Issue 125

ReNew

Technology for a sustainable future

Water saving issue

ON THE ROOF

Wildflowers, vegies and even chickens!

Josh's house

10 Star inside and out

Rainwater Tank

Buyers Guide inside

Flushed with pride

Water saving toilets

Gas vs electricity

Time for a sustainable switch?

Issue 125 October–December 2013
AU $7.95 NZ $8.95
www.renew.org.au
ISSN 1327-1938
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9 771327 193010

Darwin to Adelaide: our solar challenge guide; **The basics:** all about solar hot water; **DIY:** Netduino monitor project

WIN

a solar hot water system from Apricus!

*Australian residents only

Export your *turbine power directly to the grid

AUSTRALIAN MADE

The Latronics® Turbine Controller utilises a highly sophisticated micro-controller design to deliver a stable and safe supply of power to our grid connected inverters.

Designed specifically to integrate with the Latronics PV Edge Grid Connect inverters, it allows battery-less grid connection of DC or 3-phase AC wind and water turbines.

Electronic Smart Brake

The electronic braking system progressively increases the braking until the turbine comes to a complete stop. This will extend bearing life and prevent damage during extreme conditions.

Versatile

*Suitable for use with Wind Generators, Micro Hydro and other Renewable Turbine Sources.

Multiple Input Types

The Latronics Turbine Controllers come standard with a voltage rectifier. This means 3 phase AC or DC Voltage can be fed into the Turbine controller.

SPECIFICATIONS

Model	TC48	TC96
Voltage	48V	96V
Maximum input	Max 1kW Turbine	Max 2kW Turbine
Brake voltage	75VDC	150VDC
GC Inverter	PVE-1200	PVE-2500
Dimensions	260mm x 160mm x 100mm	
Warranty	2 years	

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DIY Solar & Power Solutions

Powertech Monocrystalline Solar Panels

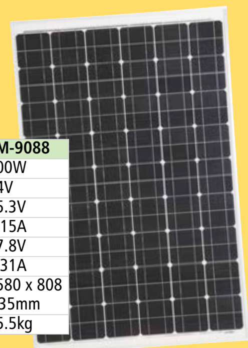
Strong and tough at an attractive price. Each panel is made by connecting up an array of hand picked individual silicon solar cells to match the power specification of the panel. The larger 80W and above panels are fitted with an approved waterproof junction box with cable glands and the smaller panels are fitted with a slimline junction box with silicone cable sealant. For approval details and full specifications, ask in-store or visit our website.

- Tempered glass front panel
- Extruded aluminium frame

12V 80W ZM-9097 $249.00
12V 90W ZM-9086 $279.00
12V 145W NEW ZM-9087 $369.00
24V 200W ZM-9088 $599.00

FROM $249.00

Cat.	ZM-9097	ZM-9086	ZM-9087	ZM-9088
Maximum power	80W	90W	145W	200W
Rated voltage	12V	12V	12V	24V
Open circuit voltage	21.8V	22.2V	22.8V	45.3V
Short circuit current	5.23A	5.39A	8.96A	6.15A
Voltage at max power	17.6V	18V	18V	37.8V
Current at max power	4.55A	5A	8.06A	5.31A
Dimensions	1200 x 540 x 28mm	1200 x 540 x 28mm	1250 x 808 x 35mm	1580 x 808 x 35mm
Weight	8.2kg	8.2kg	12kg	15.5kg



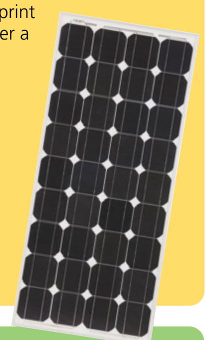
120W 12V Monocrystalline "Narrow" Solar Panel

The same power as the more typical size 120W solar panel, but in a more narrow footprint (around 150mm shorter) to fit over a smaller surface area.

- Max. power: 120W
- Rated voltage: 12V
- Weight: 10kg
- Size: 1190(H) x 660(W) x 35(D)mm

$329.00 ZM-9085

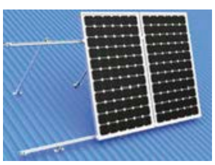
NEW 2013



Ecotech Solar Mounting Hardware

Designed to be used with either tiled or tin roofs, with any slope from 0-60˚. For use with 35mm thick modules.

- Vertical or horizontal panel mounting
- Suitable for aluminium framed panels
- Rails, splice, hooks and clamps sold seperately



Rails:

2 rails required for each row of solar panels in portrait layout

2560mm, for 3x 800-825mm width panels HS-8800 $49.95
3405mm, for 4x 800-825mm width panels HS-8801 $69.95
4200mm, for 5x 800-810mm width panels HS-8802 $84.95

RAILS FROM $49.95

Mounting Accessories:

End Clamps 35mm HS-8804 $3.95
Mid Clamp 35mm HS-8805 $3.95
Tin Roof Hook HS-8807 $8.95
Rail splice HS-8803 $9.95
Tile Roof Hook HS-8806 $26.95

Note: Not stocked in all stores, but can be ordered. Please contact your local store for more details.

ACCESSORIES FROM $3.95

Solar Panel Angle Mounting Brackets

An ideal solution for mounting a single solar panel so that it can tilt at a desired angle and easily fold it back down again when not in use. Holes are pre-drilled to line up with common panel sizes such as 80W, 120W and 200W.

- Size: 670(L) x 30(W) x 60(H)mm, folded

$59.95 HS-8785

Power Management System

Packed inside each Combi Series Interactive inverter-charger are three main components: a powerful low-frequency pure sine wave inverter, a high power 4-stage battery charger, and a fast action automatic AC transfer switch. It provides fully automatic operation and management of your entire power system. Ideal for caravans, motorhomes, marine vessels, off grid homes, or backup power system.

- Intelligent grid & generator power management
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- Power output rated to 70ºC
- 2-phase and 3-phase capability
- Stackable for more power
- Power Support feature
- Dynamic Power Shifting
- 4-Stage adaptive charging system
- Auto generator start function
- Aux. battery charge output
- Programmable Aux. relay outputs (x3)
- Interactive Pure Sinewave Inverter-Charger

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MASSIVE SAVINGS 20% OFF

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was $2199.00 now $1759 save $440

24V 1500W Super Combi MI-5251
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was $3699.00 now $2959 save $740

12V 1500W CombiPlus MI-5270
was $1999.00 now $1599 save $400

24V 1500W CombiPlus MI-5273
was $3199.00 now $2559 save $640

Want more info? Have a burning question to ask? www.jaycar.com.au/powertech

Viribright 240V 8W Mains LED Light Globes

Mains LED light globes that are a true replacement for traditional lighting, offering brilliant lumen performance also spreading that light evenly over a wide output angle. Unlike other inferior LED light globes, our LED light globes have the LEDs angle mounted evenly around a cone arrangement within the globe, giving a truly even light output across a 270° output angle.

- 8W Dimmable LED Light Globe

Warm White, Bayonet	SL-2230	$22.95
Warm White, Screw	SL-2231	$22.95
Natural White, Bayonet	SL-2232	$22.95
Natural White, Screw	SL-2233	$22.95

$22.95 EACH

NEW 2013

VIRIBRIGHT The bright side of light

5W and 10W Globes also available. Ask in-store or visit website (http://www.jaycar.com.au/ledbulb_landing.asp) for details.

