to function that has reached the end of its useful life. Up to 2011, we were sending over 90% of our e-waste to landfill, endangering not only the environment, but ourselves; computers and televisions contain materials that are hazardous to humans, such as lead, cadmium, mercury and zinc.

Worse, we were wasting the materials in this electronic junk—the majority of which could be fully recycled and used in other products. To give an example: the amount of gold recovered from a tonne of electronic scrap from PCs is more than can be recovered from seventeen tonnes of gold ore! These valuable and non-renewable resources are lost when they are thrown into landfill, and so are the resources that were used to make them, like water and oil.

↑ Ghanaians working at an e-waste dump in Agbogbloshie, a suburb of Accra, Ghana.

National recycling scheme

To address these issues, in 2011 the federal government launched the National Television and Computer Recycling Scheme (NTCRS) under the Product Stewardship Act. The scheme states that the companies and businesses making computers and televisions are also, to a certain extent, responsible for funding their product's recycling programs around Australia.

The NTCRS is a stepped implementation and will take place over a number of years. It started in 2012–2013, with the aim that industry would take responsibility for 30% of the collection and recycling of their products. The ultimate goal? By 2021–2022, industry will have taken 80% of the responsibility for the recycling of computers and televisions.

Before the NTCRS was launched, a 2010 report stated that industry funded 17% of the recycling for that year. In the first year of the scheme (2012–2013), a total of 40,813 tonnes were recycled by industry—98.8% of the scheme target and almost double the estimated levels of recycling prior to the introduction of the NTCRS. In the latest report (2013–2014), out of 131,607 computers and televisions that reached their 'end-of-life' in Australia, industry was required to fulfil a 33% target (43,430 tonnes). By the end of the year, industry recycled 52,736 tonnes, which was 7% over the scheme target, and 40% of the total recycling that year—a marked improvement. Liable parties—the companies within the television and computer industry—were also reported by the Department of the Environment to have mostly complied with the scheme, with an impressive 99.2% complying in proportion to the weight of liable imports.

E-waste often contains materials that are hazardous to human health, and therefore

"From 2007 to 2008, an estimated 15.7 million computers reached their 'end-of-life' in Australia, but only 1.5 million were recycled. The rest went to landfill."

must be disposed of properly. When they are sent to e-waste recycling plants, products are broken down into their various categories of components and separated for recycling. For example, CRT televisions have a high concentration of lead in the glass of their screens and must be crushed in a contained environment, separated and cleaned. The lead can be used as flux material to remove slag from newly mined lead, and the glass can be used in new computers or televisions. Plastic casings are turned into pellets and used for resins for new products and fuels, while any remaining scrap metal can be melted down to make new products. In the case of computers, their circuit boards are shredded down to a fine powder and separated into plastics and precious metals to create new jewellery, electronic components, and an entire host of other items. By weight, 95% to 98% of all components can be fully recycled for future use.

The scheme created a need for e-waste recycling drop-off points, which are run by Recycling Near You and five co-regulatory arrangements, recognised by the federal government in June 2013. These companies collect and recycle all types of e-waste, and they number in the hundreds, all around Australia. Head to www.recyclingnearyou.com.au to find a service near you. There are also other recycling services for mobile phones, printer cartridges and batteries, such as Cartridges 4 Planet Ark, Mobile Muster and the Australian Battery Recycling Initiative. ALDI stores all over Australia also provide a battery recycling service.

However, there are issues that are becoming increasingly challenging for councils to deal with over time. The National Television and Computer Recycling Scheme (NTCRS) only applies to televisions, computers and other associated electronic equipment like printers and mouse devices, as befits its title. This means that industry only funds the NTCRS, but councils must still pay a hefty bill for recycling everything that isn't covered by the scheme—refrigerators, batteries, mobile phones, vacuum cleaners and other appliances. Furthermore, some remote or regional Australian councils—particularly in Queensland and Western Australia—are not participating in the NTCRS, so they have to shoulder the expenses of e-waste entirely by themselves.

What happens to the waste?

Focusing on the e-waste that is being collected at drop-off points, another question presents itself: where does it all go?

Some is sent to social enterprises for recycling, some given to the recycling plants, and some gets exported overseas because it is cheaper to send it overseas than to recycle it or store it. This in itself is not the problem: some shipments are sent, with a hazardous waste permit, to countries where the e-waste will be handled and dealt with in an environmentally friendly manner. The real dilemma is when e-waste is sent to countries that are ultimately used as a dumping ground—places like West Africa, India or China, where the e-waste is sorted, sold as scrap metal or burned to extract materials, polluting the environment and exposing all workers and children in the area to hazardous toxins, resulting in debilitating and life-threatening diseases. These workers are often poorly paid and work in substandard conditions.

Last year, the Department of the Environment confirmed they had seized 21 containers of e-waste since 2010 that were being smuggled out of Australia without a hazardous waste permit, destined for places like Nigeria, Ghana and Vietnam. However, the Australian Government did not prosecute the smugglers for trying to ship the e-waste overseas (www.bit.ly/1Mv6vDm). This continues to happen worldwide—70% to 80% of e-waste is shipped overseas where the e-waste is not disposed of properly, but continues to endanger the lives of workers and the environment.

These issues are not easily solved. On the bright side, there is something we can do about it. Spreading awareness about the NTCRS and ensuring old but useable mobile phones, televisions and computers are passed on to relatives or friends will have an impact on how much e-waste ends up in landfill. There are also companies that collect e-waste that is not covered by the NTCRS, further avoiding the huge amounts of hazardous e-waste left to degrade and release toxins into our environment. Likewise, keeping an eye on and finding out where these collection companies are sending their e-waste will have an effect on where the e-waste goes, and how it's managed.

Australia's recycling schemes are still in the early stages of implementation, perhaps infantile in comparison to the exponential growth of e-waste, but as more awareness is spread about these issues, we can make a difference. ✱

Kirsten Tsan is a Year 10 student in Melbourne who did work experience at the ATA, *ReNew*'s publisher, in June this year. She has, among other things, had a short story published in the 2011 edition of *Golden Harvest* magazine, been invited to proofread a book for Sally Rippin and written a fantasy novel with a friend; and this year they are writing the sequel.

Resources:

www.recyclingnearyou.com.au/ewastescheme

Each council has a different strategy for managing residential e-waste; Check your council's website or waste collection calendar.

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From earth, cans and tyres
Earthship Ironbank

It's taken a few years, but Australia's first permitted earthship is almost ready to set sail in its new life as B&B accommodation, and as a living laboratory. Owner-builder Martin Freney describes the voyage so far.

IT'S BEEN three years since I first wrote in *ReNew* about my earthship research and my own building project in Ironbank, in the Adelaide Hills. In that time, I've completed my PhD looking at the environmental impacts of earthships compared to other forms of building and living, and Earthship Ironbank is almost finished.

The exciting news is that Earthship Ironbank has become the first permitted earthship in Australia, with planning approval granted three months after submission (the only design tweaks needed were the addition of exit lights and outward opening doors, as these are required for a B&B) and building approval granted in six weeks.

The one thing I couldn't get approved was the wastewater system, which includes irrigating food with greywater and flushing the toilet with biologically treated greywater. The greywater system was constructed but not commissioned—this will be done at a later date if I can influence the laws on this to be changed (fingers crossed).

I enlisted a crack energy assessor who knew how to convince the ratings software to predict the performance of a home with earth tubes, a greenhouse and many tonnes of earth piled up around its earth-filled tyre walls. The result was a 6.3 Star rating, but in reality I believe the home will be 9 or 10 Stars and I'm going to try to prove it...

↑ Martin's almost-completed earthship in Ironbank, in the Adelaide Hills, South Australia. The design is based on the Simple Survival Model, adapted for use in Adelaide's warmer climate. The north-facing greenhouse sits in front of the main room which serves as bedroom, living area and kitchenette. An airlock entry room is at the east end of the greenhouse, and a bathroom at the west.

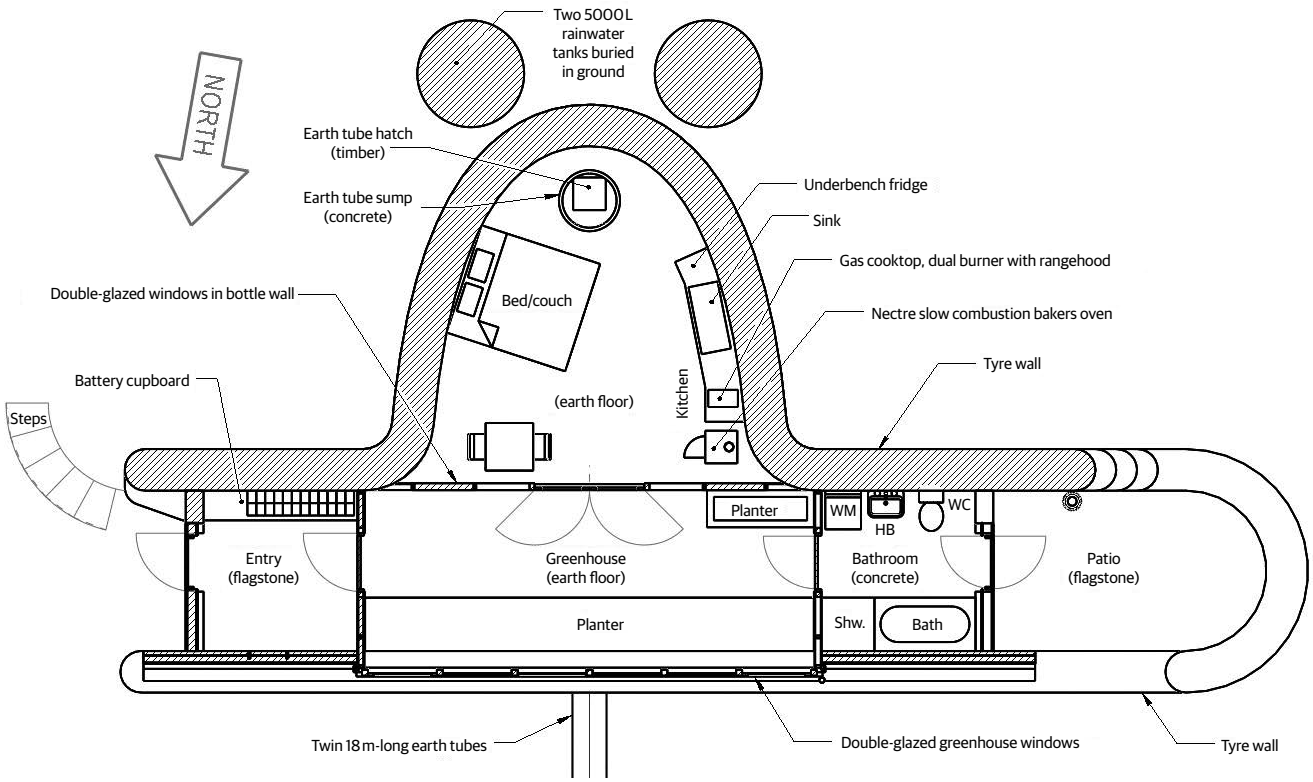
A living laboratory

I intend the earthship to be a living laboratory yielding new knowledge about sustainable housing. It's going to be a B&B, giving me the opportunity to survey the many different occupants about living off-grid, with questions such as—was it comfortable, were they concerned about running out of power or water, did they have to change their behaviour and what would be needed to get them to commit to their own off-grid eco-change?

It's also wired up to collect data. It has temperature sensors buried in the roof, in the berm, under the main floor and under the greenhouse floor to provide a better understanding of how heat flows through tyre walls and earth-bermed structures in general. These will also let me check the energy rating.

Adelaide climate tweaks

There were some design changes I made to adapt the earthship design to the Adelaide Hills in climate zone 6 (mild temperate), a very different climate zone to Taos, New Mexico, where the earthship design evolved. Taos has extremely cold winters (-20 °C) and, compared to Adelaide, mild summers (35 °C maximum), with summer nights usually below 20 °C. In Adelaide we often suffer from very warm nights when it's impossible to use cool night-time air to cool our homes by opening windows. We also have overcast winters, whereas in Taos they are blessed with abundant winter sunshine, essential to passive solar functioning in the otherwise bitterly cold conditions. The winter sunshine



↑ The earthship's layout is quite simple, with very little wasted space.

also means they can use relatively small PV arrays and battery banks.

To allow for this, I increased the area of north-facing roof so that I could fit a larger solar PV system as well as a solar hot water service (24 evacuated tubes, close-coupled with the roof-mounted tank). With a 24 V, 600 Ah battery bank and 65% DOD, this gives almost three days of autonomy for my predicted usage of 3 kWh per day. The roof also incorporates two double-glazed operable skylights to regulate hot air venting out the greenhouse roof (similar to Reynolds' roof vent boxes, but more elegant to my mind). I may install internal blinds to block summer sun, but I am anticipating that it will be important that the greenhouse heats up sufficiently to cause a natural thermal convection cycle to draw air through the earth tubes for natural cooling.

Many earthships feature angled glazing which minimise heat loss and maximise heat gain. Double glazing is quite expensive (I paid about $220/m² for argon-filled 5/10/5 double-glazed units, installed) and angling it to maximise winter solar gain means you need less glass for the same winter performance, thus saving money. However, angled glazing could lead to excessive heat gain in Adelaide's harsh summer sun as well as complexity in construction: it may void the warranty as it can tend to sag and be more prone to breakage.

My approach was to try a bit of everything: I have a small area of angled glazing (the skylights) which can be easily shaded if necessary. These let winter sunlight deep into the main room to warm the thermal mass floor and walls. I have also made provision for a shade structure, with roof beams extending past the glazing to be used to train deciduous vines on high-tensile wires.

Earth tube cooling

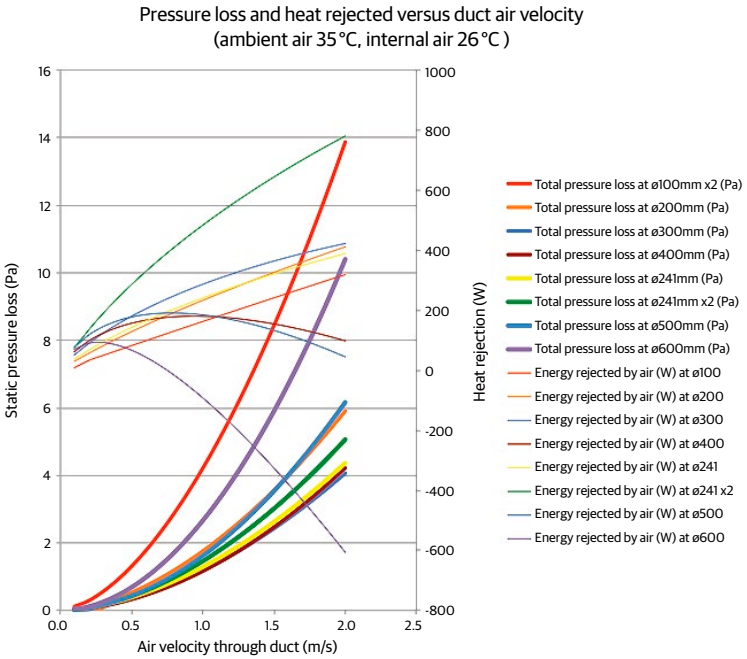
I had the good fortune to meet Alex Swanson, a natural ventilation engineer, who was keen to get involved with the design of the earth tubes. I did some basic energy modelling to estimate the summer cooling load and Alex calculated the earth tube parameters to provide adequate cooling. He investigated a range of diameters of PVC earth tubes, ending up with a design for two 240 mm-diameter tubes each 18 metres long, buried at a depth of one to two metres at the deepest point, and

What is an earthship?

The invention of US architect Michael Reynolds, an earthship includes passive heating and cooling, natural and recycled or reused construction materials, off-grid renewable energy, rainwater collection, on-site wastewater treatment/recycling using biological methods, and food production, generally using wastewater.

The overall aim is to create a highly self-sufficient home that provides its own services so that it is not reliant on the polluting infrastructure that conventional homes rely upon. It should passively provide comfortable indoor temperatures and aim to use low embodied energy materials.

Furthermore it aims to be affordable. Reynolds claims that an earthship costs about the same as a conventional home to build yet the savings on electricity, water and sewage bills over the earthship's lifetime are substantial. Owners need a savings plan to replace system components such as batteries, but this should be more economical than paying for the same services from the grid. Another key principle is that it uses simple construction methods which enable the owner (plus friends and family) to get involved in the construction of their home.



→ This graph models various tube diameters and the heat rejected by earth tubes. The thin lines show the amount of cooling (large positive values are good) and the thick lines show the drag or friction caused by the pipe diameters and air flow rate.

both feeding into the main room.

A typical Earthship Biotecture earth tube is made of 250 mm diameter corrugated galvanised steel and is about 7 m long, with just one per room. My design changes were aimed at addressing Adelaide's very hot summers and overcoming some problems I anticipated with other materials. Although PVC pipe is not a very eco material and not a good conductor of heat, it should have a long life, its smooth walls will be easy to clean and other Australian systems have reported good performance with PVC pipe. [*Ed note:* Earth tube systems must be designed to prevent mould growth and moisture buildup. They should also be easy to clean if needed. For more information on basic earth tube design requirements see www.bit.ly/1Ny9YDd and www.thenaturalhome.com/earthtube.php.]

The longer length of tube is important to enable sufficient surface area and time for heat exchange to occur. The rate at which the air is drawn through the tube is also critical: too fast and the air doesn't have time to cool down; too slow and you don't get enough cool air into your building. The longer the pipe the greater the drag, so small diameter pipes may 'jam' (stop the airflow) if they are too long.

I have also incorporated a small sump where the earth tubes enter the building. This may serve as a mini cellar for storing wine and perishables but can also house an earthenware pot filled with water for evaporative cooling, ideal for the dry (low humidity) Adelaide summers. The sump has a water outlet for filling the pot and an electricity outlet to power a fan to enable air to be sucked into the earthship if it is cooler at night. The fan might also be useful if the greenhouse fails to perform its natural convection cycle overnight.

← The tyre pounding process starts by ensuring the tyre is fairly level. You add a layer of cardboard (beer carton is a good size) in the bottom of the tyre and half fill it with earth, which can be sandy, clayey, gravelly or recycled concrete rubble as the tyre provides the structural integrity. You then compact the first layer of fill using a tamping device such as a sledge hammer. Stomping with your boots also works for this layer! You then gradually add two or three more layers of fill to make it easier to compact fill under the rim of the tyre, a process that requires an angled, sideways swing of the sledge hammer, well aimed to just miss the tyre rim. This levels the top (it doesn't have to be perfect). Finally the tyre is adjusted sideways (in/out of the wall) to ensure it has the right 'batter' (slope/angle) to resist the tipping forces of the berm, or in some cases the tyre wall might be built plumb. We corrected the (anti) batter of one of my walls with a gentle yet persuasive nudge from a backhoe bucket!

Other building changes

As the earthship is going to be a B&B, I decided to provide backup heating for prolonged overcast winter weather. A small wood stove in the kitchen provides both heating and cooking. It also provides backup for the solar hot water system via a water jacket (wetback/boiler).

All timber is termite-resistant as this seemed the most practical way to deal with the termite issue, something they don't have in Taos.

Exposed timber also had to be bushfire resistant. The site was assessed as being BAL 19, so it was important that the design respond to the bushfire threat. A green roof over the main room has a 150 mm thick gravel layer which will be planted with fire-resistant, succulent ground covers. The greenhouse roof is corrugated iron, and lime or cement-based renders cover the rest of the earthship; tests by EcoFlex Pty Ltd, a NSW-based civil engineering company, demonstrate that so long as tyres (used as a wall material, see below) are protected by render they are not a bushfire hazard. The main weak points are the double-glazed windows on the greenhouse. I am going to protect these with butterfly sprinklers (also designed to wet down the corrugated iron roof) powered by the earthship's tank water supply and electric pump. This is electric to avoid the need to deal with explosive fuel in a bushfire and is more suitable for automation.

Tyres as a wall material

Approximately 800 tyres were reused in the construction of the earthship and another 300 for the fire-fighting rainwater tank. Reusing tyres as a wall construction material has many advantages: they are free and they enable you to use another low-cost material —earth—to make your walls. Also, they are typically shipped off to Asia (millions per year from Australia alone) and burnt in waste-to-energy plants, releasing toxic particles into the atmosphere, so I think it is a better solution for this problematic waste material. The question of leaching or off-gassing of toxins from the tyres is often raised, but my research indicates that the risk from an earthship is low, as the tyres are isolated from water, air and extreme heat (see more about this online).

↑ Xiang and Agua creating the cob wall sculpture.

I contacted my local council and the EPA to check whether they had any issues with the use of tyres. There are rules in South Australia about how many tyres you can handle per annum (500) and there are guidelines about how to store them to avoid issues with rats and mosquitoes breeding in them and how to manage the fire hazard. I also found that, as I had council approval for my project, I could have had a limited licence, at a cost of $800, to 'dispose' of a certain number of tyres in the construction of the earthship.

As I had already substantially completed my tyre wall, however, this is something for next time. Many tyre retailers were willing to pay about $1 per tyre for me to take the tyres, so long as the EPA approval was in place.

Finding the right-sized tyres at times proved challenging. You can use just about any car tyre for an earthship wall but it's easiest if all the tyres are a similar size. I tried to get the retailers to put aside the sizes I was after, but I often ended up having to dismantle huge piles of tyres to get at the ones I wanted.

In the end, I tracked down where most used tyres were being taken—a facility that shredded thousands of tyres every day to be packed into shipping containers bound for Asian waste-to-energy plants—and found this to be a brilliant source; they would put aside a huge, neatly stacked pile of my favourite-sized tyres for me to load into my ute/trailer. So good!

Tyres are such a versatile building material. Usually we just used them whole, putting some scrap cardboard (another reused material) in the bottom to prevent the earth from falling out the hole, but occasionally we cut them using a reciprocating saw to make half tyres, useful for the end of a wall. We also tried cutting out the upper side wall—tyre pounding is much easier with the side wall removed—but even though it only takes less than a minute to cut out the side wall, we felt that a whole tyre results in a better rubber-to-rubber connection between courses of tyres and therefore a more 'bomber' (earthship-speak for superior!) result.

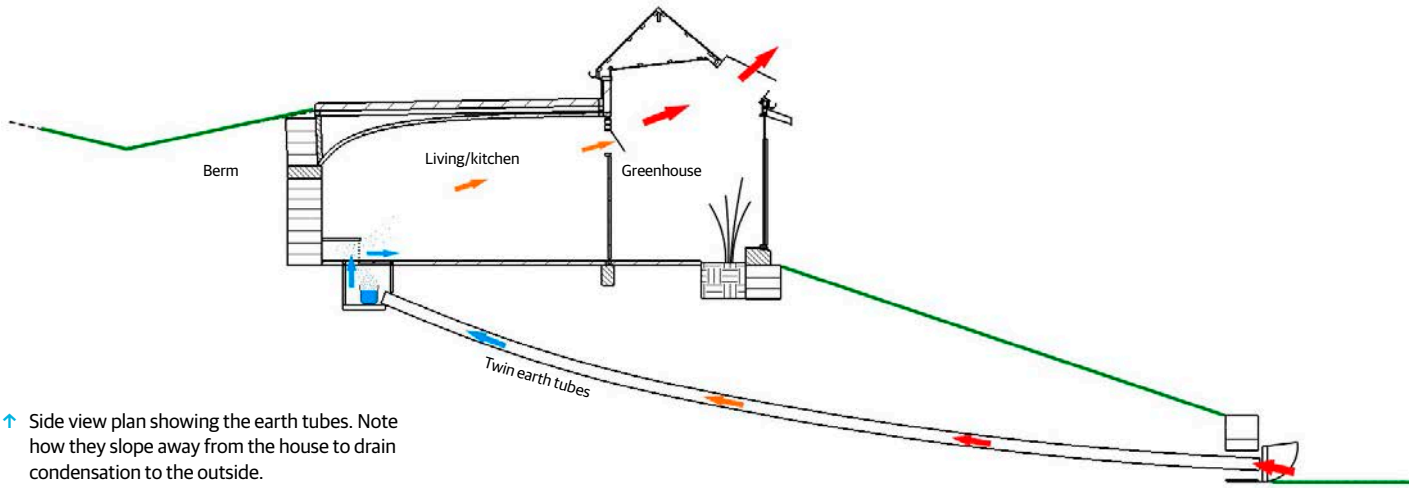
The majority of fill for the tyres came from the initial excavation of the site. Very high in clay content, this was also used for adobe render and cob. We sourced some additional fill for backfilling the tyre wall via a 'clean fill wanted' sign at the end of the driveway.

↑ Growing in the greenhouse is an array of amazing fruits and vegetables: bananas, kale, tomatoes, lemongrass, rosemary, mint, passionfruit, broccoli, lettuce, basil, eggplant, guava, chives and more!

A shortage of bottles and cans!

An unusual challenge building an earthship in South Australia was sourcing beverage containers for the bottle and can walls that are typical of earthships. In South Australia, beverage containers have a 10 cent deposit so they can be hard to come by. All the wonderful people who came to help build the earthship did an excellent job 'making' empty beverage containers, but we fell short of what we needed and had to buy empty cans! The recyclers weren't licensed to sell us cans (they thought we were mad), but in the end we found one who was willing to do this.

We tried various methods to cut the bottles including bottle cutters, flaming string and thermal shock, but found that the Earthship Biotecture method of a wet tile saw was the quickest and most reliable, although the downside was the noise, mess from glass shards and danger. We cut off the neck of the bottle to the right dimension to suit the bottle wall, washed the bottle and, when dry, used duct tape to join the bottoms of two bottles together, sometimes mixing colours to get an interesting new colour. Many of the bottle



↑ Side view plan showing the earth tubes. Note how they slope away from the house to drain condensation to the outside.

necks were recycled in the concrete bathroom floor as aggregate, replacing much of the gravel we would have otherwise used, but some were recycled, reluctantly accepted by the bottle recycler because we had not thought to separate the different colours of glass.

Many hands, many friends

The earthship was built in a series of workshops of about 20 weeks total duration. Most of the workshop participants had little building experience, which is quite typical of those involved in earthship construction, as it involves simple, easily learnt (though labour-intensive) construction methods, such as tyre pounding and rendering. The builders came from all over Australia and the world: from Canada, New Zealand, Taiwan, Italy, America, France, UK, Germany, Singapore and more.

Many camped on site. This led to wonderful friendships and information exchange on the construction site and around the campfire. Although there was a substantial carbon footprint arising from all the interstate and international travel, balancing that was a growth in ecological awareness, new skills and ideas about living sustainably, which shouldn't be discounted.

It was occasionally a bit stressful taking care of all these people, but in fact they were very self-sufficient and looked after themselves wonderfully well. I took out a public liability insurance policy which somewhat eased my anxiety, but thankfully there were no serious injuries on the construction site.

Sometimes over-enthusiasm and lack of experience meant a lower quality of workmanship and we had to redo things, but this didn't happen very often. We re-did part of a tyre wall and also one bottle wall to ensure they passed muster, but the amazing instructors, whom I hired with the funds raised from the workshops, taught the participants well. Some of the participants were even tradies, who were an absolute blessing, rocking up with a ute-load of tools and a brain-full of know-how.

The final accounting

Currently the building is at lock-up stage with many of the internal finishes complete. There is still the bathroom to complete and a kitchen to build. This last stage is going slowly, as I'm only able to dedicate about a day a week to it, but it has been a great opportunity to spend time with my dad who is a great problem-solver and amateur builder. He often helps me on weekends, hanging doors, installing the extra-low-voltage DC lights, sanding, painting, etc.

Everyone asks how much it has cost. I estimate the final cost will be approximately $150,000, including the solar panels and batteries, rainwater tanks (three 5000 L poly tanks and one 40,000 L tyre tank), greywater system, septic system, pump—things that grid-connected houses don't need to factor into the budget. Of that, around $16,000 was for the renewable energy system of 1 kW PV array, 600 Ah 24V sealed lead-acid battery bank and 3 kW SP-Pro inverter.

That equates to about $2000 per square metre, which is fairly typical of a bespoke house design, although it should be noted that most of the labour for tyre pounding and rendering was free, via workshops. The cost is comparable to what Reynolds quotes for this Global Model Earthship design (US$200/sq ft). With the benefit of hindsight I'm sure I could reduce the cost. ✸

Martin recently launched Earthship Eco Homes (www.earthshipecohomes.com.au), a sustainable design consultancy aimed at helping people with their earthship-inspired projects. He also lectures in sustainable design and product design in the School of Art, Architecture and Design at the University of South Australia. Earthship Ironbank B&B will be open for business early in 2016 and there will be ongoing open days and workshops. See www.earthshipironbank.com.au for details.

ReNew 122 covered Martin's research and initial design approach, with some of that information available online. See renew.org.au/wp-content/uploads/2012/12/Earthships-downunder.pdf.

See www.renew.org.au for more articles on Martin's PhD research and the approvals process for the earthship.

Peak plastic
The proliferation of plastic

Dorothy Broom tells a personal story of the history and sociology of consumer plastics. She is 70 years old; her lifespan encompasses the development and proliferation of petroleum-based consumer plastics.

Photo: Andri Tambunan, Greenpeace

↑ Abah Dayat is a former West Javan fisherman who now collects rubbish from the river instead. The number of fish has significantly declined due to industrial pollution.

MY TRAINING is in social science, not natural science or chemistry, so I won't try to tell you anything about marine biology, biodegradation versus photo-degradation, how big the Great Pacific Garbage Patch has become, or why we have minute plastic beads in toothpaste and face wash.

When I was a child, we had practically no modern plastics—certainly no single-use plastics. I remember food packed in plant-based cellophane, waxed (not plastic-coated) paper, alfoil, glass and cardboard. Grocery bags were paper. Food and beverage containers were returned and refilled, including the metal pie plates from the local bakery. Drinking straws were glass, metal or cardboard. Take-away drinks were sold in glass bottles or metal cans or cardboard cups with no lid. I remember getting my first few plastic bags in the 1960s which were scarce and robust so we washed and dried them so they could be reused. Cling wrap was around, but it was an expensive luxury. If anybody was concerned about pollution or harm from plastics, I didn't know about it.

By the late 1960s there was an awareness of air and water contamination. Having grown up in Los Angeles, I knew about air pollution from personal experience. Rivers in industrial areas were catching fire. After university, I read books such as *The Population Bomb* (1968) and *Limits to Growth* (1972) and began to worry about what we humans were doing to the planet. I joined small, grassroots community organisations which lobbied for environmental protection, retaining deposits on beverage containers and municipal recycling. One group took a field trip to the local tip. It was deeply disturbing to see the astonishing quantity of potentially useful material being discarded by a university town of only 30,000.

My activism on environmental issues continued after migrating to Australia in

How much plastic do Australians use and recycle?

Over one million disposable plastic grocery bags are produced every minute on this planet. They are made from fossil fuels and only one in ten of them will be recycled. Plastic use is on the rise—1,535,200 tonnes of plastics from domestic production or imported resin were consumed in Australia in 2013–14. This was an increase of 4% from the previous year. In Australia about one fifth of plastics are recycled; in 2013–14 the overall plastics recycling rate was 20.4%, down slightly from 20.8% in 2012–13.

Plastic packaging refers to material used for the containment, protection, marketing and/or handling of a product, including primary, secondary or tertiary (freight) packaging in both commercial and industrial applications. 231,300 tonnes of plastic packaging (43.9%) was recycled in 2013–14.

Non-packaging plastic refers to plastic material used for a broad range of consumer and industrial products, with varying life-spans. This includes items such as medical consumables as well as pipes, cable casings, computer cases/enclosures, furniture and building products. 82,400 tonnes of non-packaging plastic (only 8.2%) was recycled in Australia in 2013–14.

*source: National Packaging Covenant Industry Association 2013-14 National Plastics Recycling Survey published by Sustainable Resource Use Pty Ltd

Photo: Karin Malmstrom/Marine Photobank

↑ When most people hear about the gyres, or floating garbage patches, they picture a floating island of plastic. In reality, the gyres are made of tiny bits of plastic called microplastics, that are barely visible to the eye. This photo from the North Pacific Plastic Gyre shows tiny marine animals called vellelas surrounded by microplastics.

"Our plastic footprint is taking a greater toll on marine life than our carbon footprint is." Charles Moore, co-author, *Plastic Ocean*

The five gyres: garbage patches in the ocean

Most plastic in the ocean starts out as litter on land. Rain washes litter into storm drains or into the creeks, streams and rivers that lead to the ocean. After plastics enter the ocean they photo-degrade, or break down, into smaller pieces. Marine pollution can prevent photosynthetic producers such as algae and plankton from receiving enough sunlight to create nutrients. When these organisms are threatened, the entire food web is jeopardised.

It is strange where plastics end up; for example, plastics from Ireland end up on England's shore, plastics from England wash up in Sweden, and Japan's plastic litter ends up on the coast of Alaska. While plastic rubbish clogs shorelines all over the world, most of it remains at sea. Ocean gyres, or currents, lead to high concentrations of marine debris in five main areas of the world's oceans.

Plastics in landfill

Plastics don't go away, they just break down into smaller particles because the polymer chains they are made of are extremely difficult to biodegrade. "Except for a small amount that's been incinerated, every bit of plastic manufactured in the world for the last 50 years or so still remains. It's somewhere in the environment," writes Anthony Andrady, author of *Plastics and the Environment*. Australia has a strong dependence on landfills as a method of waste management. It is unknown how many of the toxins found in the buried plastic contaminate the surrounding water and soil, but it is known that plastics, which make up about 15% of landfill content, break down at much slower rates than previously thought. Hazardous substances from plastic may leach into the surrounding soil.

1971. I was part of a team that prepared a research paper on beverage containers for a parliamentary inquiry. I sewed calico bags for friends and was naïve enough to think that threats to the environment were the result of ignorance. I thought that when the potential hazards were documented and better known the problems would disappear. The task was to raise consciousness. For me, plastics remained an occasional convenience but were not yet on my radar as a particular concern.

Around the 1990s I noticed that plastic was everywhere, including in a lot of places it didn't belong such as waterways, around the necks of sea turtles and in the gullets of pelicans. Always a lover of the ocean and its inhabitants, I found the images of dead and suffering marine life enormously distressing. Efforts to ban plastic six-pack rings (seen to be a significant culprit) provoked push back from the plastics and packaging industries.

My understanding has continued to grow, along with my distress and determination to act responsibly in what has become a slow-burning catastrophe. The proliferation of plastics is not so much the result of a need as it is a consequence of industries searching out new uses for their product. Some airports now have someone who will (for a fee) wrap your luggage in kilometres of heavy-gauge cling film. Am I the only one who feels I'm losing my mind when I see this?

Last year when I participated in Plastic-Free July I grew alarmed at the amount of plastic that I use. Through planning and preparation, I have measurably reduced my plastic use, but it is discouraging to discover that I am a long way from eliminating single-use plastic. I get plastic every time I have a prescription filled, buy a piece of fresh fish, a loaf of gluten-free bread, a packet of rice cakes or a seedling for the vegie garden. Painkillers come in a plastic blister pack. Purchase anything online and it comes wrapped in plastic. So does buying from bricks-and-mortar shops, it's just that we don't usually see all the plastic in which our new shoes and clothes come packaged because shop assistants unwrap them. Go to the dentist for a check-up, or have a minor surgical procedure—more plastic! Recently when I chose take-away food not wrapped in plastic, the person who prepared my corn tortilla wore disposable plastic gloves to assemble it.

Engaging shop assistants in respectful conversation presents new challenges. Some are keen to talk, like the young man from whom I was buying fresh poultry recently. After thanking him for supplying paper carry bags, I asked whether I could forgo the thin-film plastic bag. The answer was that it was a public health requirement that he use the bag to remove the food from the display and weigh it. We commiserated about the prospect of a very hygienic dead planet. Equally unsuccessful but for different reasons, I tried to engage a produce manager about overpackaged fruit and veg, explaining that I wanted to buy zucchini but wouldn't because they were wrapped in cling film on a Styrofoam tray. He sneered 'majority rules' and turned away. Still, I make a point of explaining why I'm doing so when I decline a carry bag. Sometimes people praise and thank me for it, which I find enormously heartening in what can feel like a lonely crusade.

I am also trying to alert friends and family via social media. On my birthday, I asked all of my social media friends to give me the gift of using a KeepCup if they planned to get take-away coffee, or refusing the plastic lid if

they didn't have a KeepCup. Even though I remember how little plastic there was when I was growing up, I struggle to imagine a return to those levels when I see how many people everywhere are carrying take-away coffee in a cup with a single-use plastic lid, or buying water in plastic bottles. And then there's the litter.

In the last few years, I find myself picking up plastic litter when I walk. It has slowed my walking pace considerably and introduced me to the location of every recycling and rubbish bin on my daily routes. The way plastics blow and otherwise migrate means they can easily make their way into creeks, rivers and oceans. Litter is a constant visual reminder and signifier of how little we care for our fellow creatures, appreciate the beauty of the natural environment, or value the ecosystem. It is easy to become overwhelmed and feel impotent.

Canberra now prohibits supermarkets from giving away free plastic bags. What strikes me as a modest step in the right direction is viewed by some people as an infringement of their civil liberties, a reaction that is even more common in the USA. Recycling of soft plastics occurs through supermarket collection bins, and recycling of rigid plastics through co-mingled kerb-side collection. How much of this is actually recycled is another matter. I'm reluctant to think about it, knowing that the co-mingled recycling stream can be fouled when people include cling wrap and plastic bags (some of which are printed with the promise that they can be 'recycled', whatever that means). Enough of the wrong stuff, and the whole lot ends up on the tip face.

Less harmful plastics and 'bioplastics' aren't the solution. They don't break down in the compost or if they do, it is glacially slow. Hang around the environmental movement for awhile and you learn the four Rs—refuse, reduce, reuse, recycle— in that order. Given best estimates that only 15% of plastic is actually recycled, those first three Rs become all the more urgent. It's pointless trying to stop a flood with a sponge at the door. We need to act upstream to stop it at the source. I hope for the sake of our children and grandchildren that we are willing to make the change. ✸

Dorothy Broom is a mother, grandmother and professor emeritus of population health.

What do those triangles mean?