Remote Solar Power Packages (NEW & IMPROVED)

For those living in locations where mains electricity isn't available, or is expensive to have connected, a remote solar power system is the best solution for household power needs. Whilst a remote solar power system can be a major investment, Jaycar offers packages to suit your needs and there are government incentives & rebates that may support your purchase*. Each package includes the necessary solar panels, a fully-featured interactive inverter-charger power management system, MPPT solar charge controllers, high capacity deep cycle battery banks, cables, connectors, and circuit protection. Just add the appropriate panel mounting hardware to suit your application. Contact our Powertech Team for a customised quote, powertech@jaycar.com.au

Remote Getaway System

3kWh Per Day with 1.2kW Solar Array

Three days system autonomy at 3kWh per day usage. Includes 1500W inverter-charger, 24V-600Ah battery bank and 50A MPPT solar charge controller.
MP-9002

FROM $10,490

Remote Living System

5kWh Per Day with 2.0kW Solar Array

Four days system autonomy at 5kWh per day usage. Includes 3000W inverter-charger, 24V-1350Ah battery bank and 80A MPPT solar charge controller.
MP-9004

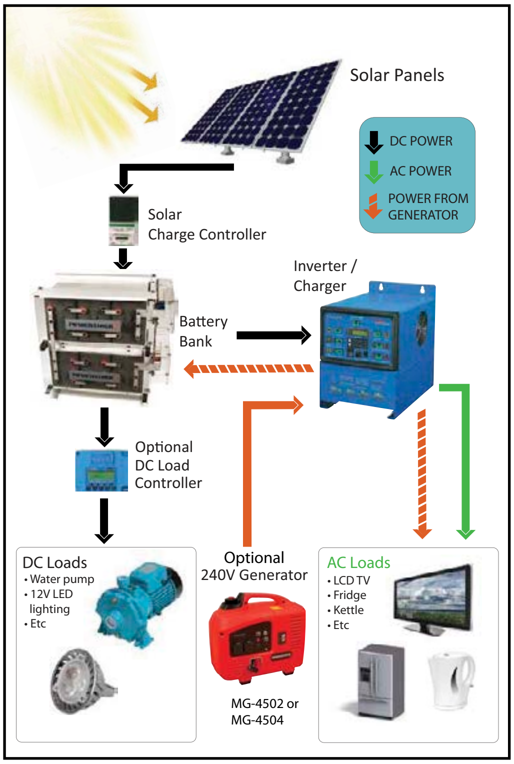
FROM $17,990

Remote Luxury System

10kWh Per Day with 4.0kW Solar Array

Four days system autonomy at 10kWh per day usage. Includes 6000W inverter-charger, 24V-2700Ah battery bank and two 80A MPPT solar charge controllers.
MP-9006

FROM $33,990



***Must meet criteria for Solar Credits Scheme. See www.orer.gov.au for details.**

Pure Sine Wave Inverter

These new pure sine wave inverters include models from 180 to 800 watts for a variety of mobile and permanent power installations. All models include a standard 230VAC mains outlet and a USB port for powering and charging USB devices. The advanced control logic system within each inverter provides standard protection (overload, low battery, etc.) as well as additional features which give improved performance and protection. The control logic applies a system check during start-up, soft start for high in-rush loads, three stage overload detection and prevention, high temperature shutdown and restart.

See the website for full specifications and full range.

NEW 2013

- 12VDC Input voltage

180W
- Size: 186(L) x 117(W) x 57(H)mm

MI-5700 $189.00

FROM $189.00

360W
- Size: 230(L) x 118(W) x 57(H)mm

MI-5702 $229.00

800W
- Size: 295(L) x 165(W) x 57(H)mm

MI-5704 $399.00

1500W
- Size: 350(L) x 230(W) x 74(H)mm

MI-5708 $849.00

2000W
- Size: 450(L) x 230(W) x 74(H)mm

MI-5710 $1099.00

2000W, 24VDC
- Size: 450(L) x 230(W) x 74(H)mm

MI-5712 $1099.00

Deep-Cycle Gel Battery

These are genuine deep-cycle batteries that can be operated and charged in any position. They are leakproof and completely sealed. Ideal for remote area solar power systems etc. Three types available:

12V 26Ah
- Size: 165(W) x 172(D) x 110 (H)mm

SB-1698 $129.00

12V 38Ah
- Size: 197(W) x 165(D) x 170(H)mm

SB-1699 $189.00

12V 100Ah
- Size: 330(L) x 173(W) x 223(H)mm

SB-1695 $379.00

FROM $129.00

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Croydon	(02) 9799 0402
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Gore Hill	(02) 9439 4799
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Caloundra	(07) 5491 1000
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Cairns	(07) 4041 6747
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Mackay	(07) 4953 0611
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Mermaid Beach	(07) 5526 6722
Nth Rockhampton	(07) 4926 4155
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Melbourne	(03) 9663 2030
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Shepparton	(03) 5822 4037
Springvale	(03) 9547 1022
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Northbridge	(08) 9328 8252
Rockingham	(08) 9592 8000

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Jaycar Electronics
Better, More Technical

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Issue 125, October – December 2013

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Water saving ways
In the house, garden and on the roof!

↑ TAFE SA and their car Solar Spirit 3 are competing in this year's World Solar Challenge. Page 24.

↑ This reed bed treats greywater before final sterilisation in a Sydney suburban garden. Page 36.

Features

↑ Josh Byrne installs the Grey Flow greywater system in Josh's House. Page 28.

Special feature: water saving

← **Cover image: Brod Street.** Our cover shows Brod's green roof, which he built on the sloping west-facing roof of his 1890s Melbourne terrace home. The garden includes a colourful array of Australian native flowers, including the yellow common everlasting (*Chrysocephalum apiculatum*) and tall bluebells (*Wahlenbergia stricta*). He argues for the beneficial biodiversity potential of green roofs, along with their use in temperature moderation. Page 44.

Rainwater tank buyers guide

Reader projects

Regulars

← A rooftop garden on Minifie Park Childcare Centre. Page 44.

About
ReNew and the Alternative Technology Association

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

ReNew is available from newsagents, by subscription and as part of ATA membership. ATA membership starts at $75 and offers a range of benefits. www.renew.org.au

Sanctuary magazine
In addition to *ReNew*, the ATA publishes *Sanctuary: modern green homes*, providing inspiration and practical solutions for a sustainable home. The current issue features 10 star homes and a Sustainable House Day Special.
www.sanctuarymagazine.org.au

ATA branches
ATA branches are involved in activities such as running monthly seminars, visits to sustainable homes and projects, and attending community events. See page 85 for a list of recent activities. www.ata.org.au/branches

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

Alternative Technology Association
The Alternative Technology Association is Australia's leading not-for-profit organisation promoting sustainable technology and practice. The ATA provides services to members who are actively walking the talk in their own homes by using good building design, conserving water and using renewable energy. The ATA advocates in government and industry arenas for easy access to these technologies as well as continual improvement of the technology, information and products needed to change the way we live.

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

Advocacy and projects
As well as advocating to government and industry, the ATA also conducts research projects with partners from government, industry and community sectors. Recently the ATA and Alviss Consulting found that solar customers are not getting the full choice of retail energy offers given to non-solar customers. Many Australian households with rooftop solar panels may not be on the best retail deal for both their solar electricity, and the electricity they purchase from the grid. www.ata.org.au/projects-and-advocacy

International projects
ATA volunteers have just returned from East Timor where they installed cheap, green solar lighting and trained local technicians. On this trip they installed solar systems in schools, community centres and houses. For more information and to make a donation to give the gift of light in East Timor, go to www.ata.org.au/ipg

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Contributions are welcome; guidelines available at www.renew.org.au or on request. Next editorial copy deadline: 21 October 2013.

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Next advertising deadlines:
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Advertising copy: 8 November 2013

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

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Editorial

Water saving ways: In the house, garden and on the roof!

WE don't often get the chance to feature a garden on the cover of *ReNew*. On the roof of a heritage terrace in Melbourne sits this haven of biodiversity, which also acts as a temperature moderator for the home below. With a 10 °C drop in summer temperatures in the roof space and a sprinkling of Australian native flowers to behold, this is sustainable technology meets botanic beauty.

The accompanying article argues for the many advantages of green roofs, with an added plea to think beyond the introduced succulents commonly used. Brod Street has found plants he recommends for both beauty and bees—and, luckily, he's prepared to share them with us!

The wider question we tackle this issue is water saving. We felt strongly it was time to put the spotlight back on water, especially given the changing weather and rainfall patterns around Australia.

As part of our water saving focus, we tour a 10 Star home where the garden and water saving features are an integral part of that design, making it what we call 10 Star inside and out. Interestingly, the design is 'open-source' with plans, videos and more info available online. It's also affordable, with a deceptively simple design to show that you can do 10 Star on a budget. It's the brainchild of ABC *Gardening Australia*'s Josh Byrne and is part of his mission to push sustainable building into the mainstream.

Our buyers guide this issue fits the theme too—it's on rainwater tanks, with a clear breakdown of tank types and a discussion of the sustainability of each.

One of the big water users in a household can be the toilet, so we ask the question: how low can you flow? We present a range of low water-use toilets and even get a quick guide to a DIY composting toilet. We also provide a reminder of the big and little things you can do to save water around the home, apart from 'befriending a bucket or two' (my dad's chosen water saving technology!)

We've also got a couple of other home projects this issue, one with a high-tech water recycling system that's made a Sydney home 96% self-sufficient in water, and one using greywater for food production. And we look at alternative technology for housing estates—a communal stormwater harvesting system to provide water cleanup, a water resource and public parkland.

Plus: Richard Keech argues it's time to switch our thinking away from gas as a sustainable energy source, we round up the Australian entries in the World Solar Challenge, Rhys Freeman takes us through the thinking behind an EV van conversion, and we follow a DIY project using a Netduino microcontroller to monitor a solar hot water system. All our regulars are in too, of course. We hope you enjoy the water saving theme and the many other articles—let us know!

Robyn Deed
ReNew Editor

In *ReNew 126*, out mid-December

- Solar panel buyers guide
- Sustainable caravanning and camping
- Solar ovens

ONE of the most disappointing aspects of this year's federal election campaign (result unknown as we go to print) has been how climate change and the environment in general have slipped off the political radar. It is a long way from the 2007 federal election that had climate change front and centre, along with policies to take action. Climate change and the environment instead are only talked about in the negative.

This is despite the ABC Vote Compass showing that the majority of voters believe the federal government should be doing more to tackle climate change. This was across party lines with over 42% of Coalition supporters wanting the government to do more about climate change, even though many oppose a carbon price/tax.

It is timely that *ReNew* is focusing on water saving this issue, as this too seems to have gone out of fashion. With the end of the drought across large parts of Australia, the incentive for households to reduce their water use or to capture and reuse our water resources has similarly ended. It is sad to think that the only time environmental issues rate highly is when we are suffering from extreme weather conditions such as drought, fires or floods, events that are only going to become more frequent with increases in climate temperature.

Whichever party has won it looks like it will be up to the community once more to take the leadership role in pushing for action on climate change—something *ReNew* readers will be at the forefront of.

Donna Luckman
CEO, ATA

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Up front

Women Power aims to use 20% less energy with the help of energy monitoring

A campaign called One Million Women is well underway to reduce energy use by changing personal behaviour.

"Our goal is to inspire 1 million Australian women to take practical action on climate change by cutting 1 million tonnes of carbon dioxide (CO_2), the main greenhouse pollutant causing global warming."

The campaign's recent project called Women Power sees 10 women given energy monitors to reduce their homes' energy use by 20%.

Head to their website and you can discover up to 50 ways to cut your pollution immediately. You will also find articles, talks and interviews with celebrities such as Maggie Beer and Katie Noonan who feature as champions of the campaign. www.1millionwomen.com.au

GreenPower that gives back to the community

The Community Climate Chest or 'C3' is a new initiative that gives households and businesses access to cheaper, tax-deductible GreenPower and carbon offsets online, with a share of the proceeds directed to local environmental groups.

Until now, electricity retailers have dominated the GreenPower market and set premium prices to maintain healthy profit margins, without providing clear information about the source of their renewable energy.

In contrast, the not-for-profit C3 scheme offers people cheaper GreenPower from a range of clearly identified renewable energy generators, which can be easily compared.

C3 only buys 100% government-accredited GreenPower, plus carbon offsets accredited under the rigorous international Voluntary Carbon Standard (VCS). C3 charges only minimal administrative fees. Payments to C3 are tax deductible and GST does not apply.

The combination of direct purchase, reduced margins and the tax deductibility of buying GreenPower and carbon offsets through C3 mean consumers save in the range of 25% to 50% dependent upon current certificate prices and personal taxation levels.

Beginning in rural Victoria, C3 is now creating a national coalition of charitable environmental and community groups called C3 Community Agents, who can market GreenPower and carbon offsets to their members and partner organisations.

The ATA, along with the Macedon Ranges Sustainability Group and ACX Argyle Pty Ltd, administer C3. To find out more, go to www.climatechest.org.au/host/ata.

Large PV becoming more common

Sometime *ReNew* correspondent David Coote recently submitted this photo (below) of a 90 kW photovoltaic array on a commercial building in South Australia. According to David, arrays like this have become fairly common at industrial and commercial sites in South Australia, as are installations over 10 kW on farms and large houses.

Other large installations include a 99 kW system on the roof of the Euston Club Resort (on the NSW-Victorian border), while the Rules Club in Wagga Wagga has installed a 76 kW system.

Solar projects steaming ahead—except in Australia!

It seems everyone is installing multi-megawatt solar PV and solar thermal projects, and leading Australia in this regard.

The Khi Solar One, a 50 megawatt (MW) superheated steam solar tower with two hours of thermal storage, and KaXu Solar One, Abengoa's 100 MW parabolic trough plant also under construction in the Northern Cape, will be the first concentrating solar power plants in operation in South Africa.

The South African Department of Energy

Zero carbon satellite launches!

Modern society relies heavily on satellites, but they are traditionally bus-sized machines designed to survive the rigours of rocket launches and space travel. As a result, the amount of fuel—and hence emissions—required to put them into orbit is huge.

Titan Aerospace has a different way of thinking and has proposed that a solar-powered aircraft, much like the Solar Impulse that featured in the last issue of *ReNew*, could take the place of many forms of satellite, such as weather monitoring, communications, surveillance, mapping and many other tasks performed by very expensive traditional satellites.

Titan's aircraft, the Solara 50 and the newer Solara 60, are designed to be autonomous, taking off, performing their tasks and then landing all on their own. The aircraft will be able to carry payloads of up to 32/113 kg respectively into what Titan calls "atmospheric orbit" at 20,000 metres (65,000 feet).

The Solara 50 is covered in 3000 solar cells, generating 7 kW of power in total—more than is required to keep the aircraft permanently aloft. Extra energy is stored in lithium batteries inside the wings, and is used to keep the aircraft on track during the night as well as powering the payload. As the Solara will fly well above any weather, there are no cloudy days to contend with, so flight schedules can be calculated with precision.

Indeed, the plan is that the aircraft may stay in the air for up to five years—a similar timespan to the useful life of many satellites. www.titanaerospace.com

intends to bring 17,800 MW of renewable sources online by 2030, framing South Africa's strategy for energy independence.

The solar projects have also created around 1400 local construction jobs, and about 70 permanent operation jobs, as well as reducing the country's carbon dioxide emissions by about 498,000 tonnes each year.

Abengoa designs, constructs and operates its own plants and is one of the few companies that uses both parabolic trough and tower technology. It currently has 21 plants in operation with a total installed capacity of 843 MW, as well as 810 MW under construction worldwide. Sadly, none of it is in Australia! www.abengoa.com

But geothermal moving ahead?

Petratherm is set to ramp up activities to develop geothermal energy in Australia after being awarded a new $13 million grant from the federal government.

Recently announced by the Australian Renewable Energy Agency (ARENA) as part of its Emerging Renewables Program, the grant will underpin the next stage of works at the Paralana geothermal energy project in South Australia's far north, which Petratherm is currently developing with joint venture partner Beach Energy.