The Society of the Plastics Industry implemented the resin identification code in 1988 to help identify the different plastics. When it comes to recycling, the types of plastic collected differ according to council and the processing facilities available in your area, so check with your council to be sure. In many areas, rigid plastics (not able to be crumpled) of types 1 through 6 or 7 are collected, but the most commonly recycled are types 1 and 2. Soft plastics such as plastic carrier bags (type 4) are collected for recycling by RedCycle at Coles. In most kerbside collections such soft plastics are excluded as they jam the sorting machines.

1 PET

1. PET (Polyethylene teraphthalate). Clear, tough, solvent-resistant plastic, often used as a fibre. Water bottles, soda bottles, toiletry bottles, meal trays. The easiest plastic to recycle, recycled into bottles and polyester.

2 HDPE

2. HDPE (High-density polyethylene). Very common plastic, usually white or coloured. Milk and cream bottles, detergents, shampoo bottles and cleaning products. Readily recyclable.

3 PVC

3. PVC (Polyvinyl chloride). Hard, rigid plastic, may be clear. Pipes, toys, food trays, cordial and juice bottles, furniture, blister toiletry packs. Rarely recycled because PVC contains chlorine so during recycling toxic gases are released.

4 LDPE

4. LDPE (Low-density polyethylene). Soft, flexible plastic, waxy surface. Many different kinds of wrapping, carrier bags, sandwich bags, bin liners, bread bags, frozen food packs, bubble wrap, plastic lids for milk containers, squeeze bottles. Can be recycled into different kinds of wrapping.

5 PP

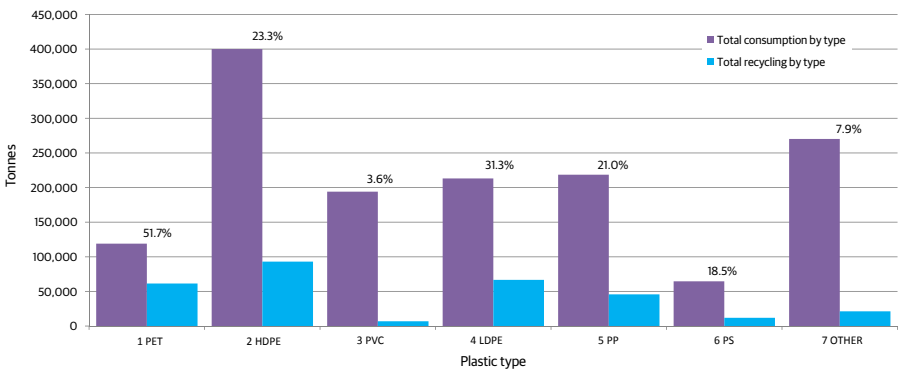
5. PP (Polypropylene). Hard but still flexible plastic. Take-away containers, trays for microwaveable meals, ice cream containers and lids, clothing, bottles, tubs and ropes. Can be recycled into fibres.

6 PS

6. PS (Polystyrene). Clear, glassy, rigid, brittle plastic. Yoghurt containers, margarine/ butter containers, foam food trays, burger boxes, vending cups, protective transit packaging. Polystyrene foam is a problem as it's bulky yet lightweight and that makes it uneconomical to transport for recycling.

7 OTHER

7. Any other plastics. A composite of any of the above or plastics not readily recyclable such as acrylic, nylon, polycarbonate and polyurethane. Includes clear rigid plastic sheeting (window glass alternatives), electrical equipment components, plastic lampshades and fittings, foam insulation. Avoid it if you can.



↑ Consumption and recycling rates for each plastic type in Australia in 2012–2013. Recycling includes export for reprocessing, which in many cases is higher than domestic reprocessing, e.g. 14,900 tonnes of PET were reprocessed domestically compared to 46,600 tonnes exported. The recycling rate for some plastic types is very low, but this may be partly due to their use in items with a longer life, e.g. PVC pipes. Data source: 2012–13 National Plastics Recycling Survey—National Packaging Covenant Industry Association.

Image: www.5gyres.org

↑ Microbeads are very small plastic particles, made from polyethylene or polypropylene, with most around 1mm across, like grains of sand. Added to some toothpaste and exfoliants, they are a significant pollutant in the ocean, where they have been found in the gut of many marine creatures. Many companies have now stopped their use and there are calls for bans, including a ban just announced in California.

Tips to reduce your plastic load

1. Just say no! When offered a plastic bag, refuse it. Keep a reusable bag in your pocket or bag.
2. Don't buy vegies in plastic trays or wrap. If you can't find what you want without the added plastic, find the section manager and complain. Use the paper mushroom bags or bring your own reusable bags for vegies that need a bag.
3. Look for produce in glass bottles or jars, preferably with metal lids. Steel lids can go in with the recycling as they are separated by magnets at the recycling centre. Even better, find a local bulk buy store and take your own containers (though we realise this is not an option available to many).
4. Avoid using cling wrap. Get a good set of storage containers, glass or plastic, and use and reuse them for storing your vegies, cheese and leftovers. Or use and resue alfoil.
5. When buying electronics goods, look for the smallest device that will do the job. This reduces the plastic volume in the goods themselves, as well as the packaging. Many manufacturers are now omitting plastic completely from their packaging. Reward them by favouring their products.
6. Don't use products containing microbeads. Microbeads are tiny particles of plastic that are added to some personal care products such as toothpaste and facial scrubs. Wastewater treatment plants are not designed to filter out microbeads and they end up in the ocean.
7. Avoid disposable tableware of all types. Bring your own cup, say no to straws, and if you can't avoid disposable cutlery, ask them for degradable types such as wood or bamboo. If they don't have them, ask them to get them instead of plastic. Even better, get yourself a set of camping cutlery; folding sets fit easily in a pocket or purse.
8. Wear natural fibres instead of synthetics if possible. While synthetics tend to perform better (and some people are allergic to some natural fibres or find them uncomfortable), they are a considerable source of micro particles in the environment.
9. Consider bottled water to be the incredibly unnecessary product that it is. Get yourself a good stainless steel water bottle and avoid plastic bottled drinks if at all possible.
10. Read up on what others have done. There are some great books out there on going completely plastic free, such as *Plastic Free—How I Kicked the Plastic Habit and How You Can Too* by Beth Terry or check out her website at www.myplasticfreelife.com.

"Litter is a constant visual reminder and signifier of how little we care for our fellow creatures, appreciate the beauty of the natural environment, or value the ecosystem."

Going Zero Waste: A rock and a hard place

by Sarah Coles

After calculating that the average Australian creates 65kg of plastic waste per annum I tried a zero-waste experiment. I made the mistake of telling my partner—a peak oil geek with a stack of back issues of *ReNew* the size of a converted freezer—who launched into a lecture we shall call, "Oh No What is the Point?" He raised some salient questions such as: "Are you going to use the internet during that week?" "Are you going to catch a bus?" "Will you use electricity?"—his point being that to be truly zero waste you have to cut your ties with industrial society. While I didn't want to disappoint him by being smug about my KeepCup, I wasn't ready to quit my job and move to the Papuan highlands.

The big challenge for me is share-house living and the compromises that entails. I live with hedonists who love nothing more than to throw lobster claws in with the plastic waste and torment me by cranking the ducted heating to 23°C. I tried to convert them, "Come with joy into the house of zero waste", failed, and had to go it alone. It occurred to me that, considering the amount of planning it requires, to be zero waste is a part-time job. I had so many questions: Do cardboard boxes count if I compost them? Do I have to get a feather quill? Whose idea was it to stick these stupid stickers on apples? Does the plastic wrapping the papaya count if I gleaned it out of a dumpster?

Post-experiment I will keep trying to create the least amount of waste possible because I'm a fan of the ocean, a proud supporter of Surfrider Foundaton, and am none too keen on plastic vortexes. As a bonus, going zero waste may help to distance me from over-consumption. Zero waste is challenging: we live in a world where people want to give you a plastic fork every chance they get. We waste in a world where only 20% of plastics get recycled but people get an endorphin rush separating their rubbish into the different council bins. It can feel futile to try to change something at a grassroots level but it's better than landfill. ✷

Photos: Christian Gahle, nova-Institut GmbH - Work by Christian Gahle, nova-Institut GmbH. Licensed under CC BY-SA 3.0 via Commons.

← These packaging peanuts are a bioplastic made from thermoplastic starch, the most common form of bioplastic. Starch-based bioplastics are often blended with plastics that are not biodegradable, but have a lower carbon footprint than petroleum-based plastics. The packaging blister pack is made of cellulose, the oldest bioplastic and still, some would argue, the best. The pen is made from polylactide (PLA), a bioplastic produced from corn or dextrose. It shares characteristics with PET, but it is biodegradable and may be compostable. Many bioplastics are marked as compostable, but that is often only in industrial facilities as these operate at a higher heat. In home compost, they may break down, but very slowly.

Bioplastics: Two steps forward, one step back?

Bioplastics are made from plants instead of fossil fuels, the most common being polylactic acid (PLA), a polymer made out of plant sugars and used to manufacture plastic water bottles, cups and containers. Bioplastics biodegrade faster than petroleum-based plastics and their production uses less fossil fuels and produces less carbon dioxide emissions and toxic waste. Bioplastics aren't new but they account for less than 1% of the global plastics market, though their uptake is predicted to be huge. Standards vary about how much plant material a plastic has to contain in order to earn the title bioplastic. In Japan, it must contain a minimum of 25%, in the USA, 7%, and in Australia, 50%.

Bioplastics have several downsides. One study [see further reading] shows that "None of the biobased plastics currently in commercial use or under development are fully sustainable." Co-polymers are the Frankenstein of plastics, they are manufactured out of petroleum or gas-based plastics combined with biobased plastics and additives. Most products are indulging in a spot of greenwash when they flaunt the words 'made partially from plants' on their products. The PlantBottle by Coca Cola is made up of 30% plant-based and 70% petroleum-based plastic, for example. Combining bioplastics with regular petroleum-based plastics often results in a product that can't be recycled because of its biodegradable content, but can't be composted because it contains petrochemicals. Drop-in plastics were created to deal with this problem. They are bioplastics that don't biodegrade very much and so are more compatible with petroleum-based plastics and can often be recycled. Drop-ins are touted as the next big thing but creating a bioplastic that doesn't biodegrade negates some of the benefits.

The most common bioplastics are made out of corn, potato, sugarcane and beetroot, all food sources. In this way bioplastics contribute to the global food crisis by taking over large areas of land previously used to grow food crops. The market for bioplastics is growing by 30% a year so the loss of land can have a serious impact. Some bioplastics are made from non-food sources such as switchgrass and agricultural waste but these require expensive technology to create. These types of bioplastic could prove promising further down the track. Bioplastics that are made from 100% plant-based materials often still wind up in landfill where, due to a lack of microbes, light and oxygen, they behave similarly to petroleum-based plastics and don't break down, or if they do, they degrade anaerobically (without oxygen), releasing methane, a potent greenhouse gas.

The most sustainable form of bioplastic may be the oldest: cellophane. Cellophane is made by processing cellulose from trees into rayon using carbon disulphide. This is converted into cellophane by immersion in acid baths.

FURTHER READING

www.orionmagazine.org/article/polymers-are-forever

Plastic Ocean by Charles Moore and Cassandra Phillips, 2011, New York: Avery Books

www.bioplastics.org.au/faq/what-is-the-as4736-standard-for-biodegradable-plastics

Rubbish! The Archaeology of Garbage by C Murphy and W Rathje, 2001, University of Arizona Press

www.adrift.org.au

www.surfrider.org.au/rise_above_plastics

'Sustainability of Bio-based Plastics: General Comparative Analysis' by CR Álvarez-Chávez et al, 2011 , 3rd International Workshop on Advances in Cleaner Production, São Paulo, Brazil.

A PET project
Hothouse in Canberra

Environment teacher Deb Shaw found an innovative way to teach the principles of reduce, reuse, recycle to her students, at the same time as helping the school's vegie seedlings thrive in frosty Canberra.

"A PICTURE in a magazine of a greenhouse built from reused drink bottles planted the initial seed of the idea," says Deb Shaw, the environment teacher at Wanniassa Hills Primary School in Canberra.

Deb had been on the lookout for projects with a strong sustainability focus to fit in with the school's environmental education program. With a new kitchen garden at the school, a greenhouse built from reused materials fitted the bill perfectly.

"Students were able to do the building, which was great in itself, plus they also got to see a waste material like PET bottles getting used," says Deb. It helped the students to both think about the amount of waste in their own homes and to consider how waste could be used as a resource instead of being put in the bin.

An added bonus, of course, was that the result would be really useful in the kitchen garden. The hothouse enables the school to grow seedlings all year round, preserving plants through the school holidays and helping to compensate for Canberra's short growing season.

To design the hothouse, Deb found a website with instructions and measurements, which they then adapted to suit their needs.

The school's hothouse ended up using almost 2000 PET bottles. Students enthusiastically collected bottles over a period of months, with most coming from home and some from the "Aladdin's Cave of treasures" at the rubbish tip.

The school didn't specify particular bottle sizes as they realised that could dampen enthusiasm. "Bring in everything" was the message, and students then sorted the bottles into sizes and shapes that went together.

↑ Students threading the bottles onto the canes.

→ Fitting the completed strings of bottles into the frame to make the greenhouse walls.

The design is clever and simple, and the students were able to take part in almost every stage of the construction. A builder-parent donated the wood and built the frame, and Bunnings donated the bamboo stakes which hold the bottles in place.

The students cut the bottoms off the PET bottles, stacked them inside each other and threaded them on the bamboo stakes to make the wall and roof structures.

The students also slotted the bamboo stakes into the pre-drilled holes on the frame to make the walls. The pre-drilled holes meant they needed to be careful about which bottle sizes they used together to ensure a reasonably snug fit.

The result looks great and has been working really well since completion in 2012. The school hasn't taken temperature measurements yet, but the seedlings have a much higher success rate inside the greenhouse than out.

It prevents plants being affected by frost even on icy Canberra mornings in late winter and early spring. "We've had an aloe vera plant in there all this year," says Deb, "which just wouldn't have survived without the greenhouse."

The structure isn't airtight, with small gaps between the rows of bottles, and Deb would like to better seal the roof (and possibly also the walls) at some stage. There are advantages, though, to having gaps in the

↑ The resulting greenhouse used around 2000 PET bottles collected by students and parents, including from the "Aladdin's Cave of treasures" at the tip. Completed in 2012, it's been a great success.

roof, as the rain can then water the seedlings.

The hothouse keeps birds out, and largely prevents access by cabbage white moths, snails and slugs. A few snails do get in, but they're easily controlled by hand (and shoe!).

Many schools have visited to see the greenhouse in action, with some taking the idea back to their schools or adapting it slightly. For example, one school used polycarbonate corrugated sheets for the roof, instead of the bottles, for a more sealed result.

The hothouse gets used mainly in late winter and early spring to germinate seedlings, but there's something growing in it year round. Even in summer they use it to protect plants, but they cover it in shade cloth to keep the temperature down.

Early this year a grandparent donated geranium cuttings that were potted up by the students, and then kept safe and warm in the greenhouse until being given as presents on Mother's Day. Yet another great example of reusing resources from this low-cost innovative project. ✷

Wanniassa Hills Primary School has a a strong focus on environmental education and educating students for a sustainable future. The school is actively involved in the ACT Actsmart Schools Program (www.actsmart.act.gov.au).

You can find the hothouse instructions adapted by Wanniassa Hills Primary School at www.bit.ly/PETBOTGH2.

Another website has tracked the performance of their own PET bottle greenhouse over time, and it has performed and lasted well: andrewdouse.hubpages.com/hub/plasticbottlegreenhouse.

New choices in lighting
An LED buyers guide

The move to LED lighting has become mainstream, with more options appearing constantly. Lance Turner takes a look at what's available.

FOR many homes, lighting is one of the most overlooked aspects. Incorrect lighting can make a room unpleasant to be in, or make it more difficult to perform tasks such as reading or cooking. Getting it right can take a bit of effort, and though this guide won't answer all your questions about lighting design, hopefully it will give you a headstart when thinking about the types of lighting to use and the questions to ask.

With almost all lighting technology moving towards LEDs, this guide focuses on LED bulbs. Even the reasonably efficient technologies such as fluorescent tubes and compact fluorescent lamps are rapidly being replaced by LED lighting. It's likely that within 10 years, most other light sources will have disappeared in favour of the robustness, longevity and energy efficiency of LEDs.

→ It looks like a regular oyster-style fitting, but the XL-LED 18 watt Circular Ceiling Light from Crompton Lighting produces 1100 lumens of 4000 K neutral white light or 1200 lumens of 5600 K daylight white light from a maximum of 18 watts.

What is an LED?

LEDs (light emitting diodes) are unlike any other lighting system. They contain no glass tubes or heating filaments, instead using a small piece of semiconductor material (as used in computer chips) that emits light directly when a current is passed through it.

LEDs produce light in a range of colours, without the need for coloured filters; thus, to get white light, a phosphor is used over a blue or UV LED chip, similar to what's used in a fluorescent tube.

Note that the LED is actually the small light producing element(s) in a light bulb or fitting, but most people now erroneously refer to LEDs as the entire bulb or fitting.

LED specs

There are a number of specifications that are useful to consider when buying LED lights.

BULB WATTAGE

All light bulbs have a wattage rating, which measures how much power they consume. This is where LEDs have a shining advantage over older, more inefficient technologies. For domestic LED lights, the rating is usually between one and 20 watts, compared to a typical incandescent rating of 25 to 100 watts.

LIGHT OUTPUT:
LUMENS, LUX AND BEAM ANGLE

Many LED bulbs include an 'equivalent-to' wattage rating, showing the wattage of the incandescent bulb that the LED bulb is equivalent to in terms of light output. For example, a six watt LED bulb might be rated as putting out the same amount of light as a 50 watt incandescent.

This 'equivalent-to' rating is based on the light output in **lumens**. The lumen rating of an LED bulb, usually included on the packaging, measures the total light output, relative to the response of the human eye.

For bulbs that are suitable for general room lighting—those with wide beam angles, above 60 degrees, but preferably 90 degrees or more—matching lumens for lumens should give you the result you need. Thus, for these types of lights (these are generally found in the common Edison screw, bayonet or 'oyster' fittings), the 'equivalent-to' rating should be all you need to determine if the bulb is a suitable replacement.

For directional lights, often known as spot lights, it's a bit different. These are lights with a smaller beam angle, up to around 60 degrees. Such lights are generally used for task lighting, directed onto a desk or work area. Halogen downlights are an example of these—it's because of their small beam angle that so many of them were needed to light a room! For these spot lights, small differences in the beam angle can make a big difference in how bright the light appears. Many people have had the experience of buying an LED bulb which was meant to be equivalent to a 50 watt halogen, but found that it appears much less bright. The lumens may have been lower, but more likely the beam angle was narrower, creating a bright light directly under

the light but darker patches around it.

So just what is the **beam angle?** Beam angle is the angle at which the light is dispersed—usually considered to be the angle at which intensity, or brightness, falls below 50% of the brightness directly under the light.

When comparing directional lights, you can compare both the **beam angle** and lumens to give you an idea of the lighting levels the lamp will produce. A spot light with a small beam angle (say 30 degrees) will concentrate its light intensity in a small area directly underneath and 15 degrees either side of the light. A spot light with a larger beam angle (say 60 degrees) will spread its light output over a much larger area, and thus the intensity will be lower, even if it has the same lumen rating.