The next stage of works includes drilling of the project's second deep well, Paralana 3, a producer well drilled into the hot rock reservoir created around the existing Paralana 2 deep well. Together the wells will provide a circulation loop through the hot rock to enable commercial production of geothermal power to begin. www.petratherm.com.au

"The not-for-profit C3 scheme offers people cheaper GreenPower from a range of clearly identified renewable energy generators."

Extreme water saving

In response to the last *ReNew* readers prize competition on water saving around the home, we received a great range of intriguing responses. The winner, Indija Mahjoeddin, is the proud winner of a Flexi Rain Tank water cube. Congratulations! Go to www.facebook.com/ReNewMag to check out some of the entries.

Up front

The ATA's John Knox reports on how government and industry are tackling climate change.

Upbeat report tracks progress to a low carbon economy

On 31 July, Climate Works launched their report *Tracking Progress Towards a Low Carbon Economy*. The report was upbeat and suggested that we are on track to reduce our emissions by 5% (from a year 2000 baseline) by 2020. This was good news—up to a point. While graphs and tables showed how we have reduced our emissions per unit of GDP or per square metre of floor area, it was notable that most emissions have in fact increased in real terms and we are yet to see any actual reductions in the quantity of CO_2 we are pumping into the atmosphere!

This notional 'reduction in intensity' shows that we are starting to de-couple our economy from fossil fuels and that is a good thing. It is of little consequence, however, if net emissions are still rising given the potential impact upon our nation that climate change poses and indeed has already wrought—for example, record floods in Queensland for two consecutive years, the 2009 heat wave and bush fires in Victoria or the record warm winter and recent record hot summers.
www.climateworksaustralia.org/project/current/tracking-progress-towards-low-carbon-economy

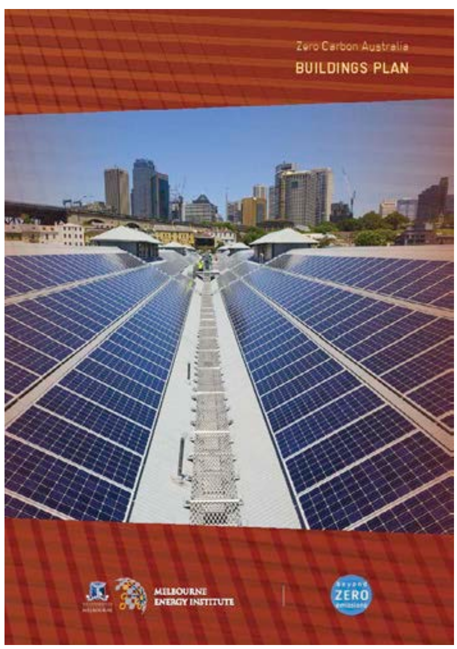
Payback times lead to energy efficiency action

In August, the Department of Climate Change and Energy Efficiency held a roadshow of workshops showcasing the current status of energy efficiency in large (high-carbon emission) industry.

There is much work being done to encourage high-emitting industries to get a handle on their energy use and the means by which they can reduce it, and thereby reduce their exposure to the carbon price. This is yet another area that the Rudd/Gillard/Rudd government has been invisibly active in helping to reduce GHG emissions—you might call this a failure in communication!

There were a number of presentations from industry leaders describing initiatives they have implemented to reduce their energy use. Some of these had paybacks of just seven months, which begs the question: why hadn't they addressed these years ago? Astonishingly, one industry leader also mentioned that their company would not even consider an efficiency measure unless it had a payback of three years at most (which equates to a return on investment of over 25% per annum!) Just what will it take to get companies to embrace energy efficiency, if not for the environmental benefits, at least for the bottom line?

Having said that, there are a lot of companies out there doing good things and this program could do with greater exposure so that companies not in the high-carbon emission category could benefit from these experiences. With some paybacks in that seven-month timeframe, we could all do with changing the way we use energy.



Beyond Zero Emissions grand building plan

From the people who produced the ground-breaking Zero Carbon Australia Stationary Energy Plan, Beyond Zero Emissions, comes a practical plan to fix the existing building stock of Australia and reduce its energy intensity by over 50%. These are, by and large, engineers, some of the most conservative practitioners in industry, and they have used extensive research, modelling, and analysis to arrive at their conclusions. They have also comprehensively worked in partnership with industry to create a plan that is both practical and doable. Their plan uses a suite of proven off-the-shelf building and appliance measures, including full insulation and draught proofing, efficient window glazing, better shading and cool roof paint.

They have also identified over 44% savings possible in the non-residential building sector.

It is their intention that every Australian building can produce a large proportion of its own electricity using solar photovoltaic (PV) technology. Arguing that gas is not a bridge to the future but rather a gangplank to climate catastrophe, they make a great case for the total replacement of all forms of gas with high efficiency electric counterparts. Highly efficient heat pumps for both heating and cooling and hot water feature prominently in this plan. This will lead to significant reductions in energy use and hence costs.

Of course, LED lighting plays a significant role in this plan as well, as does their intention of making today's best appliances tomorrow's benchmark. Energy efficiency standards and their strict enforcement will make for a better, less expensive and, importantly, greatly reduced carbon intensive life for all Australians. Oh, and you will also live more comfortably!
bze.org.au/buildings

↑ LED lighting, like this 10 watt bulb, are all part of the Beyond Zero Emissions plan.

Letters

Solar not worthwhile?

I have major concerns with future domestic solar installations regarding the future of feed-in tariffs (or lack of them).

As of 1 October 2013 in South Australia, any new solar installations will get zero feed-in tariff, other than what electricity retailers will pay, which is currently around 8c/kWh. I am not sure about other states, but I expect this will be country-wide at some stage.

I live in southeast SA and have a 5 kW solar system. This has been feeding energy to the grid for about 580 days, with an average production of around 20 kWh per day. The concern is that, of this total production, only 28% is swapped one-for-one with usage—the remaining 72% is returned to the grid.

We try and run washing machines, dishwashers etc at night to maximise the return to the grid as we receive a feed-in tariff of 52 c/kWh. Future solar installations will find that even if they try and run high-usage equipment during the peak of the day instead, it will be difficult to get less than two thirds of their generation going back the grid at 8 c/kWh, which is around 25% of the actual peak cost of electricity. Peak usage for a 'working family' is from 7–8 am and 5–10 pm. Peak solar production is between 10 am and 2 pm. Thus you will have to generate 4 kWh to pay for 1 kWh of peak usage.

I think people will find that their bills will still be quite high because of this situation. I don't know what other people expect from their solar installations, but I want to remove, or at least drastically minimise my energy bills. Any money back is a bonus.

Retailers currently try to match system size with energy consumption, but this method will not work as only 30% of the solar production will be swapped one-for-one with usage.

This raises a couple of questions in possibly maximising efficiency with this scenario. Are there existing electronic 'smart' devices that may be able to utilise electrical equipment at times of peak solar production, such as switching hot water services on and off? Another solution, on-site battery storage, which can be used when the home requires the energy, seems quite expensive. This may mean solar setups get back to costing $20,000 to $30,000. Do you have any thoughts or comments?

Justin McCarthy

While the current suite of feed-in tariffs (FiTs), at around 8 c/kWh, aren't perfect, there is good policy justification for the reduction in feed-in tariffs that has generally occurred around the country over the past few years.

The reason that FiTs were set at typically between 40 and 60 c/kWh back in 2009/10 was that the cost to install PV was so high. With prices falling from $14/watt to now around $2/watt installed, no longer are premium FiTs required—and nor can they be justified on public policy grounds, as a FiT is ultimately paid for by all other electricity consumers.

The appropriate level for FiTs now is the value of the commodity itself in the market—which many governments have set at between 5 and 10 c/kWh. ATA would argue that the pure economic value is somewhat higher than this (due to the additional benefits of solar at the wholesale market level), and we argue for somewhere between 10 and 20 c as being 'value reflective'. However, given some government's and industry's opposition to solar, we are lucky to have any FiT at all in some states.

This does mean that a small to medium sized system is more economically effective for most households as opposed to a larger system. We're pretty happy with this approach as the idea is not to consider solar on its own, but as part of a whole-of-energy management approach, which includes getting on the cheapest tariff you can and making your home/building as energy efficient as possible.

As an example, there is no point having a large solar system if you have no insulation or draught sealing, run halogen lights or have a 10-year-old inefficient fridge.

In regards to smart devices—have a look at the AS4755 Standard, which is employed by a number of new smart devices, including air conditioners and pool pumps, that can talk directly to the new Victorian smart meters or be remotely controlled by the consumer. These will make using energy during solar generation times, or cheap ('off peak') times for the purchase of electricity from the grid, much easier. Our new *Smart Meter Guide* talks a bit about these smart devices: www.ata.org.au/news/atas-consumer-guide-to-smart-meters/

Damien Moyse

Easy biochar

I would like to add a suggestion to the *ReNew 124* article on producing biochar for adding to gardens. If one does not want to go to the trouble of collecting leaves, twigs, etc and using controlled burning of it to produce biochar, and one has a wood fire for heating or cooking, there is an easier alternative.

I used to leave the unburned coals from the previous day's fire in the fireplace. They would burn away next time the fire was lit. Now I collect them and throw them on the garden—ideally they would be crushed first.

Dave Clarke

Wind for Macquarie

I read the article 'Energy access: small wind emerges' in *ReNew 124* with interest.

I spent 12 months on Macquarie Island a number of years ago. Macquarie would be an ideal location for smaller wind turbines to be installed to generate electrical power and reduce dramatically the amount of diesel fuel and aviation turbine kerosene (ATK) used there. The diesel is used in the mains power supply for the base while ATK is used in the heating of some buildings, or at least it was while I was there.

The power plant while I was stationed there consisted of two 40 kVA generating systems used

Ditch the petrol generator

Greetings from the US! Here in upstate New York, I enjoy seeing your mag from over the pond.

As shown in this picture, I've got a solar generator on my truck. Instead of using oil and gas to run a generator, I turn on the inverter and use the energy being stored in my batteries. I use the system when I go to a job site that has no power—I just run a cord to my truck, turn on the inverter and I'm running my tools.

The picture is the right side of the work truck with the solar panels.

This system cost me about $1400 to set up and install and works quite well. There's no need for fuel or oil and should last me 20 to 25 years with proper maintenance.

Quintin Bullis

alternatively to supply power to the station. Today they have two 125 kVA plants to do the same thing. Admittedly, the size of the base station has increased over the years.

The point I want to make is that the average wind speed on Macquarie is around 30 km/h and a calm day or night is rare, so considerable saving on diesel and ATK could be made by using wind-turbine generators. The large multi-megawatt units would be unsuitable, but medium-sized units of 100 kVA or so would seem to me to be quite practical, with enough output to easily supply all lighting, power and heating at the base station. The diesels would need to be retained for the few days when the wind is absent.

There are already a number of the small 200 watt or so wind generators with batteries used at some of the outstations on Macquarie.

I contacted the department responsible for the Antarctic and received a letter in reply giving nine reasons why it was impractical to put such systems on Macquarie. Yet currently there are moves to put quite a large wind farm on King Island and run power cables to Tasmania to put energy into the Tasmanian grid, and hence also the Victorian grid via the undersea cable between Tasmania and Victoria.

Political pressure by weight of numbers can bring results, as has happened in another problem area on Macquarie. Feral pests introduced back in the 1800s have caused enormous damage to flora and fauna on Macquarie. So a project to rid the island of feral pests—wekas, cats, rats, mice and rabbits has been undertaken. At a cost of around $25 million they believe that the project has been successful, with no feral pests seen in the last two years.

If enough people pressure the government (of whatever persuasion is in power) to install wind power electrical generation on Macquarie Island it will occur. If enough like-minded people pressure their MPs for this change it could occur and I'm sure would, as happened with the pest eradication project.

Rodney Champness

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.

Send letters to: ReNew, Level 1, 39 Little Collins St, Melbourne VIC 3000, Australia or by email: renew@ata.org.au

Thinner pipes save water

The following describes an energy and water saving technology that could be applied to domestic hot water services.

The supply to a domestic handwash basin is nominally 15 mm diameter pipe, or actually 12.7 mm diameter. The bore area is 93 mm² and this sized pipe contains 0.093 litres per metre of pipe length. There is a length limitation imposed by AS4809 which limits the length of 15 mm pipe to three metres.

AS4809 shows 15 mm pipe conveys 0.279 litres per second, or 16.74 litres per minute, which is significantly greater than the recommendations of AS3500, which is 6 litres a minute for a standard tap or 1.8 litres a minute for a spray tap. If the installation uses PEX (plastic pipe), the standard requires it to be 16 mm.

If instead the copper pipe from the water heater to the basin were 10 mm diameter, the bore area would be 47 mm² and the pipe volume 0.047 l/m, which at the maximum recommended velocity delivers 0.141 l/s or 8.46 l/m.

If the pipe length was not limited by the rules and the pipe could be 7.5 mm PEX, the installation would be much simpler. The thermal loss would be about 30% of a standard pipe and the water lost when draining down the cold content of a hot water line would be less than half of that wasted by the conventional system.

This proposition was put to Australian Standards on 5 May 2010 for the attention of Committee WS-14. The proposition would entail a dedicated hot water branch to each fixture group, where normal use would be one fixture.

No friction loss issues showed up on tests in the JEM Australia NATA-approved lab, based on the recommended flow rate and system pressure of 250 kPa recommended minimum for mains pressure systems.

In domestic dwellings there would be an appreciable saving of water and energy. In healthcare institutions the savings would be significant. The big gain is waiting time in hospitals, where sensor taps are used and the current philosophy is to have a hand rinse after each patient contact to minimise the possible spread of disease.

Dave Creasey

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

Smart slow cooking

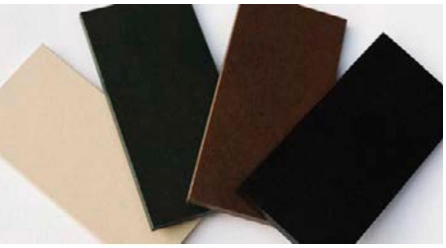
Haybox cooking is a process whereby food is brought to cooking temperature and then placed in an insulated container (commonly a box full of hay, hence the name). The stored heat in the food continues to cook it at a reduced pace, without any extra heat input.

However, haybox cooking hasn't really taken off in Australia, perhaps due to the prevalence of busy lifestyles here. However, there are a lot of advantages to this type of cooking, including reduced energy bills, better retention of food nutrients and the portability of food that is still cooking.

The EasyOven is a simple hatbox cooker design consisting of a circular insulated fabric bag with a simple drawstring closer on the top. It includes carry handles, is completely washable and comes in a range of colours and designs.

The initial cooking can be started on the kitchen stovetop, gas burner, paraffin stove or an open campfire using a cooking pot. Once your dish has been cooking for the recommended time, the pot is simply placed in the EasyOven to continue the cooking process for the required time.

RRP: $49.99. For more information or to buy, contact EasyOven, PO Box 5094, Kenmore East QLD 4069, ph: 0410 040 707, sales@easyoven.com.au, www.easyoven.com.au



02

Benchtops from paper

Australian-made Paperock is a high-strength building material made from multiple layers of 60% recycled or sustainably sourced paper (not certified) which can be used for benchtops. It is bonded with phenolic resin and heat, and pressure cured to form an extremely strong material.

It is virtually impervious to water, highly stain resistant, can be worked like hardwood and is available in a number of colours: black, sand, brown, green, a black and brown sandwich and a black and sand sandwich.

Because of its high strength, benchtops made from Paperock need not be as thick as with other materials, saving weight and cost. Paperock produces no VOC emissions and is heat resistant to 180 °C.