So, when shopping for replacement/retrofit spot lights, look for bulbs that have similar beam angle and lumen figures as the bulbs you are replacing. That way you are assured of similar brightness and light distribution.

However, we should mention that the limitation experienced with halogen downlights of beam angles generally not being available wider than 60° does not exist with LEDs. While many LED downlight retrofit bulbs have narrow beam angles like halogens, you can also buy LED downlight bulbs with wide beam angles, such as those from Click, with a 100° beam angle. Wide-angle bulbs are ideal replacement bulbs for general illumination where multiple downlight fittings have been used to light a room. The end result is more even illumination, with less pooling of light. Just make sure you choose bulbs with adequate lumen ratings to provide appropriate illumination levels.

This leads us to the measure of light intensity, which is **lux**. For an example of how beam angle affects lux levels, see the diagram below. Lux diagrams are sometimes included on spot light packaging, but if not, you can calculate it based on lumens, distance from the light source and the beam (or lens) angle of the light. See www.bit.ly/1NbqDsE and www.bit.ly/1LxK2Ex for two such calculators.

While the desired level of light intensity is subjective, there are standard recommended lighting levels for particular situations, which can be found in the Australian/New Zealand Standard for Interior Lighting AS/NZS 1680. Typical levels can be found in a range of publications and websites, such as www.bit.ly/1TvHokf.

EFFICACY: LUMENS PER WATT

The number of lumens produced per watt of electricity used gives you a way of comparing the efficacy (or efficiency) of LED lights. For instance, if you have two LED bulbs, one producing 500 lumens and one producing 600, but both using six watts, then you immediately know which is the more efficient. Generally, the higher the lumens per watt, the better, although the light also needs to be fit for purpose, in terms of beam angle and light quality. Currently, a baseline is to aim for at least 60 lumens per watt (making them at least as good as the best compact fluoros), although that will continue to improve over time. There are some lights already available providing 100 lumens per watt.

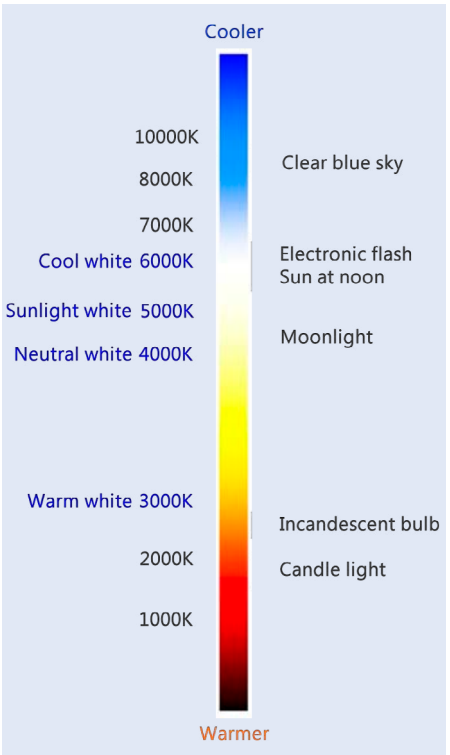
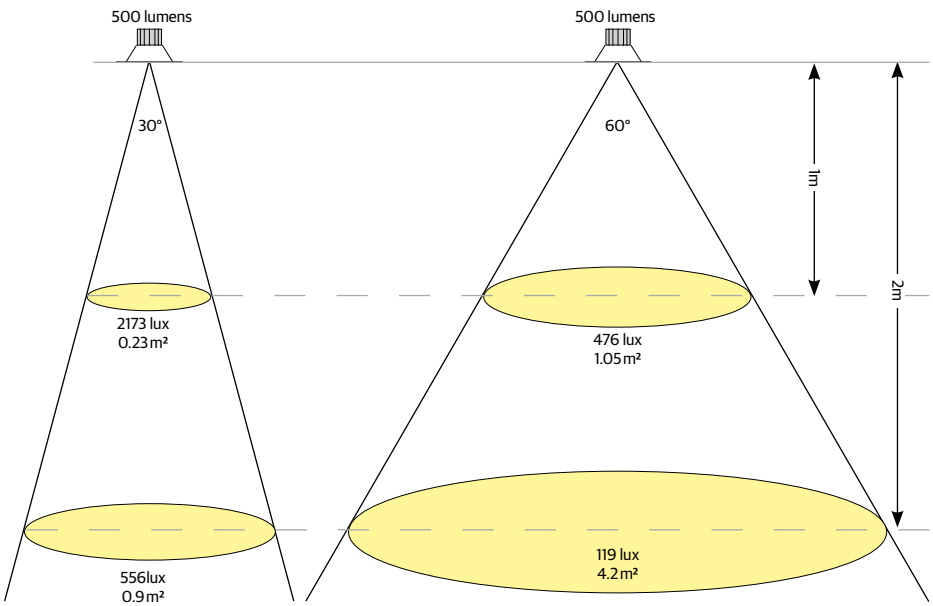


Image: www.buenoopto.com (modified).

↑ Colour temperature varies from low to high, corresponding to warmer to cooler. Warmer light is usually better for lounge rooms, or rooms frequented after dark, whereas cooler light is often more suited for work areas and kitchens. But ultimately it comes down to personal preference.



↑ Lighting intensity levels (lux) depend on both the total light produced by the lamp (in lumens) and the beam angle. For the same light output, wider beam angles result in lower illuminance levels but more even illumination, so go for narrower beam angles for task lighting and wider angles for general ambient lighting.

LIGHT QUALITY: COLOUR TEMPERATURE AND CRI

Beyond the light output, there are two important aspects of light quality that will affect the light's suitability, including the colour temperature and colour rendering index (CRI).

The light's colour temperature, usually specified in Kelvin (K), tells you the type of light you will get. Warm white is generally any number up to 4000K. Neutral white is 4000K to 5500K and cool white or daylight white is 5500K and above. Different manufacturers use different ranges, but remember that the lower the number, the warmer, and redder, the light, and the higher the number, the cooler and hence bluer the light. Warm white is the colour many of us are used to from the original

"Halogen downlights come in two styles—12 volt MR16 (which include a voltage transformer) or 240 volt GU10—and there are LED replacements for both styles."

tungsten incandescent lights, but neutral or cool whites may be better for close-up tasks or where higher contrast is required. (See en.wikipedia.org/wiki/Color_temperature.)

Another important measure of light quality is the colour rendering index, or CRI. This is a number from 0 to 100 that tells you how well the light will render colours, with 100 being the best. Most LEDs are above a CRI of 80 nowadays, and this is considered good enough for domestic lighting. Some high-end fittings will use LEDs with CRIs over 90, but these fittings tend to cost a bit more. But if you are using LED lights in your art studio, for instance, then you probably want the highest CRI lights you can find.

LIFESPAN AND LUMEN MAINTENANCE

The rated lifespan of LED lights is given in thousands of hours, just like other forms of lighting. Normally you will see figures somewhere between 10,000 and 100,000 hours, depending on quality, design, and how realistic the manufacturer is with these figures. But what does that lifespan number actually mean? Will the bulb die after that many hours?

Like other lighting types, LED lights lose a small percentage of their light output over time. The rated lifespan usually refers to an output in lumens of 70% of the original figure. So if a light is rated at 1000 lumens and 20,000 hours, then at 20,000 hours it should still produce at least 700 lumens. This is the lumen maintenance figure.

Unlike other lighting types, which tend to suffer complete failure before too much degradation of output has occurred, LED lamps that have reached their technical end of life can still be used where less light is required, giving them an even longer lifespan. They will still draw the same power, so their efficacy will have dropped, but this may not be an issue, for example, if they are moved to rooms such as bedrooms and laundries, where they see only short-term intermittent use.

Retrofitting LED bulbs

If you are building or renovating, you are not limited in which LED fittings or lamps you decide on, as your favourite light fitting style can be integrated into the new build. But if you are looking to use LEDs in an existing home then there will be some limitations, depending on the amount of work you are willing to do and your budget.

↑ These two downlight retrofit bulbs from Crompton Lighting look similar, but are quite different. The bulb on the left has a GU10 base and runs straight from mains voltage, so requires no transformer. The other bulb has a GU5.3 base (commonly referred to as an MR16 lamp) and requires 12 volts and hence the use of a transformer.

HALOGEN DOWNLIGHT REPLACEMENTS

Replacing inefficient halogen downlights is where the domestic LED lighting industry started, at least here in Australia. The easiest retrofit for halogen downlights is a direct plug-in LED bulb for the original halogen bulb.

Halogen downlights come in two styles—12 volt MR16 (which include a voltage transformer) or 240 volt GU10—and there are LED replacements for both styles. It will be printed on your bulb which type it is—you can also tell by looking at the connector. The biggest problem with LED halogen downlight replacements is that they can run hot in the cramped space of a halogen downlight fitting, and heat can be damaging to the electronics in LED bulbs. However, improvements in LED efficacy and smarter bulb design mean this is becoming less of a problem (see box 'Keeping your LEDs cool').

Another consideration is the transformer. For GU10 bulbs, which run directly from 240 volts, there is no transformer—you simply fit the LED bulb and you're done. But for MR16 12 V halogens you may have to look at a transformer replacement for each bulb.

The transformer's function is to drop the 240 volt mains voltage down to 12 volts. Being nothing more than a heating element, halogen bulbs are rather forgiving in the type of power they receive. But, as electronic devices, LED bulbs are not always compatible with the average halogen transformer.

Electronic transformers (supplied with most newer MR16 halogen fittings) are smaller, lighter and more efficient, but they are not really designed for the small loads LED bulbs place on them, and many will malfunction, resulting in lights that flash or turn off after a brief period. When retrofitting with LED MR16 bulbs we highly recommend using transformers designed specifically for running LED bulbs. This requires the old transformers to be removed and new ones fitted—usually a job for an electrician. However, if your fittings do currently have electronic transformers, try the new LED bulbs with them and see if they operate correctly—you might be able to avoid swapping all the transformers. You are unlikely to cause any damage to either bulb or transformer and it will be immediately obvious if there is a compatibility problem. We don't recommend that any LED bulbs are used on the old ferromagnetic transformers as the transformer may be wasting more energy than the LED bulb is actually using! A better solution is a complete fitting replacement to eliminate the need for transformers altogether. The old fittings can be replaced with either GU10 fittings and GU10 LED bulbs, or, preferably, dedicated LED fittings (see 'Dedicated LED fittings' later in this article).

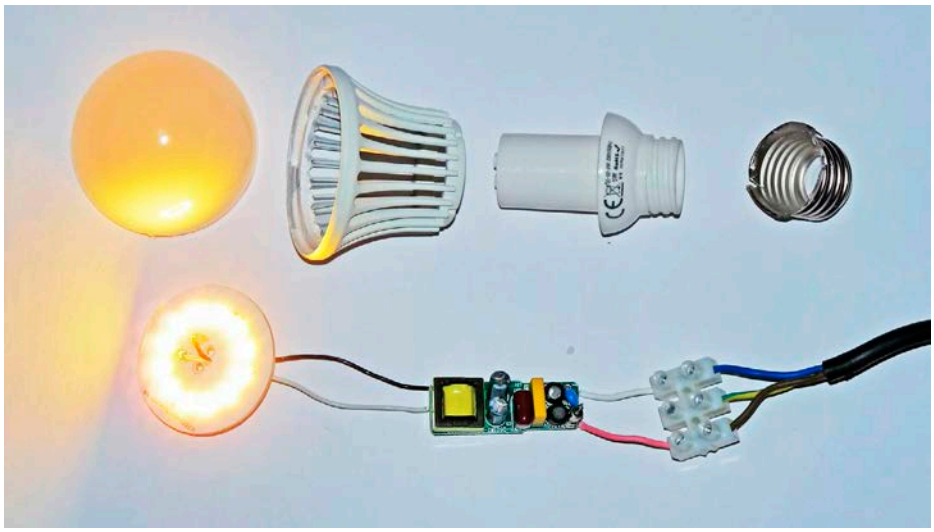


Image: Wikipedia user Dmitry G

↑ Inside a typical LED Edison screw replacement bulb. Clockwise from top-left (ignoring the terminal block, which is not part of the bulb) are: plastic diffuser dome, metal heatsink, plastic body/insulator, screw base, LED driver, and LED array.

↑ High-output GLS bulbs are few and far between in Australia, but this is slowly changing. This 18 watt unit from Philips puts out 2000 lumens and should be available here by the end of the year.

GLS BULB REPLACEMENTS—BAYONET AND EDISON SCREW FITTINGS

GLS stands for general lighting service—in short, the standard-sized incandescent bulbs that everyone knows about, that were phased out with the first stage of the lighting MEPS (minimum energy performance standards). If you have standard light fittings that take bayonet (BC15 or BC22) or Edison screw (ES14 or ES27) sized bulbs, then using LEDs may be as simple as swapping bulbs—with some considerations.

GLS lamps fall into two broad categories. The first type, a power LED bulb, uses a small number of power LEDs (LEDs fall into three broad categories—low power, under 100 mW, medium power, up to 0.5 W, and power LEDs, which are generally 0.5 W and above), or a greater number of lower power LEDs, such as the common 5050 (5 x 5 mm) sized devices. The LEDs are all mounted on one (usually circular) circuit board with a diffuse or clear dome over the top. This type of bulb usually has a metal or ceramic body with lots of heatsink fins for cooling.

The other type is known as a corn bulb.

"GLS lamps fall into two broad categories: power LED bulbs, which use a small number of power LEDs, and corn bulbs, which use dozens to hundreds of low-power LEDs."

Keeping your LEDs cool

The primary consideration when using LED retrofit bulbs is heat dissipation. Incandescent lamps are designed to run hot, but for LEDs, heat is the enemy.

Most LED bulbs have adequate heatsinking, provided they are used in fittings that allow for some convective airflow. However, there are still bulbs pushing the limits, with too much wattage and too little heatsink surface area to dissipate the generated heat. This problem is most common in downlight replacement lamps, usually in the 12 volt MR16 and GU10 types, but some Edison screw/bayonet, candle style and 'fancy' style (the little round globes used in chandeliers and the like) replacement bulbs have less than adequate surface area.

However, provided you have a good-quality, well-designed bulb, the main issue to be aware of is the type of fitting you are using it in. There's no point having lots of heatsinking if the bulb is used in a fitting that simply doesn't allow the heat to dissipate. This is less of a problem nowadays, as LEDs are more efficient and so produce less heat per rated watt, but it's still something to be mindful of when selecting bulbs and fittings. Fittings with at least a few cooling holes near the top to let warm air escape should be used. If you have sealed fittings such as oyster fittings, you are better off replacing the fitting with a dedicated LED unit, as the entire metal base of the fitting is used as a heatsink.

Heatsink material and finish also play a role. There are still some manufacturers making bulbs with chrome-plated heatsinks. Shiny surfaces like chrome plating do not emit heat well and a chromed heatsink may cause a lamp to run 20 °C hotter than the same heatsink in a black anodised or high emissivity finish.

Some (although very few) LED bulbs use tiny integrated fans, allowing LED lamps up to 10 watts to be used in a standard downlight fitting. The disadvantage of this is that you introduce the problems experienced with all fan-cooled devices—fan noise, bearing wear and dust build-up.

Another method of dealing with heat is to make the lamp much longer than the original halogen bulb. This is how the Brightgreen retrofit bulbs work, as do many others including low-cost Chinese models. This only works in fittings with an open back, with the bulb connector on a cable rather than fixed to a bracket. For fittings where the bulb connector is fixed in place you can only use replacement lamps the same length as the original halogen.

This type get its name from its appearance, as a corn bulb consists of dozens to hundreds of low-power LEDs, usually surface mounted, fitted to multiple circuit boards that are then assembled to form the body of the lamp. Corn lamps may or may not have a plastic cover to protect the LEDs. Units without a cover pose more of an electrical shock hazard and so only fully enclosed units should be used.

Many retailers of power LED bulbs will dismiss corn bulbs as being cheap and low-grade. While this can be true, many not only perform well, but their driver designs are amazingly simple, so there's very little that can go wrong.

FLUORO REPLACEMENTS

Despite their relatively high efficiency, even fluoro tubes are being replaced by LEDs. Reasons to do this include flicker elimination, dimmability and the reduction of toxic materials (fluoros use mercury, LEDs don't).

Replacing fluoro tubes can be done with a simple tube replacement with an equivalent LED tube (sometimes requiring bypassing of the fluoro fitting's ballast), although for a nicer appearance a complete replacement LED panel fitting is often the best option. LED panel lights have a diffuse lens and smooth integrated appearance and generally look a lot nicer than the fluoro fittings they replace.

Dedicated LED fittings

When building or renovating it's best to consider dedicated LED fittings. Unlike retrofit lamps, these are a complete fitting designed as an LED light from the ground up.

The fitting usually has an array of LEDs mounted on a circuit board which is attached to the base of the fitting. Also included is a matching driver (see 'LED drivers' section for more on drivers), usually also mounted inside the fitting. The metallic circuit board is attached to a heatsink or the metal fitting itself to dissipate heat. So, while an LED fitting may look like a regular fitting that uses replaceable bulbs, inside they are very different—there are no bulb sockets, and the LED array is designed to last the lifetime of the fitting (anywhere from 15,000 to 100,000 hours of runtime). While both the LED array and driver can usually be easily replaced by a suitably experienced electrician (or a competent DIYer), this is rarely needed.

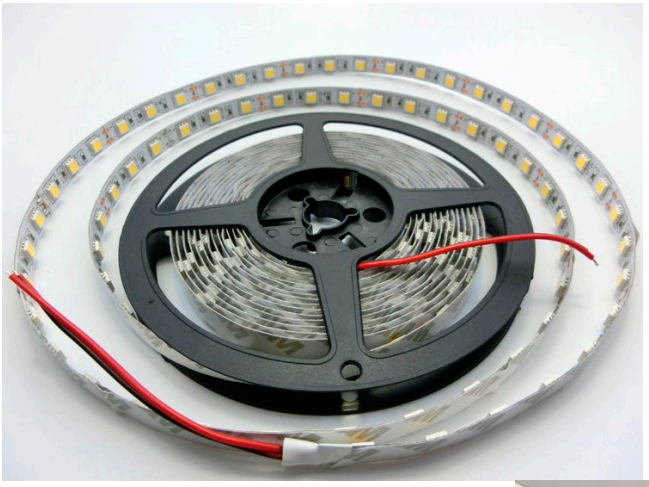
Dedicated fittings come in a large variety of shapes and sizes, from flat panels for office lighting, to flush-fitting downlights, wall washers, uplighters, oyster fittings (see example p. 70) and even outdoor floodlights.

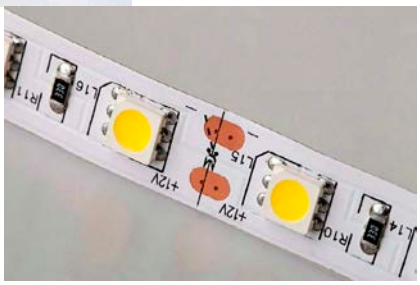
Driverless LED arrays are also available. These consist of strings of many low-power LED chips bonded to a ceramic substrate. There are so many LEDs in each string that they can handle full mains voltage without the need of a driver. They do have a maximum input voltage, above which they can be damaged, but most driverless arrays can handle voltages typically seen in most homes. These arrays have mainly been seen in outdoor floodlights so far, although they could be used in any light fitting.