Paperock is made to order and is available in 3, 6, 10, 18, 25 and 32 mm thicknesses, with 50 mm on special order. Standard sheet sizes are 2.44 x 1.22 m or 2.85 x 1.35 m sheets. Maximum sheet size is 2.85 x 1.35 m.

Paperock also supply a similar US-made material, PaperStone, made from FSC-certified recycled paper and bonded with phenolic resins made from natural materials like cashew nut shells.

For more information, contact Paperock, 21 Hill St, Leichhardt NSW 2040, ph: (02) 9518 0520, info@paperock.com.au, www.paperock.com.au

03

Ultra low-power server

Servers are usually large, ugly computers that suck electricity like there's no tomorrow. Reliability and processing power is usually prioritised over energy efficiency, but it doesn't have to be that way.

CompuLab has a reputation for making amazing, tiny computers with very low energy consumption. They have recently expanded their range with the uSVR, a beefy little server suitable for a great many uses.

Features include a completely fanless, all-metal case measuring just 60 x 160 x 260 mm, Celeron or Intel Core-i7 processor, up to 32 GB ECC RAM, four internal 2.5" HDDs in RAID 0, 1, 5, 10 or JBOD configuration, optional mSATA drive up to 480 GB for the operating system, up to six gigabit ethernet ports and various other options. Power consumption is rated at a tiny 8 to 35 watts, depending on system configuration and load.

At time of writing we hadn't found any retailers of this amazing little server and so it is only available from CompuLab directly. Wholesale price for 1000+ quantities start at US$556 and the one-off price is 20% higher, or US$667. An evaluation kit is also available. Note that there are minimum purchase quantity restrictions for non-standard configurations.

For more information or to purchase, contact CompuLab Ltd, PO Box 687, Yokneam Elite, Israel 20692, ph: +972 4 829 0111, sales@compulab.co.il, www.compulab.co.il

04
High efficiency bulb replacement

When it comes to direct replacements for higher wattage GLS bulbs, there are not as many options in Australia as there are overseas. A new LED bulb, the BR1000 from Brightgreen, has provided another nice option for those wanting alternatives to incandescents and CFLs.

Touted as a replacement for a 100 W incandescent, the BR1000 consumes just 12.5 W while generating a maximum brightness of 1050 lumens, to give an efficacy of 84 lumens per watt. This is not as much as a regular 100 W incandescent, but the BR1000 should be able to replace any bulb up to at least 75 W and a 100 W unit in many cases.

Unlike the majority of LED bulbs that only emit light in a 180° spread, the BR1000 has a full 270° beam spread for more effective illumination.

The BR1000 has a colour temperature of a warm 3000 K and a CRI of 83. It is dimmable from 10–100% and comes in both B22 bayonet and an E27 screw bases—so it should fit almost anywhere a regular GLS bulb does.

The bulb uses a passive cooling system that allows the bulb to be mounted at any angle without compromising performance or longevity. Rated lifetime is 30,000 hours and it comes with a three-year warranty

RRP: $39. For more information, contact Brightgreen, PO Box 1400, Collingwood VIC 3066, ph: 1300 672 499, info@brightgreen.com, www.brightgreen.com

05
Low-cost portable solar lighting systems

Small solar lighting systems are popular with campers and caravanners, as well as anyone with an off-grid building with lighting and minor power requirements.

Commodore Independent Energy Systems has a new range of 12 volt portable solar LED lighting kits which can meet the lighting and electricity needs of many travellers or of small remote buildings.

There are three models, with 10, 20 and 30 watt solar panels and 7, 12 and 28 Ah lead-acid batteries respectively. Each kit comes complete with solar panel, central battery/controller unit, two 3 watt super bright LED light bulbs, and two bulb holders, each with a 5 metre cable and on/off switch.

The central units also include two USB sockets and a USB charge cable with 10 adaptors, providing a quick charging solution for smartphones, GPS and other USB devices.

The six metre cable on the solar panel allows you to place the main unit in a convenient location well out of the weather.

All Commodore portable solar series kits come with a 12-month parts warranty.

RRP: $149, $189 and $288 respectively. For more information or to buy, contact Commodore Independent Energy Systems, ph: (03) 5795 1567, sales@commodoreaustralia.com.au, www.commodoreaustralia.com.au

06
Easy system monitoring

In the last issue of *ReNew* we looked at monitoring systems for renewable energy systems, but one of the better systems on the market didn't get a mention.

The Splash Monitoring system consists of the Splash STREAMbox coupled to the user account of the system owner. The STREAMbox collects data from the system and feeds it via the internet to the Splash servers, from where the data can be displayed using easy to understand animated graphics. There are around 70 different graphics available, so there should be one to suit most systems, and custom graphics are also available.

Should the internet connection be lost, the STREAMbox can store up to four month's worth of data and transmit it when the connection is restored, so no data is lost, provided there is no power interruption.

The Splash system is compatible (at time of writing) with the following systems: EnaSolar, SMA, Fronius, Samil , Steca and power-one PV inverters, APS micro inverters, with support for Selectronic and Kaco inverters coming soon.

You can also monitor solar hot water systems, with Technische Alternative, Resol DL2 and Senztek solar controllers supported.

For more information, contact Splash Monitoring, 15B Saturn Place, Albany, Auckland, New Zealand, ph:+64 9 442 0996, www.splashmonitoring.com

Products

07

Go camping permanently

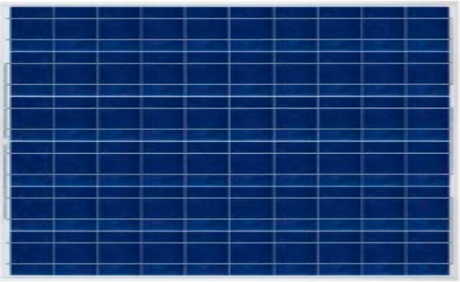
The idea of living in a tent is usually associated with camping, but tents have come a long way in recent years and have even evolved into permanent structures.

The Eco Tent range from Eco Structures Australia are fully featured canvas tents with a full-steel internal structure. They come in two ranges—the Deluxe, which include a full floor and decking, and the standard, which come without floor and verandah, ready to assemble onto suitable pre-existing platforms. They have a great range of uses, from weekenders to emergency housing, granny flats and eco tourist accommodation.

There are three standard sizes in the range—3 x 3, 4.2 x 4.2 and 6.3 x 6.3 metres. Add-on soft-wall bathroom enclosures are available as well as a number of other structures in the Deluxe and Eco Module ranges. All kits include the structural steel frame which complies with the highest Building Code of Australia (BCA) standards and the maximum cyclonic wind rating of Australia for any structure (Region D).

Eco Tents are supplied in a flatpack kit, ready for you to assemble. They come with a 25-year guarantee on the steel frame and a 10-year guarantee on the canvas.

RRP starts at $9375 for the 3 x 3 metre standard unit through to $30,000 for the 6.3 x 6.3 metre Deluxe. For more information and a quote contact Eco Structures, ph: (08) 9193 8007, www.ecostructures.com.au



08

Really (really) big 12 V solar panels

Most 12 volt solar panels are under 200 watts, but if you want more output at 12 volts, then you have to use multiple panels, adding to the wiring required.

Low Energy Developments now has a 300 watt, 12 volt polycrystalline solar panel for those larger 12 volt systems. These panels are ideal for mobile homes, buses, caravans, standalone systems, or anywhere you want to minimise the amount of wiring on a system.

Maximum current is 15.8 A at a maximum power voltage of 19 V, which is a little higher than usual for a 12 volt panel. We would recommend using a MPPT charge controller to get the most out of these panels. Maximum power temperature coefficient is -0.47%/°C.

The panels measure 1956 x 992 x 50 mm and weigh 25 kg. Despite their size, they have a good wind loading capacity, rated at a maximum wind speed of 60 m/s (216 km/h) or 200 kg/m². The panels come with 900 mm long 6 mm² flying leads.

Warranty is 5 years on the whole of product, with a 90% after 10 years and 80% after 25 years power output warranty.

For more information, contact Low Energy Developments, 544 High St, Preston VIC 3072, ph: (03) 9470 5851/(03) 9478 0080, www.lowenergydevelopments.com.au

09

More efficient outdoor lighting

While there are plenty of LED versions of the monster halogen floodlights around, getting an energy efficient lamp for Par38 light fittings has usually meant using a compact fluorescent lamp. The big drawback with CFLs is that they take several minutes to warm up, and turning them on and off constantly, which happens with motion-activated security lights, can shorten their lifespan.

The ATA (publishers of *ReNew*) now has an LED version of the common Par38 bulb. It draws just 18 watts of power to produce 1500 lumens of light, making these globes a direct replacement for 150 watt globes found in outdoor spotlights and sensor lights.

The bulb is IP55 rated for outdoor use, produces a natural white colour temperature of 4000 K and has a beam angle of 90 degrees, so it's definitely a floodlight, not a spotlight. Efficacy is over 80 lumens per watt, making it considerably better than the best compact fluoros.

RRP: $49.50. For more information or to buy, contact the Alternative Technology Association, ph: (03) 9639 1500, ata@ata.org.au or go to shop.ata.org.au

10
Give a crap about the planet

Toilet paper is not something many people give a lot of thought to, unless it is not as soft or as strong as it should be!

While there have been a number of toilet papers made from recycled paper or other more sustainable fibre sources, they are often thin and weak or still come wrapped in plastic.

The wonderfully titled Who Gives A Crap toilet paper range was created using crowdfunding site IndieGoGo. The company now makes the three-ply toilet paper using 100% recycled fibre, with no chlorine, inks, dyes or perfumes used. The paper is safe for septic tanks and similar systems. Each roll is 200 sheets long, with a new 400-sheet roll in the works and due out soon.

Perhaps the best thing about WGAC paper is that 50% of the profits are donated to Wateraid (www.wateraid.org) to help build toilets and improve sanitation in the developing world.

WGAC toilet paper is available in 24 and 48 roll cartons, and larger lots for offices and businesses. Delivery is free in major cities and just $8 elsewhere.

RRP: $20 for 24 rolls, $30 for 48 rolls, $137.50 for five 48 roll boxes and $250 for 10 boxes. For more information and to buy, contact Who Gives A Crap at wedo@whogivesacrap.org, www.whogivesacrap.org

11
Permaculture calendar 2014

The 2014 Permaculture Calendar from Permaculture Principles is just out and now includes the much-requested addition of a moon planting guide, with icons to guide gardening activity for each day.

Unlike common glossy calendars, the calendar is made from 100% post-consumer recycled pulp on certified carbon neutral paper that is manufactured and printed in Australia using 100% renewable energy. Printing plates and paper waste are all recycled, while inks are vegetable based and so don't release unnecessary VOCs into the atmosphere or require harmful solvents for clean up. Once the calendar has reached the end of its life you can recycle or compost it, hang the pictures, or keep it intact as a reminder of the principles and important events over the year.

Further, Permaculture Principles support the ethic of Fair Share, as 10% of the net return from sales of the calendar is donated to Permafund, supporting permaculture projects internationally.

RRP: $12.50, with discounts of up to 50% for quantity purchases. The 2014 Permaculture Calendar is available from Permaculture Principles, www.permacultureprinciples.com

12
This kettle should urn its keep

Reducing energy usage for boiling water can be done both by behavioural change and the choice of the right kettle.

The Kambrook Mini Urn features a volume controller which dispenses just the right amount of water for your cuppa—whether it be in a smaller 180 ml cup or a 350 ml mug. Unlike a regular urn, the Mini Urn doesn't heat all the water, just what you need at the time. It can boil up to 350 ml of water in just 60 seconds, making for a fast cuppa at that.

There is no need to worry if you haven't made the right cup size selection as the Mini Urn also features a manual 'stop' button to halt the auto pour if required.

Other features include a two-litre clear view water chamber with blue 'on' illumination, a secure locking pop-up lid for easy refilling and a removable drip tray. Warranty is 12 months, and the urn has been durability tested by Kambrook to boil over 4500 litres of water.

RRP: $79.95. Available from Kambrook retailers Australia-wide. For more information contact Kambrook Australia, ph: 1300 139 798, askus@kambrook.com.au, www.kambrook.com.au

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Delta has a dedicated **Australian** office and **service team**, with engineers and electricians who provide the best in technical support.

Delta's state of the art SOLIVIA 15TL and 20TL inverters have up to **98.0 % efficiency** and are designed to operate over a wide temperature range in harsh outdoor conditions. Both have a wide input voltage range of 250 V up to 1000 V, as well as 2 MPP trackers that support asymmetrical DC input loading (33/67 %) to provide **ultimate flexibility and maximum yield** from your PV installation.

Coming soon: New generation 4 inverter range with a 3 phase, dual tracker 5kW-TL, 30kW-TL and latest the micro-inverter technology.

DELTA

Methane matters
Is the future electric?

Richard Keech critically examines the sustainability of gas.

I'VE heard it said that 50% of what we've learnt is probably wrong; the trick is knowing which 50%. I submit that the received wisdom that gas is a clean fuel is probably wrong.

Consider more generally the burning of materials for their direct energy content. The use of wood, then coal, then oil and gas has underpinned the entire arc of human progress and achievement. But the advent of electricity meant much of that combustion no longer took place with the end user. At a time when renewable energy sources such as solar thermal, solar PV and wind can displace increasingly large amounts of that burning, why are we still persisting with policies that favour the burning of gas?

Perverse policies

At present in Australia fossil methane gas provides about 25% of all the energy to homes and business. It is generally viewed favourably as a safe, cheap and clean fuel.

That prevailing view of gas is influencing environmental policy. For example, various state rebates favour gas hot water units. This is based on the idea that gas produces fewer carbon emissions than the coal-fired electricity required for an equivalent electric hot water system.

But the electricity for a hot water system does not have to come from coal. Although it is still true that most of our mains electricity does come from coal, retail electricity customers have the option to source their power from renewable sources.

A policy that penalises hot water services because of the upstream deficiencies at the generator is perverse; in fact, the lowest emissions way of heating water is to use electric (or electric-boosted solar) hot water with zero-emission electricity.

Gas vs coal emissions

The direct emissions from burning gas are about half those of burning brown coal. The problem here is that 50% fewer direct emissions does not equal low emissions—and arguably hinders the push to the level of long-term emission reductions that we need. The direct emissions from burning gas are about 51 kg CO_2/GJ—still a high value in absolute terms.

Per unit of energy delivered, the emissions associated with gas are increasing as conventional gas reserves are depleted and unconventional forms of gas such as coal-seam gas and shale gas are brought into production. Emissions from ageing conventional reserves are also going up. In these reserves, it is necessary to actively compress where previously the gas came out under its own pressure. In addition, extra processing of the gas stream is required as progressively lower quality reserves are tapped, with entrapped CO_2 separated and vented to the atmosphere.

Fugitive emissions

Combustion emissions are not the only emissions associated with gas. The net emissions are also influenced by leakage, or 'fugitive' emissions. Two main factors influence the calculation of emissions from the leakage of gas: a) the global warming potential (GWP) of methane, and b) the rate of leakage of methane in gas production, processing, distribution and consumption.

Warming contribution of methane

The warming contribution (or GWP) of atmospheric agents other than CO_2 are significant, and dealing with them has been called the 'second front in the climate war'. It is estimated that methane has contributed about 30% of total human-caused warming since 1750.

As shown in Table 1, official estimates of the GWP of methane, stated relative to the effect of CO_2, have increased over time. Because different warming gases last different times in the atmosphere, it is customary for both 20-year and 100-year GWPs to be cited.

So which GWP figure to use? The current Australian government guidelines still use the older value of 21. Given the increasingly compressed timeframe for effective action in reducing emissions, the use of the 100-year GWP no longer seems appropriate. It is more reasonable to use a GWP timeframe consistent with the time remaining for mitigation efforts to be effective. The IPCC is soon to release an updated assessment. In the meantime, widely cited research by Shindell of NASA estimates the 20-year GWP as 105.