Even if you are not renovating or building, using a dedicated LED fitting will usually give the best result, regardless of the type and style. However, replacing a complete fitting rather than just swapping a bulb will cost more and usually needs an electrician, increasing the cost considerably.

Halogen downlight fittings are usually easily removed from the ceiling and there are LED equivalents that simply slide into the same hole. Unless the new fitting requires a larger hole, the only onerous requirement is that an electrician might be needed to make the electrical connection (although some just plug in to power points in the ceiling).

The same applies to surface-mounted fittings such as oyster fittings and the like—dedicated LED versions are usually available and they just need to be installed by a qualified electrician.





↑ LED ribbon or strip on a roll usually comes with short flying leads already attached. Connection to a power supply is done either using a terminal block or screw-on sockets, which mate with the plugs used on most 12 VDC general-purpose power supplies. LED ribbon can be cut every three or six LEDs (depending on the ribbon design, see the cut point at right) using just a pair of scissors, although you will need to solder new wires to the cut ends, so some DIY skill is required (solderless clips are available but they are less reliable than soldered joints).

LED RIBBONS

LED ribbons and strips are available by the roll where they are just unrolled, stuck into place and power applied. These are ideal for hidden lighting above cupboards and pelmets.

The other advantage with LED ribbons is that they are a DIY solution. Because they run from extra-low voltage DC, such as 12 or 24 volts, you can install them yourself and power them from a suitable mains power supply or plugpack, which are readily available from electronics stores.

LED strips are also available in complete kits precut to shorter lengths, say 300 mm or 500 mm. They usually have short leads with plugs and sockets already fitted and you simply stick them in place, plug them together and plug them into the matching power supply supplied in the kit.

OUTDOOR LIGHTING

Outdoor lighting is also rapidly becoming LED-powered, with halogen floodlights and spotlights being replaced with LED equivalents that use 20% of the power and put out more light. Other forms of outdoor LED lights include deck lights (like downlights, but recessed into

the deck to point upwards instead), highlighters (for specific garden features such as interesting plants or statues), path lights, bollards and every other type of light that previously used halogen or incandescent lamps.

There are also solar-powered lights which, while often low-powered units, can make it easy to light areas with no access to electricity.

On the commercial level, there are large ES40-based streetlight lamps, waterproof outdoor floodlights, commercial bay lighting and just about any other form of lighting you can think of. And, of course, lit signage is almost completely dominated by LEDs nowadays. Even neon has largely been replaced with flexible LED 'neon' materials.

Special features

Nothing comes close to LEDs for special features. Because they are electronic components, you can easily control them to do pretty much anything you like.

Bulbs and fittings are available that can be operated using remote controls, or even over wi-fi or Bluetooth via your phone or tablet. Functions include dimming, soft start (where the brightness ramps up over a second or two), colour temperature adjustment and complete colour selection, depending on the bulb design and the LEDs used. Most devices like this use controllers that remember the last settings used, even when turned off. This is a level of versatility not seen outside of commercial lighting controllers until LED bulbs hit the market.

There are several proprietary systems that allow control using a home's wi-fi network and apps on smartphones and tablets. A typical example is the Philips Hue system (www.meethue.com), which uses smart bulbs that talk to a hub (also called the bridge as it links the wi-fi to the bulb control network). The bridge can handle up to 50 bulbs and allows them to be operated over the web, so you can control your lighting from anywhere.

There are a number of similar systems, including some with wi-fi enabled bulbs that don't even need a bridge, simplifying the system further, such as the Ilumi smartbulbs (www.ilumi.co).

Lighting can also be controlled using a broader smart home system such as the Clipsal C-Bus system, which controls lighting, environmental systems, security, home theatre and even keyless entry. If you are planning a smart home then check to see what lighting control options are included.

Of course, all of these smart control systems require that the light switches are left on so that the bulbs or fittings have power. There is a small standby power draw for each bulb, fitting or hub, although standby for each unit is generally less than 1 watt. However, if you have many such lights, the total standby may be several watts in total, adding a small but measurable amount to energy consumption; but this is tiny compared to the energy savings from using LEDs over other forms of lighting.

Many newer LED bulbs, including retrofit replacement bulbs, are also dimmable using standard triac dimmers (the dimmers used for incandescent bulbs), although some work with a particular type of dimming only, such as leading-edge or trailing-edge dimming. If your bulb has these restrictions then you must use the correct type of dimmer. Also bear in mind that some dimmable bulbs may flicker slightly when dimmed down to a low light level.

LED drivers—integrated or separate

Most LED lighting has a driver built-in. LEDs require careful control of the current flowing through them, so an electronic circuit called a driver is used to do this.

For retrofit bulbs, the driver is built into the bulb, so you don't have to worry about it. With dedicated fittings, the driver may be integrated as part of the fitting or separated from it.

Having the driver separated from the LEDs means that it will not be affected by the heat the LEDs generate (and any heat it generates won't overheat the LEDs)—provided the driver is not mounted on top of the heatsink as is the case with some fittings! It also means the LED fitting and the driver can be replaced individually should there be a problem with either, thus reducing replacement costs.

↑ Corn bulbs should always have full insulating covers for safety.

Because LED configurations usually fall into specific voltage and current ranges and many after-market drivers have flexible output voltage ranges, you don't have to use a driver identical to the original in order to repair a failed fitting—often a generic off-the-shelf driver will do, provided it has the same current output as the original and its output voltage range encompasses the LEDs' forward voltage requirements.

Zero-energy options

While this article deals with electric lighting, there are a couple of other options that should be considered. Skylights and light-pipe systems can provide more than adequate lighting levels with no use of electricity at all and, if well placed, won't heat the room unnecessarily.

An alternative to the conventional skylight is the solar skylight. These use an LED light fitting (usually a circular or square panel) directly connected to a small solar panel on the roof. This allows much greater flexibility of placement of the light panel and can allow solar/LED lighting in rooms that would not be able to use a conventional skylight—with zero running costs. The Illume system from Kimberley is a good example of such a system.

Another option is the tracking mirror, or heliostat. While normally reserved for large-scale solar thermal power systems, there are domestic-scale heliostats designed to reflect sunlight into rooms that normally have no solar access, such as south-facing rooms. The Sunflower from Wikoda (see *ReNew 120* or www.wikoda.com) tracks the sun and reflects it in through a window onto a fixed spot in the room, usually on the ceiling. On a reasonably bright day, one Sunflower can reflect several thousand lumens of light into a room, completely eliminating the need for artificial lighting.

A second similar option is Lucy (www.solenica.com) and while new and as yet a bit of an unknown, it looks simple enough that it should be fairly reliable.

↑ It may look like an incandescent lamp but it uses LED 'filaments'—thin metal strips with many series-connected LED chips on them. There's a small driver in the bulb base. While you might think the LED filaments would overheat, they are designed to handle high running temperatures while giving reasonable service life and efficacies of 100 lumens per watt or more. We can attest that these sorts of bulbs work well and look great, although lifespan is unknown as they are quite new to the market.

LED limitations

LEDs do and don't have limitations. That sounds silly, but generally issues with LED lighting are the result of poor (or compromised) design of the LED bulb or fitting rather than the LED light sources themselves. Indeed, LEDs are the most versatile lighting by far—they can be used in places that were simply impossible for other lighting technologies.

The limitations tend to be in the low-cost consumer-oriented bulbs and fittings. For example, there is a tendency for bulb manufacturers to make their GLS bulbs with a beam angle of around 180° so that light is emitted out of the end of the bulb. This is done as most of these bulbs are used hanging down in pendant and similar fittings, so they light the lower half of the room, where the occupants are, quite well. It also allows lower wattage (and hence cheaper to make) LED bulbs to produce illumination levels in the lower half of the room similar to a higher wattage incandescent than would otherwise be expected by comparing total lumen outputs. However, if you prefer the lighting to be more even, without the upper part of the room being dingy, then you will need to choose a LED bulb that has a wider beam angle—at least 270°—and a more appropriate total lumen output rating.

In Australia we still don't have the full range of retrofit bulbs that are found in other parts of the world, and many are more expensive. For example, we don't have the fantastic GLS bulbs made by Cree for the US market. They retail for under US$20 (and less than US$10 after government incentives!), have a wide beam angle and even light distribution and are similar in size and light output to a regular 100 watt incandescent—they are even dimmable.

While all electronic devices are required to have C-Tick approval for electrical noise emissions, there is still a problem with some LED bulbs in that they may emit electrical noise that interferes with other devices, especially with radio and TV reception.

It's possible to buy bulbs that have C-Tick and other compliance stamps, but that have not undergone testing. As a regular LED product buyer, I have had numerous overseas suppliers offer to print on their products whatever compliance marks I require, and some will even provide fake compliance certificates. While most Australian suppliers are selling certified products, the question for most consumers is 'how do I know?' The short answer is that you don't, not with 100% certainty, so it's something to be aware of.

If you buy an LED bulb or fitting and it produces electrical interference on other devices, you can simply take it back. A C-Ticked light fitting should have been tested and been shown to not interfere with other appliances. If you really like that particular light then you can have noise suppression fitted in the form of clip-on ferrite beads—these can dramatically reduce emitted noise when fitted on the cables close to the light fitting.

Most currently installed light fittings are designed to be used with incandescent bulbs, so LED lamps, which generally require ventilation so their internal electronics don't overheat, may have reduced lifespan in unventilated fittings. Some fittings, such as bulkhead and oyster fittings, have limited space for ventilation, so the bulb needs to be sized so that it isn't generating more heat than can be dissipated by the fitting.

Mains power quality can also have an effect on some LED bulbs and fittings, especially dimmable ones. Of particular concern is the use of control tones (ripple signals) on the mains waveform to control particular appliances at off-peak times, such as electric water heaters. These tones have been in use for decades and have generally not been an issue with previous forms of lighting, but LED lights not designed with immunity to these tones may flicker or audibly buzz, making those lights useless when the tones are being generated. Currently only NSW and parts of Queensland use ripple tones, and the effect of the tone seems to vary inversely with the distance from the substation, so if you are in an affected area and close to a substation, make sure you ask your lighting supplier about this issue, and get a guarantee in writing that the lights are unaffected by control tones.

Buying advice

Don't just settle on the first LED light you find that matches your requirements. Find several and compare specifications, talk to the suppliers and see if they have any recommendations. And check out online information sources such as forums and review websites—it's surprising how many people write about their light fittings!

With the explosion of the LED lighting market, you can buy most sizes and types of LED light fittings here in Australia, at a price that probably makes buying from overseas no longer worthwhile—especially when you factor in that overseas fittings will not have Australian approvals, and electricians will not fit them.

There are three good reasons to buy from Australian suppliers: warranty, insurance and safety. Australian sellers are bound by Australian consumer laws, and the lights they sell are required to have Australian approvals. With regards to home insurance, should you have a fire that can be traced back to an imported, unapproved LED bulb or driver, your insurance company may not cover your claim.

Warranties vary widely, from three months to several years, with the higher quality units usually having longer warranties. For any half decent LED bulb or fitting you should look for at least a one-year warranty, preferably longer.

You should also keep your receipts for your LED lighting as you will need them in case of an early failure a year or two down the track. Because of their higher initial cost and long-rated lifespans (and hopefully decent warranties), you should treat their purchase more like that of an appliance rather than a disposable item.

Overall, before you buy any LED bulbs or fittings, look at them closely and look for any signs of poor design, cost cutting and the like—these things are usually fairly obvious—especially poor finish such as unprotected sharp edges on cable entry holes. Generally, buying brand names such as Philips, Cree, GE, Brightgreen and Osram will ensure you buy a safe, good quality bulb or fitting, although there are many other lesser know brands that are also equally good, such as Verbatim, Mort Bay and Megaman. You should also check out review websites such as Choice (choice.com.au) and LED Benchmark (www.ledbenchmark.com).

Safety

Like any electrical device, there are safety issues involved with LED lighting. The most common issue is with inadequate insulation of the internal components of LED bulbs and fittings from the external metal case/heatsink, which has been a problem for some imported devices. Another issue is that of electrical isolation (between the incoming mains and the output that drives the LEDs) of LED drivers, which are often a separate part of the fitting.

Some cheaper imported bulbs have excellent insulation around their internal driver and mains voltage components, while others have less than adequate insulation. Unless you have electrical/electronics experience it can be difficult to tell if a bulb is safely designed or not, so we recommend that you stick with Australian suppliers—bulbs and fittings from Australian suppliers should all comply with the relevant safety standards so this shouldn't be an issue with most purchases.

As for fittings that use separate drivers, or when buying replacement drivers for an existing fitting, all Australian-supplied drivers should be tested and approved and therefore safe. If you are buying fittings directly from overseas suppliers, there are good ones and bad ones. We can't recommend that you buy LED fittings from other than local suppliers, but if you do, make sure you research safety issues such as isolation and earthing before buying.

Dedicated fittings can also have some less than ideal designs. Some fittings have the mains driver built-in and the mains wiring enters the fitting through an uninsulated hole in the middle of the heatsink. This means the wiring is not only vulnerable to the sharp edges of the heatsink hole, but also the heat from the LEDs, which can soften insulation and degrade it. Again, fittings with separate drivers will eliminate this issue.

About the tables

The table lists many of the suppliers, both manufacturers and direct importers/distributors, in Australia and gives a brief indication of the products they sell. Because products, specifications and prices change so often it is not realistic to provide detailed product listings for each supplier. It is by no means an exhaustive list—indeed, it barely scratches the surface! There are so many sizes and shapes and types of light bulbs available nowadays that you should have no problem finding ones that suit your needs. *

Resources:

Minimum energy performance standards (MEPS) for lighting: www.energyrating.gov.au/products-themes/lighting

Lighting Council Australia, including their quick and easy LED buyers guide, a guide to replacing MR16 Halogen Lamps with LEDs, and a guide to choosing LEDs and LED suppliers: www.lightingcouncil.com.au

LED lighting reviews: www.ledbenchmark.com

Tables start on p. 78.

The future of LEDs

While this guide looks at LED lighting, what about the LED components themselves? What's on the horizon regarding LED developments and improvements?

There are numerous companies, including the industry leaders such as Cree and Nichia, who are steadily improving LED efficacy and durability while reducing the cost of the components. Cree is using silicon carbide as a substrate for their LEDs whereas most manufacturers use the more expensive synthetic sapphire. Silicon carbide not only costs less, it enables the manufacture of robust LEDs that can handle high running temperatures—as seen by Cree's specifications, which are given at 85°C LED die temperature (the LED chip itself is called a die), rather than the rather less realistic 25°C used by some other manufacturers. This has allowed the manufacture of LEDs capable of producing over 200 lumens per watt at the die level (there are driver and reflector/optical losses which reduce the overall efficacy of an LED light itself).

But Cree is not the only company working on ways to increase output. Numerous researchers are working on what are known as quantum dots, nanometre-sized crystals which enable LEDs to produce quite narrow bandwidths of light. This mostly has applications in LCD screen backlights, matching the light wavelengths from the LEDs more closely to the red, green and blue dots of the LCD screen, thus increasing apparent brightness with less energy use. So far, for general lighting applications, quantum dots have seen very few applications, but at least one company, QD Vision, is manufacturing quantum dot filters for LED bulbs, aimed at improving the colour rendering of the bulb by increasing the amount of red light in the spectrum. However, this is also done using different phosphor formulations and/or LED combinations. Warm-white LEDs have been available for many years, so we think quantum dots might be more suited to improving LCD backlight efficiency than LED lighting.

Another LED development that is slowly coming of age is that of the OLED (organic LED)—LEDs that use carbon-based organic materials rather than inorganics such as silicon and gallium compounds. So far, OLEDs have mostly been used in display screens for their sharpness and brightness, but a few manufacturers have made high-end OLED lighting. At this stage though, the cost is prohibitively high and efficacy lower than most regular LEDs.

So, are there any practical developments that we will see in LED lighting in the near future? LEDs are already the most efficient form of lighting readily available, they can produce any colour and any CRI level required, and with sensible design can be used pretty much anywhere. In short, LEDs are already where they need to be, from a technical perspective—we just need lighting manufacturers to catch up with the technology and fully understand the implementation requirements—something that has improved greatly in the last few years.

Table 1. Suppliers of LED lights in Australia. Includes both manufacturers and direct importers. Note that it is not an exhaustive list.

Company	Web	Email	Phone
AC DC LED Lights	www.acdcledlights.com	info@acdcledlighting.com.au	(07) 3376 5777
ADM	www.admtech.com.au	sales@admtech.com.au	(03) 9551 6922
AOD Australia	www.aodaustralia.com	info@aodaustralia.com	(02) 4577 9413
Beacon Lighting	www.beaconlighting.com.au	Via website	1300 232 266
Brightgreen	www.brightgreen.com	Via website	1300 672 499
Bunnings	www.bunnings.com.au	Check website for nearest store details	
Crompton Lighting	www.crompton.com.au	Via website	1300 799 300
Cutter Electronics	www.cutter.com.au	mark.riley@cutter.com.au	03 9873 5088
Digilin Australia	www.digilin.com.au	giles@digilin.com.au	1800 950 888
Eco Lightup	www.ecolightup.com.au	sales@ecolightup.com.au	(03) 9512 0891
EcoSmart Lighting	www.ecosmartlighting.com.au	info@ecosmartlighting.com.au	(02) 9517 2701
Ecosparks	www.ecosparks.com.au	Via website	0407 380 980
Enviroshop	www.enviroshop.com.au	info@enviroshop.com.au	1300 430 430
Fuzion Lighting	www.fuzionlighting.com.au	Via website	(07) 5503 2900
GE Lighting	www.gelighting.com	Via website	1300 762 852
Hotbeam	www.hotbeam.com	sales@hotbeam.com	(03) 9899 9411
IKEA	www.ikea.com.au	Check website for nearest store details	
Jaycar Electronics	www.jaycar.com.au	techstore@jaycar.com.au	1800 022 888
LED Australia	www.ledaustralia.com.au	info@ledaustralia.com.au	1300 408 884
LED Central	www.ledcentral.com.au	Via website only	
LED Depot	www.led-depot.com.au	contact@led-depot.com.au	1300 491 872
LED Eco Lighting	www.ledecolighting.com.au	sales@ledecolighting.com.au	(08) 8342 4900
LED Lighting Products Australia	www.ledlightingaustralia.net.au	sales@ledlightingaustralia.net.au	07 5538 3611
LED Shop	www.led-shop.com.au	info@led-shop.com.au	(07) 3245 2222
LED4Life (Luxmann)	www.led4life.net.au	info@led4life.com.au	(02) 8213 0763
LEDsales	www.ledsales.com.au	orders@ledsales.com.au	
Lighting Matters	www.lightingmatters.com.au	info@lightingmatters.com.au	1300 565 337
Lumitex LED Lighting	www.lumitex.com.au	Via Website	(08) 9250 4178
Megaman Lighting	www.megamanau.com.au	Via website	(02) 9557 9800
Mica Lighting	www.micalighting.com.au	Via website	1300 466 422
Negergy	www.negergy.com.au	Via website	1800 611 322
Osram (and Osram Sylvania)	www.osram.com.au	sales.au@osram.com	1300 467 726
Philips	www.philips.com.au	Via website	1300 304 404
Pierlite	www.pierlite.com.au	lighting@pierlite.com.au	1300 799 300
Prestige Lighting	www.prestigelighting.com.au	Via website	1300 543 573
Prismaled	www.prismaled.com.au	Via website	1300 774 762
Simply LEDs	www.simply-leds.com.au	Via website	
Soanar	www.soanarplus.com	info@soanar.com	1300 365 551
Superlight LED Lighting	www.superlight.com.au	Via website	1300 558 217
Tenrod Australia	www.tenrod.com.au	sales@tenrod.com.au	(02) 9748 0655
Tigerlight (Spectrum lighting)	www.tigerlight.com.au	info@tigerlight.com.au	1300 184 437
World Of Thought	www.worldofthought.com.au	Via website	(03) 9639 7320

LED drivers/ power supplies	LED strip/ bars	LED panel lights	LED downlights	LED bulbs (GLS etc)	LED fittings	LED 'fluoro' tubes	LED spots/ track lights	LED cabinet lights	LED outdoor lighting	Other LED lighting
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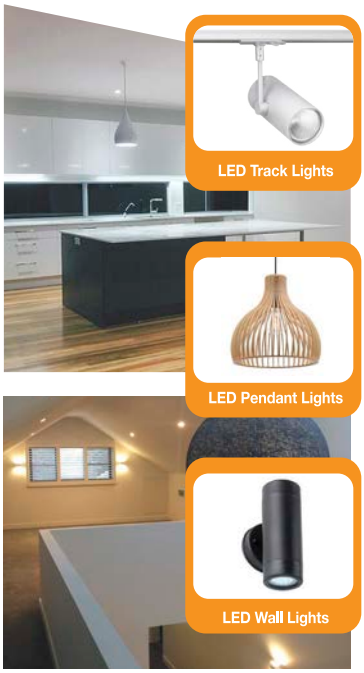

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Downlight transformers
The good, the bad, and the very inefficient

Not all halogen downlight transformers are created equal when using them with retrofit LED globes. Alfred Howell explains how the wrong transformers can be costing you money.

WITH the retrofitting of LED downlight bulbs to MR16 halogen fittings, households have seen great efficiency gains and cost savings.

However, if you change your bulbs to low-power LEDs but don't check the transformers, you may be wasting energy. Many of the older downlight fittings use ferromagnetic (iron core) transformers. While simple, they are inefficient compared to modern electronic replacements. To determine the extent of losses in these transformers I performed some simple testing.

Testing and results

I tested a typical ferromagnetic transformer alongside an Osram Redback electronic transformer. Both transformers were tested, with and without a Brightgreen DR700 retrofit LED globe. A Power-Mate Lite energy meter was used to measure power draw.

As can be seen in Table 1, the electronic transformer performs well with or without the globe. While it seems a bit pointless to test a transformer without a globe fitted, it's actually a good indicator of the efficiency, or otherwise, of each transformer. Compare the electronic transformer's 0.38 W draw without a globe with the ferromagnetic transformer's draw of an extra five watts. Indeed, the ferromagnetic transformer uses an extra five watts more than the electronic transformer with or without the globe's load.

While that doesn't sound like much, it's not uncommon to find 20 or more downlights in a home. With all 20 lights on, that would be an extra 100 watts burning a hole in your wallet—or 0.5 kWh if they're on five hours a day.

Solutions and options

To reduce this energy use, the cheapest option is to swap the ferromagnetic transformers for electronic ones when you retrofit. They are low cost, usually under $15, and available from electrical wholesalers and lighting stores. Alternatively, you could upgrade the halogen fittings to dedicated LED downlight fittings with an incorporated driver.

An even better option is to remove the downlights altogether in places where suitable. Downlights compromise ceiling insulation as they must be uninsulated to prevent the fitting from overheating. Also, many downlights, even LED ones, have a fairly narrow beam angle and so tend to produce pools of light. To get high ambient lighting levels requires a greater total wattage from downlights or a light fitting with a wider dispersion, such as an oyster fitting.

It's clear that changing the globe as part of an energy saving makeover is only part of the solution. For maximum efficiency and results, the whole lighting system, and how the system is used, needs to be evaluated. This includes behavioural changes such as turning lights off when not in use. With a bit of effort, you will be amazed at the savings that can be realised. ✸

↑ Electronic transformers (at left) waste far less power than the old ferromagnetic ones while being smaller, lighter and producing less heat. Even with no load, the ferromagnetic transformer is wasting over five watts!

Alfred Howell has years of experience managing complex machines, which he reckons puts him in a terrific position to understand how we can work as part of this complex machine we call Earth.

Type	No globe, or globe blown	10.5 W globe fitted
Ferromagnetic	5.34 W	18.23 W
Electronic	0.38 W	13.13 W
Savings	4.96 W	5.10 W

↑ Table 1. Energy consumption of electronic versus ferromagnetic transformers, with and without a load (globe) fitted.

Double glazing
A clear improvement

Double glazing can be an expensive commitment, so is it worth doing? Matt Gray takes us through his glazing retrofit and explains the advantages.

OUR home in Canberra is pretty typical of our suburb, a brick veneer three-bedroom house built in the mid 1970s, with poor solar orientation. Over the last 10 years we have been improving the energy performance of the house, adding R3.5 ceiling batts, getting wall insulation pumped in and adding solar PV and solar hot water. In 2012 we decided to replace the leaky aluminium-framed windows with UPVC double-glazed units. I thought it would be interesting to gather temperature data before and after the window installation—little did I know that it would turn into something of an obsession.

The double glazing work involved replacing the eight original windows and one glass patio door, a total of about 25m² of glazing. Most of the glass is on the east and west of the house, with one window even facing south. North-facing windows didn't seem to be a priority in the 1970s.

We placed the order in April 2012 and, in the six months it took for the windows to arrive, I had plenty of time to learn about using an Arduino and some basic electronics to measure the temperature near one of the windows.

→ The LCD shows real-time data for indoor and outdoor temperatures.

Temperature reading setup

After a bit of experimenting, I hooked up three digital temperature sensors hanging about 10cm from the inside surface of the window (on the room side of the curtains, when closed): one at the top of the frame, one in the middle of the window and one just below the bottom of the frame. I chose the south-facing window to measure, as that minimised the chance of sunlight affecting the temperature readings.

I then ran some wiring outside and hung another temperature sensor under the eaves, slightly away from the window and about 1.5m off the ground. These four sensors were read once per minute and the data written to a memory card for later analysis. I also added a flashing light to the Arduino setup so that I could see when the temperature was being read. This turned out to be a mistake, as my five-year-old son would yell "IT'S WORKING, DAD!" once per minute while we sat at the dinner table.

The temperature readings were taken on the single glazing from July to 24 September 2012, and then on the new double glazing from 26 September to December 2012.

Unfortunately one of the new windows (the largest, a three-metre long unit) was damaged in the factory and the defect was only noticed when it arrived on-site. It took another six months until that window was re-manufactured and fitted, so the temperature data is comparing the old single glazing against a mostly double-glazed house.

Initial results

So, did the double glazing make a difference? To find out, I first compared the data from the outside temperature sensor, to find nights that had similar outside temperatures throughout the night. I then compared the inside temperatures for those nights, once our heating system had turned off. The resulting graphs should show how quickly the inside temperature drops, with all things equal except the glazing.

The best nights to compare were 22/9/2012 with 1/10/2012, both nights starting at about 11°C and dropping to about 3°C by 6am, 14/9/2012 with 30/9/2012, both nights starting around 7°C and ending at about 1°C, and 16/7/2012 with 29/9/2012, both nights ranging from 7.5°C to 5°C.

The inside temperatures tended to start out at around 20°C when the heating was turned off at 9pm. By 6am the inside temperature was up to 1°C warmer after the glazing was installed—see Table 1. The before and after

"I also added a flashing light to the Arduino setup. This turned out to be a mistake, as my five-year-old son would yell 'IT'S WORKING, DAD!' once per minute while we sat at the dinner table."

Dates	Outside temp range (°C)	Inside temp at 6 am (°C)
22/9 and 1/10	11 to 3	Before: 12.9 After: 13.6
14/9 and 30/9	7 to 1	Before: 11.0 After: 12.1
16/7 and 29/9	7.5 to 5	Before: 12.3 After: 12.8

↑ Table 1. Temperatures inside, both before and after the double glazing was fitted.

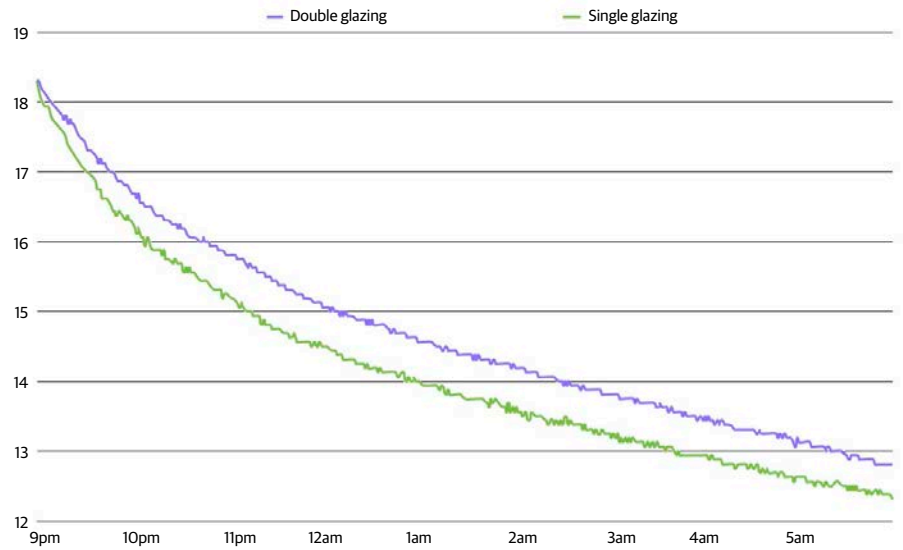
comparisons were similar regardless of whether the measurements were taken at the top, middle or bottom of the window frame—they all showed a minimal improvement with the double glazing. Figure 1 shows the temperature change in the middle of the window frame on 16/7 versus 29/9.

Heating performance

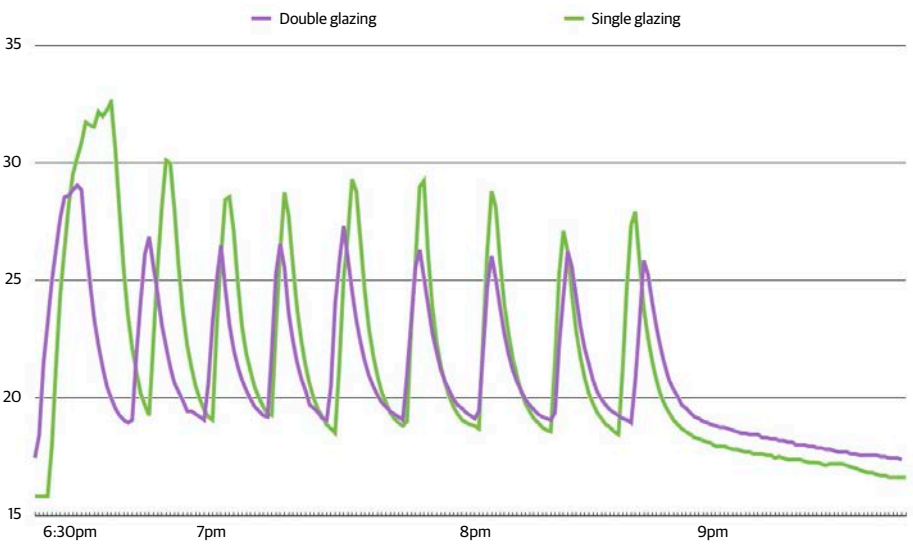
The temperature data can also be used to see if the glazing has made a difference to how long the heating runs in the evenings. We run the central heating from 6.30 pm to 9 pm each night, set to 20 °C.

I compared several nights before and after the glazing was installed and found that, for similar outside temperatures, the heater ran for about the same amount of time (to within the accuracy of my temperature samples). The time between heating cycles was also similar—the heater would be on for three to four minutes, then off for 12 to 13 minutes, then repeat. There is a slight decrease in the amount of heating needed throughout the evening (maybe two minutes over the 2.5 hours), but it is hard to measure accurately with one-minute temperature samples.

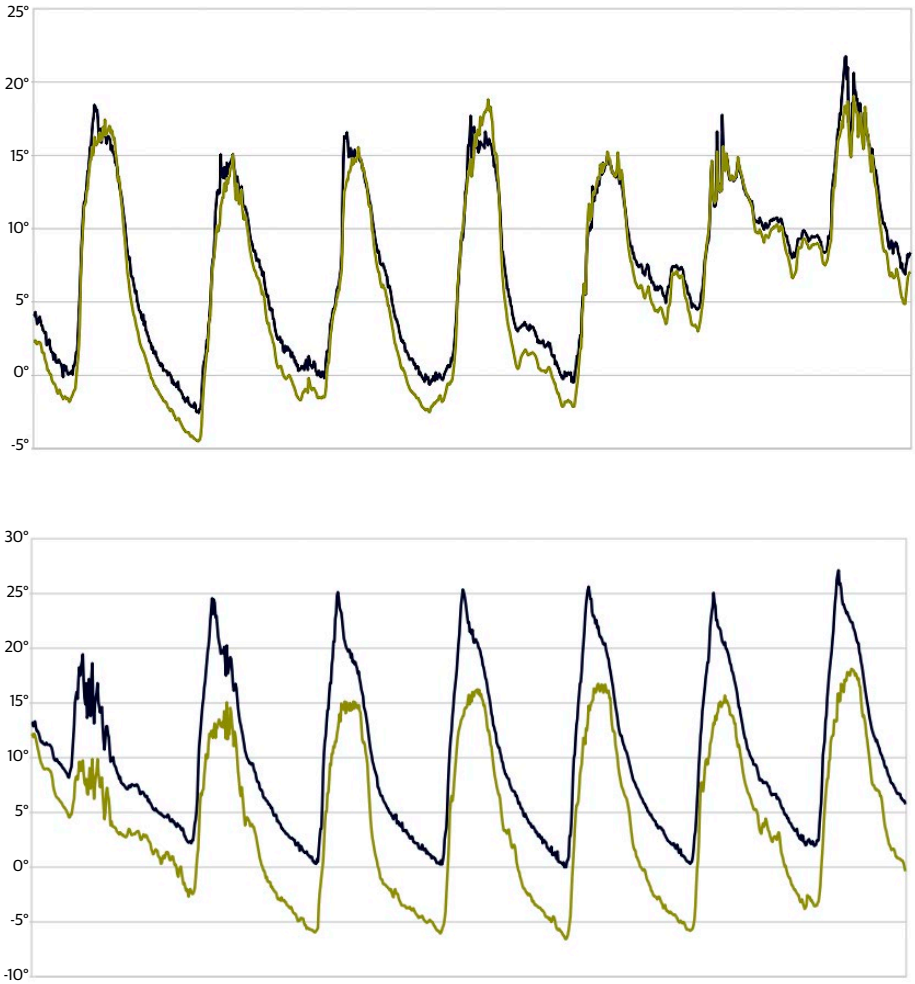
One noticeable difference is that the temperature peaks and troughs seem to be better after the glazing was installed. Beforehand, the temperature at the window would reach 30 °C by the end of the heating cycle, before the thermostat in the centre of the house reached 20 °C. With double glazing, the temperature near the window was only getting up to 26 °C or 27 °C by the time the thermostat reached 20 °C (see Figure 2).



↑ Figure 1. Overnight temperature drops on two similar nights, with single glazing (on 16/7/2012) versus double glazing (on 29/9/2012).



↑ Figure 2. Heater performance with single or double glazing (measured on two similar temperature nights), showing how the temperature peaks and troughs at the window are better after the glazing was installed. Beforehand, the temperature at the window would reach 30 °C by the end of the heating cycle, before the thermostat in the centre of the house reached 20 °C. With double glazing, the temperature near the window was only getting up to 26 °C or 27 °C by the time the thermostat reached 20 °C.



← Figures 3 and 4: A comparison of outside and patio temperatues before and after the plastic 'bistro' blinds were fitted.

Figure 3 (top) shows the outside temperature (green) and the patio temperature (black) before blinds were installed—the patio follows the outdoor temperature quite closely.

Figure 4 (bottom) shows the temperatures after the blinds were fitted. Patio temperatures are considerably higher than outdoor ambient temperatures.

Is it worth it?

Given the cost of the double glazing, is it worth it to wake up in the morning to a 1°C warmer house? If that was the only difference, I'd say no. However, there are other factors to take into consideration.

The new glazing actually seals the windows when they are shut, which is something of a novelty for us. The old aluminium frames were so leaky that the curtains would move considerably on a windy day—whether the windows were open or shut. So the air exchange with the outside is now much reduced on a windy day. The wind speed was not something I thought to measure in my setup though. It would have been interesting to find days before and after the installation with similar outside temperatures and wind speeds, to see how much difference that made to the inside temperature.

How about curtains?

Once the temperature sensors were set up, I thought of a few other experiments to try. We have thick thermal curtains on most of our windows, fitted to seal against the window frames when closed. How much difference does closing the curtains make to the heating requirements?

I left the curtains up from 6.45 pm until 9.45 pm one evening, and then compared to other nights with similar outside temperatures. I found that the inside temperature didn't seem to be changed by the curtains being up or down—a surprising result.

More sensors

Once the initial results were in, I found myself wanting to know more about the thermal performance of the house. It was simple to add more sensors to the setup, so I ramped things up a bit, placing 12 temperature sensors throughout the house, roof space and garden.

The original three sensors near the window had to go (the dangling wires were an interesting talking point for visitors). They were replaced by three sensors on an inside wall in the lounge room—one 10 cm from the ceiling, one mid-way down the wall, and one 10 cm from the floor. Three more sensors were placed in the hall and two bedrooms. Two sensors went in the roof space—one just above the insulation and one near the peak of the roof. Four sensors went outside—one in the garden, one under the eaves and two in the patio area.

At this time I also added an LCD screen to the system, mounting it on the wall in the kitchen. This allows for instant information on the temperature at any of the 12 locations in the house and garden. I have also built a website to upload the data to, which is used to generate graphs of the house's thermal performance.

Further experiments

Now that I have ample data and temperature sensors, there are more experiments that I've been doing.

"Do you know how hot it is in your roof right now?" I was able to reply "Yes. To six decimal places, at one minute intervals. Why do you ask?"

I've tested out the temperature differences when running the ceiling fan in 'winter' (reverse) mode. With the central heating set to 20 °C, the temperature near the floor is normally around 16 °C to 17 °C degrees. With the ceiling fan running, the temperature at floor level increases to 17 °C to 18 °C—about a 1 °C improvement. However, the heater now runs longer, as the cooler air from the floor level is mixing in with the air higher up near the thermostat. So, yes, you get warmer feet, but the heater has to work for it—it runs slightly longer each time it comes on.

My wife also complained that she felt colder, even though the temperature wasn't much different—the breeze created by the fan (even in reverse) was enough to make the skin feel slightly colder.

It will depend on your climate and house I imagine—if you have enough warmth entering through well-placed windows, and it is accumulating at ceiling level, and the fan makes it more comfortable near the floor without having to turn on the heating, it is a benefit. But if you need to run the heater to generate the warmth in the first place, mixing the heat around is just going to require more heating to compensate for the cool air that you are now moving up higher.

I've also compared the temperature of my roof space to that measured by Alan Cotterill in his article in *ReNew 132*. Alan's roof in Wagga proved to be an effective source of winter warmth—my roof was not so good. Alan was able to run his system for six to eight hours a day in July/August, with the fan set to come on if his roof space was over 24 °C. My roof space was over 24 °C for an average of only 30 minutes per day in July/August 2015. I also measured times at which the roof temperature was 10 °C more than the inside temperature—that averaged to just 22 minutes per day.

The readings have more potential in autumn—the roof was over 24 °C for about two hours a day in May 2015, and 3.5 hours per day in April 2015. But that's still a long way off the benefits that Alan is getting.

I suspect the difference is not so much the location (we do get a lot of sun in Canberra winters), but the roof style. Alan's roof is quite large, high pitched and well-sealed Colorbond steel. The roof space on my house is quite low pitched and small, and the material is concrete tiles, which leak air like a sieve. The warm air doesn't have time to accumulate in my roof space in winter. This is a good demonstration of how building style and material can affect the thermal performance of your house.

I also looked at enclosing the patio area with plastic 'bistro' blinds during winter. Given that the outside temperature gets down to -5 °C quite often, and sometimes even lower, I was interested to see if enclosing the patio area with plastic blinds would hold more heat in overnight. I found that after adding the blinds, the daytime temperature on the patio was boosted up from ambient temperature by about 10 °C, and the night-time temperatures stayed about 3–5 °C warmer. Result: I've now bought a banana plant for the patio.

Finally, the one night I tested with the curtains up gave a surprising result—I'd like to repeat the test a few more times to see how the curtains and double glazing interact.

Other unexpected benefits

There were several other unexpected benefits that came out of this project.

One was that when I was crawling around in the roof, installing temperature sensors, I noticed that the various plumbers and electricians that had been in our roof over the years had each removed sections of the insulation batts to speed up their work. Some large sections of the roof had no insulation, while other parts had the batts piled three high. I refitted the insulation where it should have been, which has likely made a big difference to the house temperature in winter and summer.

The 25 m² of old single glazing came out intact—the installers were very good at their job. I now have all that glass waiting for my next big project—building a greenhouse. It's sure to have temperature sensors in it as well.

Another benefit was that when a sales person knocked on the door trying to sell a roof ventilation system, and he opened with the line "Do you know how hot it is in your roof right now?" I was able to reply "Yes. To six decimal places, at one minute intervals. Why do you ask?". He didn't make a sale. ✷

Matt Gray enjoys tinkering with electronics and software, playing computer games, spending time in his vegie garden and doing amateur astronomy. He works as a software engineer at the Australian National University.

Resources :

House graphic showing sensor locations and temperatures: www.bit.ly/1O5XcLk

House temperature graphs: www.bit.ly/1Lctyio

www.arduino.cc: Official Arduino website

www.littlebirdelectronics.com: an Australian distributor for Arduino and the sensors that Matt used in his project.

A comment on the results

Peter Lyons from Fenestralia in Canberra commented on Matt's results.

It's a fascinating result! Regarding the indoor temperature improvement after going to the new windows, although 1 °C improvement doesn't sound like much, it is very significant. First of all, we know from many examples (observed and simulated) that a 1 °C drop in heating setpoint temperature, if applied, translates to typically a 10% to 15% drop in annual heating energy.

Another unseen benefit associated with the temperature improvement is that it is accompanied by an increase in glass and frame surface temperature of around 5 °C (as illustrated in Figure 2). This improvement in mean radiant temperature will be noticed by anyone sitting near the new windows. They will feel more comfortable and will be less likely to complain of a draught.

I also note that, because the largest window was damaged and not replaced until after the monitoring period, the results are not as good as they could have been. Perhaps an overall improvement in indoor temperatures closer to 1.5 °C would have been realised with all new windows.

Shop with the ATA

Why not buy your gifts from the ATA Shop? We stock 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 fill out and return the form at the bottom of the page.

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.

18 W LED outdoor bulb

Price: $49.50

At over 80 lumens per watt, this Par38 bulb is an energy-efficient replacement for the 150 W bulbs commonly used in driveways and outdoor entertaining areas.

ATA's *Green Home Cooling* eBook

Price: $5 (free for ATA members!)

The *Green Home Cooling* eBook, from the ATA's sustainable living series, includes the best articles from *ReNew* and *Sanctuary* on how to have a naturally cool and energy-efficient home.

EcoSwitch

Price: $19.95

Standby power accounts for 5% to 10% of all energy use. With an EcoSwitch, you can conveniently control power to one or a group of devices without having to climb under desks or behind cabinets. Winner of *New Inventors* People's Choice Award in 2007.

8 W LED dimmable Edison screw

Price: $14.70

A replacement for a standard Edison screw bulb, these economical warm white LED units draw only 8 W yet produce 650 lumens of light—equivalent to that of the average 60 W incandescent.

ValveCosy

Price: $20

An elegant solution for a largely overlooked problem, this insulating cover is designed to fit neatly over the pressure/temperature relief (PTR) valve on your hot water service. It reduces heat loss, conserves energy and saves you money.

Sanctuary: modern green homes issue 32

Price: $11.95

Sanctuary 32 is a heritage renovation special covering renovating by house type and a fantastic array of heritage case studies. It also covers homes that opened for Sustainable House Day, aquaponics, solar storage at home and much more!

The Energy Freedom Home

Price: $39

The Energy Freedom Home is the latest publication from Beyond Zero Emissions, giving practical guidance on how to reduce your gas and electricity bills, or even wipe them out, while making your home more comfortable.

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Clean out the dust and save money
Simple fridge maintenance

Is your fridge running all the time? It may not be worn out, just dirty. Charlie Woolstencroft explains how easy it is to fix.

THE sound of my fridge seeming to run all night prompted me to find out why. Dust on the air intake and cooling fins was the problem, so I set about cleaning them. It was a simple one-hour job, which will hopefully save me both electricity and wear on my fridge, at zero cost. Here's how to go about it.

What to clean, and how

First, and most important, unplug the fridge from the power point before beginning.

Next, slide the fridge out until the rear is completely accessible. Now, be appalled at the cobwebs, dust and fluff clinging to the air intake grill/cover, usually located at the bottom rear of the fridge.

It's now time to undo the screws holding the grill on. In my fridge's case, there are six screws around the grill. You'll then be able to see why the fridge is having trouble. All that fluff and dust is blocking the airflow through the condenser coils and cooling fins.

To reach the fluff on the cooling fins, I undid the two screws securing the plastic white control box (on the right-hand side). I gently slid this out; the wires are secured inside this box so no disconnection of wiring is required. You may or may not need to do this, depending on your fridge's design.

With the control box out of the way, you will see the full extent of dust on the cooling fins. In my case (see photo), it makes me feel ashamed that it got to this stage. Use a soft plastic brush to clean the cooling fins and suck the dust away with a vacuum cleaner. Be gentle: the fins and pipes can easily be damaged.

There is a little cooling fan on the left-hand side which sucks the air through the cooling fins. Again, in my case, there was fluff stuck to the blades which was slowing them down and making the cooling less efficient. I used my fingers to remove this fluff.

After cleaning, it's time to reassemble. Slide the plastic control box back in, making sure the wires slide in easily, without forcing. You may need to relocate the wires if they are getting caught against the back of the control box.

Replace the rear grill, making sure the power lead sits in the slot so it is not crushed by the cover when the screws are done up.

Slide the fridge back, plug in the power and if your fridge is like mine, you will notice it runs about 50% less. Success!

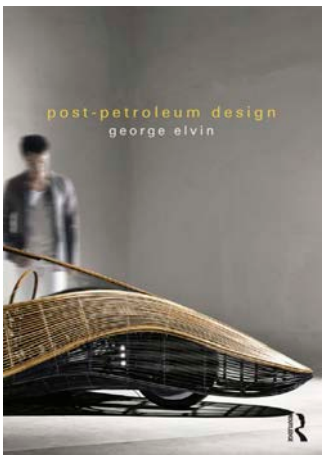
↑ After removing the grill/cover you will see the compressor (here mounted on the left), the cooling coils (middle) and possibly a controller box (right).

→ The cooling coils will probably be full of dust, which needs to be carefully removed with a soft brush and vacuum cleaner.

When you slide your fridge out, you may find that it has old-style cooling coils on the rear of the fridge or that it doesn't have an air intake grill. In the latter case, your fridge radiates its heat via the side walls of the cabinet, and it's important that there's a clear air space on all sides to allow the heat to escape. You haven't wasted your time pulling the fridge out though: look at all the treasures you've found hiding under the fridge! ✸

Charlie is a semi-retired electrician in Canberra helping low-income households to reduce their energy consumption.

Plastic-free products and projects, and net-zero homes



POST-PETROLEUM DESIGN

by George Elvin
Routledge, May 2015
$39.99 (USD)
ISBN 978-1-138-85390-4 (print)

"The oil disaster prompted an epiphany, 'How could I put more petroleum-based plastics into this world?'"

THE author of *Post-Petroleum Design* was halfway through designing an iPad case when the news broke about the BP Deepwater Horizon oil rig explosions. The oil disaster prompted an epiphany, "How could I put more petroleum-based plastics into this world? ... I made up my mind then and there that if I was going to bring a new product into the world, I was going to make it plastic-free." After developing a wool iPad case, Elvin's commitment to post-petroleum design escalated. He founded Gone Studio, a design company which pioneers zero-plastic, zero-waste and zero-electricity manufacturing.

Post-Petroleum Design caters to the booming demand for plastic-free products and projects. It brings together case studies of 40 of the world's leading post-petroleum designers, working across architecture, industrial design, transportation, packaging, electronics, clothing, furnishings and more.

This book is highly readable and is solutions-based. It opens with a historical perspective on oil and plastics, and explains the principles and actions required to move beyond them. It profiles such innovations as bamboo keyboards, buildings and packaging made from mushroom mycelium, electricity-free manufacturing, bridges constructed from 100% recycled plastics and open-source ecology.

"When it comes to architecture, alternatives to plastic abound." This book will appeal to *ReNew* readers as it goes into technical details about plastic-free building materials such as algae roofing, bioplastics, insulation made of recycled denim jeans, and hemp. An inspiring resource for design professionals and a soothing read for the plastic-ravaged soul. ✷

Review by Sarah Coles
This book is available for order at www.routledge.com/products/9781138853904

THE ENERGY-FREEDOM HOME: How to Wipe Out Electricity and Gas Bills in Nine Steps

by Beyond Zero Emissions/Richard Keech
Scribe Publications, August 2015
$39.99
ISBN 978-1-925-10671-8 (paperback)
978-1-925-30723-8 (e-book)

OK, you're concerned about climate change, or maybe you're sick of being hit with high energy bills (which are only getting higher) ... but what exactly can you do about it?

In *The Energy-Freedom Home* you will learn how to dramatically reduce your home's energy consumption, which will help address both those issues. Utilising all the techniques in this book, you could reduce your home's energy use by as much as 50% as well as improve your overall comfort.

The book's primary author, Richard Keech, speaks with authority—his own retrofitted home in Melbourne forms the basis for one of the case studies. In heating alone he has reduced energy use by a whopping 75%. By adding solar photovoltaics, his home is now a net exporter of energy and he has completely eliminated the use of gas.

Most Australian homes go through some form of renovation every five years or so. When that time comes for you, this book will provide plenty of DIY hints and resources to incorporate into your planning—from insulation and draughtproofing, to lighting, appliances, solar power and more. This book covers the entire range of activities that contribute to energy use in the home, and takes you through the nine steps to 'energy freedom' that mean lower bills, higher comfort, net-zero emissions and even energy production. ✷

Review by John Knox
This book is available for order at www.scribepublications.com.au and from the ATA's shop, shop.ata.org.au; e-books are available on Amazon Kindle and iBooks.

MAKE GARBAGE GREAT: The Terracycle Family Guide to a Zero-Waste Lifestyle

By Tom Szaky and Albe Zakes
Harper Design, July 2015
$35 (USD)
ISBN: 978-0-062-34885-2 (hardback)

A COFFEE-TABLE book about garbage may seem unusual, but this format allows the book to present an oft-ignored topic in an easily digestible way to reach a wide audience, particularly children. I got to read an online extract rather than the full book, but the presentation seems particularly user-friendly, mixing stories with information, compelling images and great infographics.

The book is organised into eight chapters, one per material type—plastics, metals, paper, textiles, glass, wood, rubber and organics—including a history of each alongside issues in their production and use, recycling tips and a 'lifecycle of': for example, the lifecycles of a polystyrene fork, a magazine and denim jeans. For the fork, the infographic story makes it startingly clear just how much work and energy goes into the production of an item with a five to ten minute useful life.

There are also 10 DIY upcycling projects that seem suitable for children, such as making a tote bag out of food pouches or a bird feeder out of a plastic bottle.

"It's the sort of book you could dip into to find interesting 'did you knows'. I didn't know that shredding paper reduces its value for recycling, for example."

It's the sort of book you could dip into to find interesting 'did you knows'. I didn't know that shredding paper reduces its value for recycling, for example. The authors are the founders of Terracycle in the USA, a company which seeks to recycle the non-recyclable (see Products, p. 21). The stats and examples in it are US-based, but it's a useful addition to a family's understanding of waste and recycling. ✷

Review by Robyn Deed

This book is available for order at: www.harpercollins.com/9780062348852/make-garbage-great

ReNew Reader Survey results

Thank you to everyone who took the time to complete the *ReNew* Reader Survey. We received over 960 thoughtful and useful responses, which we're analysing at the moment ready to feed into our planning for next year and beyond. We particularly liked hearing what you want to see more of and getting your general thoughts on *ReNew* and the ATA.

It was lovely to get lots of pats on the back with many people saying "Keep up the good work" and "*ReNew* needs to be published monthly." It was great to hear so much praise for the expert opinion provided by Alan Pears, and the dedication to information sharing by our technical editor Lance Turner (with one respondent wanting to nominate him for Australian of the Year!).

We were pleased to hear that *ReNew* is timely: "Often delighted when I am pondering some topic, then the very next edition of *ReNew* has an article about it. How do you do it?"

We also always really appreciate people taking the time to tell us the things that we could improve on. Although most people (about 80%) were happy with the technical level of *ReNew*, we acknowledge that some people would like it more technical and some less. We aim to include more boxes with basic technical info, and will continue to expand our 'basics' article series. For those wanting more technical info, we will be looking at how we can better meet that expectation.

We've noted that people want more content on low-cost retrofitting, and that we have to make sure we're considering all of Australia and New Zealand in both articles and advertising, and to look at innovations from overseas.

Survey respondents suggested that our website needs improvement. We're pleased to say that we're planning a redevelopment next year, and we welcome all of your suggestions. We'd like the website to be both a resource and a gateway to the magazine, so stay tuned!

We will be going through the comments in more detail once this magazine issue is out the door, as the suggestions are excellent. We're always very happy to receive feedback by email, so if you missed out on the survey, please feel free to email any feedback to renew@ata.org.au.

And congratulations to the winner of our survey prize, Denis McDonald, a long-time ATA member. He won a case of wine from Rosnay Organic and we look forward to hearing his review of it!

The Pears Report
Changing states

Alan Pears looks at the rapid changes in electricity policy, provides some practical perspectives on carbon pricing and discusses some good news about the national appliance energy efficiency program.

WE ARE seeing some interesting developments in clean energy at the state level as the states (predictably) move to fill the hole left by the national government.

Victoria has announced it is developing an Energy Efficiency and Productivity Strategy to be released this year. It has also announced development of its Renewable Energy Roadmap intended to re-establish Victoria as a "global renewable energy leader". In Western Australia, former head of the Institute of Public Affairs (a conservative lobby group), now energy minister and treasurer, Mike Nahan has flagged a central role for solar. Meanwhile, the ACT and South Australia continue to lead the pack.

In contrast, the electricity industry continues its struggle to come to terms with the significance of energy efficiency and demand-side management. AEMO has just released its latest Statement of Opportunities (SOO). It predicts higher consumption and peak demand than previously, reflecting stabilising prices, loss of momentum in energy efficiency policy and slower PV growth—with no discussion of the importance of actively driving demand management harder to avoid this. Its low-demand scenario suggests planned generation is adequate to beyond the next decade, while its medium scenario requires investment to provide 5780 megawatt hours of additional supply over the next decade, 3.2% higher than 2014–15 consumption. AEMO does, however, flag that next year's SOO will include analysis of demand management. That could dramatically change the outlook.

Energy companies continue to lobby for the right to apply anti-clean energy measures such as high fixed charges and low feed-in prices, while moving into the solar PV market!

The Energy Networks Association published a paper in August proposing a range of options, including grid connection fees, network exit fees, payment for grid access and payment for risk of stranded assets. It continues to assume that network operators are entitled to make a profit, and that their shareholders should be protected from losses. The age of entitlement continues.

Carbon pricing

We need some practical perspectives on carbon pricing. Although I wouldn't call a carbon price the 'centrepiece' of climate policy—as Labor has claimed in the past—it is important because it sends a signal to change, particularly to investors. And the revenue a carbon price raises can fund other abatement action. To cut emissions we now face a choice between 'polluter pays' (pricing emissions) and 'taxpayers pay the polluter' (the Emission Reduction Fund).

By removing Labor's carbon price but leaving in place assistance measures, this government has not saved Australians any money: in fact it may have increased costs to taxpayers. Under Labor, the assistance was funded by revenue from the carbon price. It must still be funded, but now through consolidated revenue, gained from taxes or borrowings eventually repaid by taxpayers, or offset by reduced services. On top of this cost, we must also pay for 'Direct Action'. Simple slogans can be very misleading.

The good news is that the cost of managing climate is proving to be far lower than expected: many measures such as energy efficiency and some renewables are even profitable. The polarised politics of 'carbon taxes' and 'Direct Action' is dumb and distracting. We need both a price on carbon emissions and direct action, along with other measures.

Empowering people to cut emissions

I and others from the Voluntary Carbon Markets Association spent a lot of time trying to get Labor to modify its carbon trading model to empower individuals, business, and local and state governments to cut emissions. Our basic concept was that all voluntary abatement should be matched by the government cancelling Kyoto permits (allocated by the UN based on our national target). This would ensure our efforts were recognised as globally 'additional' abatement beyond government-driven measures.

For example, if Australia has a target of 500 million tonnes (Mt) of emissions in a given period and households are expected to emit 60 Mt, this means other emitters are able to emit 440 Mt (440+60=500 Mt). But if households (or some other group) voluntarily cut their emissions by an extra 10 Mt in that year down to 50 Mt, the government should cancel 10 Mt of permits. The target would then effectively be 490 Mt so other emitters still have a target of 440 Mt (440+50=490 Mt). If the government doesn't cancel permits, other emitters would now be able to emit 450 Mt and Australia would still meet its 500 Mt target (450+50=500 Mt). So those other emitters would be 'free riding' on the voluntary efforts of households. And from a global perspective, Australia's emissions would not be reduced below the 500 Mt it was

originally allowed to emit; the planet would not see a reduction in emissions as a result of the efforts of households and their efforts would not lead to additional abatement beyond what the Australian government has previously agreed to.

After a carbon price was introduced, conservative state governments justified cutting abatement action with the excuse that their actions would not be additional to national action—so there was no point in a state having its own climate target or actively pursuing emission reduction. We had warned the national Labor government, but they did not want to hear: the arrogance of policy makers swamped our efforts.

Recently, one of the emissions trading scheme (ETS) architects, Martin Parkinson, gave a speech (reported by Gareth Hutchens, *The Age* 30/6/15) in which he acknowledged that they had failed to engage and empower the community. Hutchens wrote:

"[He] never gave enough weight to the fact, when designing the trading scheme, that voters wanted to feel they were making a contribution to emissions reductions, and emissions trading systems do not provide them with that feeling because they are too abstract. 'We got so hung up on the [idea that] we've got this really big problem that we have to deal with, and we've got to do it at least cost to the economy, so we delivered a least-cost way of doing it,' he said."

The situation is even worse now. The present government is using our money to pay polluters to cut emissions (including subsidising things they were already doing). And abatement actions that households, businesses, and local and state governments take which fall outside the Emission Reduction Fund (like installing rooftop solar or saving energy) allow the government to use our investments to make it easier to meet its weak and globally irresponsible abatement targets.

"By removing Labor's carbon price but leaving in place assistance measures, this government has not saved Australians any money: in fact it may have increased costs to taxpayers."

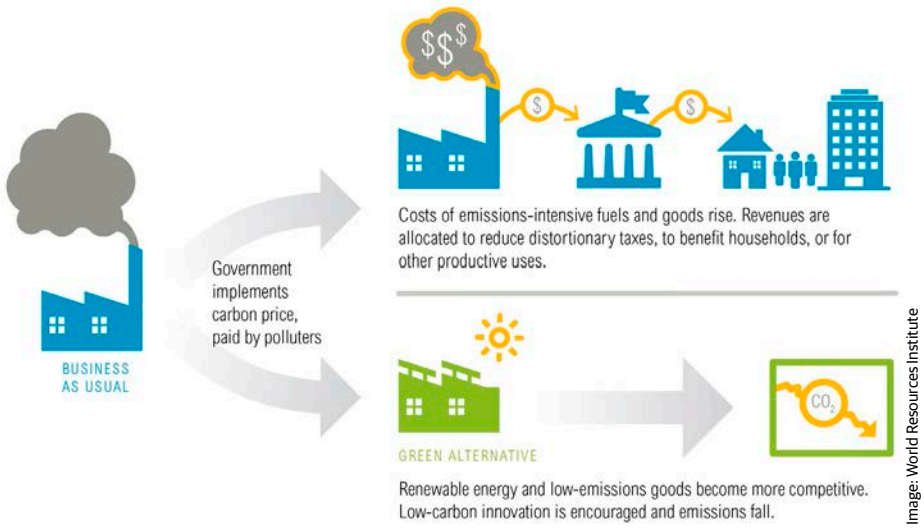


Image: World Resources Institute

↑ Pricing carbon pushes energy generation towards cleaner methods, reducing emissions.

Positive news for energy efficiency

COAG has announced that the national appliance efficiency program (GEMS) has survived a review, and will even be expanded because it is so cost-effective. This is a relief for the many who were concerned that this review was yet another government attempt to undermine progress in clean energy. The Alternative Technology Association (*ReNew*'s publisher) played a key role by making a comprehensive submission.

The program faces other hurdles, including the requirement that any additional regulations be offset by reductions in related areas. And undoubtedly the Office of Best Practice Regulation will continue to do its best to delay and block new Mandatory Energy Performance Standards, which it opposes on ideological (neo-classical economic) grounds.

State energy policies

I've recently been spending some time in South Australia and the ACT. This has led me to ask what makes them so different in their approach to sustainable energy? Could it be that the lack of powerful coal and resources industries makes it easier for them to be more progressive?

It will also be interesting to see how the Victorian government responds to a scathing study by the Brotherhood of St Laurence that shows the state's retail electricity market model is a disaster. It delivers remarkably high profit margins for retailers while many disadvantaged people pay the highest prices. This is the model lauded by many in the electricity industry as the template other states should use! ✷

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.

Q&A

Do you need to know how to make your wood heater more efficient, or want to design a cool cupboard? Ask *ReNew* your question via renew@ata.org.au.

Polystyrene foam alternatives

Q —

I found out from a friend that most of the expanded polystyrene used in building in Australia probably contains a brominated flame retardant—likely HBCD or DBDE—and that these are being banned in Europe because they are persistent, toxic chemicals.

We are about to build a sustainable house but don't want to use something that's both toxic to people and persistent in the environment.

Apparently these flame retardants are not used in polystyrene used in food packaging (phew!) but a flame retardant is required in all commercial building polystyrene.

I've called a few companies and they have trouble telling me what the exact chemical is. I've found that they import their beads from China already coated in the retardant, and then expand them here. Apparently the flame retardant is just a coating on the beads and not part of the chemical structure, so it can come away once installed, and end up in dust or in the air.

Are you able to tell me if anyone at ATA has looked into this and could you recommend a supplier that doesn't use a brominated flame retardant? I'd be a willing customer!
—Linda Meisel

A —

We are not aware of any polystyrene foams for building that use fire retardants that are not brominated. According to the US EPA publication 740R14001, *Flame Retardant Alternatives For Hexabromocyclododecane (HBCD—Final Report*, June 2014 (www.bit.ly/FRAFH14), "No non-brominated flame retardants are known to be compatible in polystyrene manufacturing and associated flame tests."

There are other products that are naturally fire-resistant and so don't have added fire retardants, such as hempcrete, timbercrete, AAC (Hebel) and similar naturally derived building materials. Insulation materials such as glass and mineral fibres are naturally flame retardant. I used Knauf Earthwool insulation in our home here; it is naturally non-flammable and the fibre binder is based on plant starches. —Lance Turner

Wood heater air intake

Q —

I was interested in getting a bit more information about Tom Chalko's article in *ReNew 123* about a wood heater cold air intake. I wanted to know what sort of duct Tom used (e.g. a car radiator/heating duct etc.) so I can figure where I might be able to get some. I'd like to do the same thing with my heater. I'd also like to know about the surprises and challenges with introducing the cold air directly into the fire box (my heater doesn't have an ash grate—but I thought I might be able to make one). —Lance Mudgway

A —

I used a piece of approximately 50 mm diameter automotive duct between the stove and the valve. It is an aluminium accordion-style duct that allows bends without changing the cross-section. The rest of the duct is PVC as it never gets warm.

The most important aspect is to collect air at static atmospheric pressure (stagnant air, not pressurised by wind). The subsequent *ReNew* (issue 124) contains my answer to a static atmospheric pressure question.

There were no surprises, but the intake required two iterations. My first version of the intake used a ducted fan and the last segment of the duct was a solid 20 mm copper pipe. This worked like a turbo charger in a car engine, but I didn't like the noise of the fan. The 20 mm diameter was too small to work without a fan, but if you don't mind the fan, this forced cold air intake is very versatile, takes less space in your firebox, can have more than one copper nozzle introducing cold air to the fire and doesn't require static air intake.

The ash tray is really convenient and doesn't need to be very high. I think I have seen ash trays in various shapes and sizes for fireplaces. Maybe you can fit one of those in your stove with some assistance from a grinder with a cut-off wheel. —Tom Chalko

Turning off the fridge

Q —

We have a couple of cottages on our property which we rent out for holiday stays. Sometimes the cottages are booked back to back, but sometimes there are several days between bookings.

Obviously we turn off the fridges if no one is staying for a week or even five days. But is it more energy efficient to turn off the fridges when no one is in for, say, two days, and turn them on again when new guests arrive?

What is the minimum break for which we should turn off the fridges, and does it depend on ambient temperatures, which can vary considerably on the mountain?

One fridge is a small bar fridge, the other a small (245 litre) two-door. Neither is particularly new! —Rosemary

A —

My thoughts are that it makes more sense to turn them off. An empty fridge can rechill itself in a short period of time, and most fridges run at a duty cycle somewhere between 25% and 50% when cold, so if the time it is turned off is two to four times longer than the rechill period then it makes sense to turn them off.

You would need to do a quick test to see how quickly it will rechill. Just turn them off and let them warm up, then turn them on and see how long it takes them to turn themselves off, which indicates operating temperature has been reached. I suspect it will only be a few hours at most, unless they are quite inefficient or have considerable door leaks.

I would expect both of those fridges are probably a bit energy hungry. It would certainly be worth running an energy meter on them so that you can get an idea of their usage compared to modern fridges. —Lance Turner

"It is possible to locate the fridge such that the heat from it can be used to drive the cool cupboard circulation."

Avoiding condensation

Q —

Thank you for the excellent article 'What's in a Wall' in *ReNew 132*. I would like to improve the thermal efficiency of my single-storey brick veneer home in Tasmania. The house has insulation in the roof and plasterboard walls. What insulation, if any, would you suggest to use in the walls? I do not want to create moisture buildup from living in a cold, damp climate, as mentioned in your article. Would rockwool be suitable? —Annette Pugh

A —

Any insulation will assist in reducing condensation, simply by making the walls less cold. However, you may not be able to prevent condensation entirely because of limited wall thickness and, without good breathability, a likely gradual increase in internal humidity. Therefore your concerns are valid. Rockwool in granular form (such as Bradford Fibretex) is vapour-permeable, whereas injected foam is not. But there is a bit more to it than that.

As always, your windows and doors are going to be the biggest problem, and steps should be taken to reduce their heat loss, whether or not you are thinking of replacing them.

The breathability (vapour permeability) of your existing walls will be dependent upon the brick type and whether it is rendered or painted externally, whether there is sarking in the walls (my reading between the lines suggests not), and what sort of paint has been applied internally. If there is no oil-based paint on any surface, then you will have some degree of permeability, but it may be too low to be effective within the daily temperature cycle in winter.

To achieve a really good turnover of air without losing heat you could look at a heat recovery ventilation system, which has an air-to-air heat exchanger. These run just a fan at relatively low energy demand, but will maintain high indoor air quality with minimal heat loss. You can manually manage a similar result by throwing wide open your doors and windows for a short period on warmer winter days—but if the daytime maximum is not more than 12 °C this will not be a pleasant experience, and that may be for some weeks at a time (depending upon where you live). —Dick Clarke

Cool cupboards

Q —

We are designing a pantry and I would like to have a cool cupboard with vents in the wooden floor (the house is on stumps) and then a closed cupboard so air can flow up to vents in the ceiling of the cupboard—we are just not sure if the air would move up?

We are also wondering if we need to have a fan in the top of the cupboard to help the air move up. Is there any information about these cool cupboards that you are aware of, or someone we can talk to please. —Catherine Carlyle

A —

Air will only tend to flow up if it is gathering heat. For example, if you have a floor vent below a fridge alcove and the fridge heats the air, then it will tend to pull air up through the vent somewhat.

It is possible to locate the fridge such that the heat from it can be used to drive the cool cupboard circulation; there's an example of that at www.bit.ly/1Ua7SO6.

If the fridge is elsewhere, then a slow running fan would be a good idea; a small computer fan would work well and may only draw a watt or two.

If you are happy to run the cupboard's top vent pipe out through the roof, you can have a metre or so of pipe above the roof, paint it black and that will produce the convection needed for the cupboard.

There are lots of ways to do this, but it depends on what suits your house design. Googling 'cool cupboard' will find a lot of good ideas and examples. —Lance Turner

Eco-foam alternative

Q —

I have some consulting jobs at the moment where I am recommending improvements in building fabric by insulating walls. My first instinct was to recommend Eco-foam, as they have a water-based product which can be pumped into walls and insulates well, is low-VOC and doesn't contain HFC propellants. Our business used Eco-foam in our office retrofit in double-brick walls, and it was great and low cost at about $20/m².

However, when I contacted Eco-foam, they advised that they no longer operate out of Victoria, unless it's a big enough job to send a crew down (which would add at least $5000 to the cost).

Do you know of anyone who has had good experience with alternative foam products, foam balls or blown-fibre products, that can be used for double-brick or other cavity situations such as brick veneer and are installed through the walls or from above? The alternative polyurethane products include HFCs, which have high GWP, although perhaps this would be insignificant compared to offset energy emissions. —Jon Fettes

A —

Icynene foam seems to be a viable option. It is water blown and generates CO_2 when installed to expand the foam, so no HFCs. More data is available at www.icynene.com.au and a Victorian installer is Sprayit Solutions, www.sprayitsolutions.com.au. Not having used it I can't vouch for it personally, but the datasheet looks okay so it would be worth talking to them. —Lance Turner

Write to us

We welcome questions on any subject, whether it be something you have read in *ReNew*, a problem you have experienced, or a great idea you have had. Please limit questions to 200 words.
Send questions to: renew@ata.org.au

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ATA BRANCHES

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: Recent meetings have included fascinating presentations from Reposit Power on energy storage opportunities for SA, Mark Clayton and Jeremy Miller from Sustainability House and Monica Oliphant AO on Renewable Energy in China.

Brisbane: The reinvigorated Brisbane branch has had presentations on topics such as smart grid-interactive PV systems (using storage and microinverters), the day-to-day of electric vehicle ownership and the 'good, bad and ugly' of fracking. The branch is eager for more interaction with local ATA members.

Cairns: The Cairns branch held an ATA stall at the recent Permaculture Expo, Carnival on Collinas, and has continued to attend the monthly Tolga Markets to promote sustainability issues.

Canberra: Energy storage is a hot topic at the moment and the recent meeting on residential solar and storage was very well received. The branch continues a close relationship with the Australian Solar Council.

Geelong EV: The branch continues to meet monthly to hear from members about their practical EV projects, alongside discussions of current and emerging EV technologies and planning for private workshop projects.

Melbourne: The Melbourne branch has also met to hear more on the topic of battery storage, especially in relation to its impact on PV system design and optimisation. They also showed *Small is Beautiful*, a film on the Tiny Homes movement.

Melbourne EV: The branch has continued to present meetings on electric transportation topics including on electric skateboards, electric buses and a 1MW electric race car. Most recently they investigated whether Australia can be a global leader in EV charging infrastructure.

Perth: The Perth branch has been surveying local ATA members with a view to reinvigorating ATA activities in the local area. If you would like to see more in the area then now's the time to get involved.

Sydney Central: The branch meets in the Interface Building adjacent to Central Station and continues to host monthly presentations. Recent activities include showing a film on a sustainable building design project in Tasmania, discussing achieving net zero emissions households and opening homes for Sustainable House Day.

Sydney West: The branch continues to meet monthly at the Hawkesbury Earthcare Centre. Recent events have included the popular Sustainability Lecture Series with workshops on solar power and earth building. The Earthcare centre was also open for Sustainable House Day.

Tasmania North: The Tassie North branch has been exploring the great range of documentary films available at the moment and they recently showed *Frackman*. They have also worked with the Meander Valley Council to promote a bioenergy forum.

Toowoomba: The most recent Toowoomba branch meeting was on 'getting the most out of solar in your home or business' and this proved to be a very popular topic. They are very keen to meet all local ATA members.

To join in and for all enquiries about branch activities, contact Doug Rolfe, ATA Branch Officer: 03 9631 5407, doug@ata.org.au or visit www.community.ata.org.au/branches.

ATA member profile
Everything is crucial in design

Thermal mass, floor mass, wall mass, the case for new materials, smart home measures, passive solar design, embodied energy and more ... *Sarah Coles* spoke to Griff Morris from Solar Dwellings about sustainability and the ethics of building a home.

GRIFF Morris from Solar Dwellings sums up his approach to sustainability quite simply. He says, "Don't just look at the surface, don't just trust the first conversation, drill deep into it. To do that, what you have to do is educate yourself so that you can then ask the penetrating questions about any product or any service that you are going to use in your home." This probably sums up a lot of *ReNew* readers too (and the *ReNew* staff)!

Griff has a long history in living more sustainably. He worked on his first passive solar design in 1976, was an inaugural board member of the Sustainable Energy Association, teaches sustainable design to the housing industry and is a passionate ATA member.

He's committed to designing homes that are naturally healthy: made using low allergen low toxicity materials. Griff says design is an important ally in the fight against allergies and toxicity in the home. "You need to build so your wet areas are on the north, to stop mould and mildew building up. Having the sun penetrating those areas and drying them out means that you diminish the need for harsh chemical cleaning agents."

Griff always considers the toxicity of materials used in the building process. "It's wise to look at the off-gassing of VOCs (volatile organic compounds) in buillding materials, particularly those used on the interior of your home such as paints and glues." He advises homeowners to paint with a good quality, low-VOC paint and warns that low-odour paints may use odour suppressors while still containing VOCs.

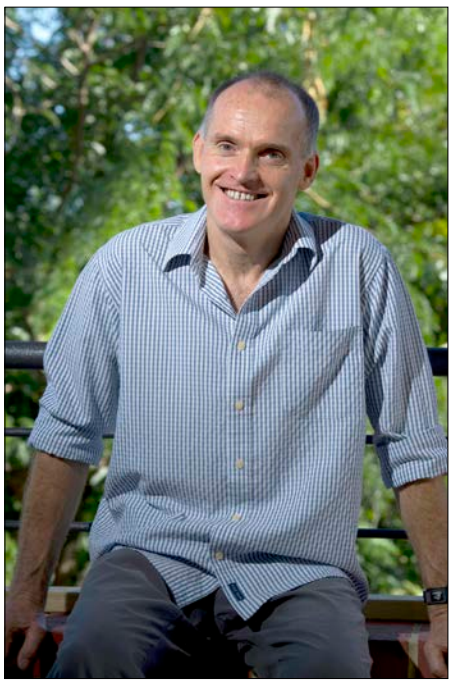
When I ask Griff if energy-efficient homes cost more to build he points out, "Good design saves you money." He says that your typical energy-efficient family home might cost between 5% and 8% more, but that the resulting efficient home will quickly gather all of that back. He adds that with energy-efficient homes it's not just a matter of financial gains but also quality of life.

> "You have to be concerned. Is the plantation sustainable? Did it replace hardwood forests? Are they poisoning the ground when they chop everything down, damaging the ecology?"

Griff says that when it comes to embodied energy you have to take life cycle into account. He gives the example of timber as a building material for roofing: "Timber has less embodied energy than steel because it locks in the carbon as it grows. People say, 'What about the termites?' There are good low toxicity treatments to prevent termites."

He points out that it is important to research sustainable timber. "You have to be concerned: Is the plantation sustainable? Did it replace hardwood forests? Are they poisoning the ground when they chop everything down, damaging the ecology?"

He reiterates the need to question, that sometimes people think they are making environmentally sound decisions when they aren't. For example, shipping products from Sydney to Perth by truck may use more energy than sending them from China to Fremantle in a shipping container—although it depends on the type of ship and the fuel it uses. With new innovative products, it's important to look at them carefully and track down the source of the materials, to check their embodied energy, toxicity and full environmental credentials.



↑ Griff Morris from Solar Dwellings in WA.

Gardening is a key part of sustainable design. Griff designed two 10 Star homes with Josh Byrne, from *Gardening Australia,* for which they won the 2012 HIA Greensmart Design Concept Award. The 10 Star homes harvest and recycle water, have a large garden area and provide a food supply. As they did with these homes, Griff says it's best practice to do the least amount of damage when you develop a block: "Keep as much of the material on-site as you can and reuse it."

In summary: plan, think, research, question: a key message gleaned from speaking with Griff is to question everything at every design phase along the way. ✸

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