The other factor in Table 1 is the residence time: how long the gas lasts in the atmosphere. Methane has a stronger warming effect than CO_2, but a shorter residence time—about 12 years rather than centuries. Interestingly, because of this, the benefits of reduction in methane will be felt more quickly than reductions in CO_2.

Production leakage rates

The current Australian standard method for calculation of methane production leakage rates uses an assumed leakage rate of 0.12%.

> "In other words, it may be that the emissions situation for gas is actually no better than for coal-fired power."

Assessment	20-year GWP	100-year GWP	Residence time (years)
IPCC, 1992	63	21	10
IPCC, 2001	62	23	12
IPCC, 2007	72	25	12
Shindell et al, 2009	105	33	12

Table 1. Emerging understanding of the global warming potential (GWP) of methane.

Numerous recent studies suggest that fugitive emissions are much greater than 0.12%. The US EPA puts leakage in 2009 at 2.4%; other studies show higher leakage, around 4% to 9%.

In Australia, a study of the literature on fugitive emissions was conducted by Pitt & Sherry in 2012. This compares numerous studies which are consistent with a leakage rate of much higher than 0.12%.

A study by Hardisty et al suggests that "if methane leakage approaches the elevated levels recently reported in some US gas fields (circa 4% of gas production) and assuming a 20-year methane GWP, the GHG intensity of CSG-LNG (coal-seam gas liquid natural gas) generation is on a par with sub-critical coal-fired generation." In other words, it may be that the emissions situation for gas is actually no better than for coal-fired power.

Distribution leakage

Leakage also occurs in the domestic gas distribution network of pipes, meters and other reticulation equipment. Harrison et al, in the USA, measured about 75% of total fugitive gas emissions to be downstream of the initial production. A 2013 study from New York City concludes leakage exceeds 5%. Data from Adelaide suggests rates of lost gas as high as 7.8%. Current official estimates from the Australian government put gas distribution leakage factors, depending on state, at around 1.5%. A study from Sydney in the 1990s inferred leakage rates greater than 10%. A realistic estimate is likely to be somewhere in between these estimates.

My own calculations suggest that the effect of gas leakage exceeds emissions from combustion when the system-wide leakage rate is above 3.3%, assuming a GWP of 87. The literature suggests that the actual leakage rate is probably in the range of 5% to 7.5%. So, gas leakage could more than double the emissions effect of simply burning the gas.

Other issues with gas

The Australian domestic gas market has historically been isolated from world-parity pricing. This ceases in anticipation of the Gladstone LNG export terminal opening in 2014, exposing Australian consumers to significantly tighter and less stable market conditions. For the consumer this means higher prices and price volatility.

A 2012 study by Bloomberg reports that life-cycle costs of new wind and PV generation is already cheaper than new gas for large-scale generation. Under business as usual, there is every possibility that gas supply will be highly contested in 20 years time.

Gas in and around our buildings is a hazard because of toxicity and flammability issues. According to the Gas Regulators Technical Committee, "Carbon monoxide is a silent killer and is the major cause of gas-related deaths and chronic illnesses throughout the world." The combustion by-products of gas include nitrous oxides, carbon monoxide, carbon dioxide (CO_2) and sulphur oxides, which can have direct effects on respiratory and cardiovascular health. Poorly maintained gas heaters can be fatal.

Methane can be synthesised from a wide variety of bio-waste streams such as sewage, landfill waste and agricultural residues; this is sometimes called biogas. In special cases it makes sense to generate and use biogas onsite, for example, for power generation in piggeries and feedlots. It also makes sense to tap landfill gas.

However, there is insufficient capacity in Australia to substantially displace current usage of fossil gas with biogas. These carbon-rich waste streams will have several higher-value uses such as in industrial feedstock, for liquid transportation fuels and carbon sequestration initiatives.

The future is electric

In a gas-free future, energy services could instead be provided by efficient electric appliances. In the case of hot water, aside from solar systems, there are now heat pump units that work in all climate zones and use less than half the energy of an equivalent resistive electric unit. For cooking, the new generation of induction electric cooktops provide efficient and responsive cooking. For space heating, efficient heat-pump split systems can provide both heating and cooling by exploiting abundant ambient heat energy.

Is there enough clean electricity to make up the energy shortfall were we to phase out gas? Based on what I know about the potential of energy efficiency and the readiness of renewables to supply baseload, I'm confident that with sufficient consumer demand and government support, we'll see abundant clean power come on stream as users disconnect from gas.

Time to 'reinvent fire'

The present-day widespread use of gas as a fuel in buildings is a legacy of questionable value. The trend of green buildings using gas to attempt to reduce their emissions is worrying and is distracting the green building movement from real sustainable solutions.

A century ago it was commonplace to get light from burning gas or kerosene. Today we accept that we no longer have to burn stuff directly to get light. Perhaps it is time for our remaining use of gas in buildings to go the same way.

The burning of materials for the chemical energy they contain will one day, I hope, seem odd. In the words of American energy guru Amory Lovins, we are "reinventing fire". ✱

This article is based on work that forms part of the *Zero Carbon Australia Buildings Plan* from Beyond Zero Emissions. bze.org.au/buildings.

The sunny side of the street
Solar cars evolve

Amy Rolfe checks out the cars competing in the 2013 World Solar Challenge, powered by nothing but solar energy.

THE battle for efficiency and sustainability can be seen in everything from recycling bins to our rooftops as Australian society becomes more concerned about the damage our way of life is having on the environment. One sector of our lives, however, has remained relatively untouched—our cars. The electric car movement has begun to work on this problem as they integrate with rooftop solar systems and upgrade petrol vehicles with electric motors and increasingly light lithium battery packs. But another group of enthusiasts has taken a different approach.

The World Solar Challenge (WSC) has been running since 1987—a marathon 3000km journey from Darwin to Adelaide powered by nothing but solar energy. Teams leave Darwin and drive as far as possible until 5pm each day, when they must stop wherever they are and set up camp until the next day. In 2013, 48 teams from 24 countries are participating in the WSC.

The vehicles fall into three different classes—the Michelin Cruiser class, the Go Pro Adventure class and the indubitably gorgeous Challenger class.

The Cruiser class is created for practicality—cars that would meet road registration requirements in their country of origin and carry the driver and at least one passenger.

The Adventure class consists only of cars that have already participated in previous races, including the WSC.

The Challenger class is at the forefront of design, striving to create faster, sleeker and more energy efficient cars than any that have ever graced the Stuart Highway. This year, 28 teams have cars in the Challenger class. Two of these teams are Australian: TeamArrow, a Queensland-based team, who are participating for their first year ever with the Arrow1, and the University of Western Sydney, with their vehicle the SolAce.

Two other Australian teams, the TAFE SA Solar Spirit team with Solar Spirit 3 and UNSW Sunswift with eVe, are partaking in the Cruiser class, and the Aurora Vehicle Association are participating in the Adventure class with their familiar car, the Aurora Evolution.

A guide to form

The Aurora team manager, Andris Sampsons, gave us an insider's opinion on the likely top contenders this year: "The Challenger class represents the pinnacle of solar vehicle efficiency. Based on previous form and their new vehicles it looks like the top picks would be Nuon Solar Team, Nuna 7 (Netherlands), Tokai University, Tokai Challenger (Japan) and University of Michigan, Generation (USA)."

But he notes: "In pushing the envelope on efficiency and performance, some teams are pushing the design rule boundaries and it will be interesting to see whether the prizewinner will be ultimately determined by post-race protest, rather than on the line placing."

We get an update from the Australian teams as they enter the final stages of preparation for October's 2013 World Solar Challenge.

UNSW Solar Racing Team

Vehicle: eVe
Class: Cruiser

The UNSW Solar Racing Team, Sunswift, is working tirelessly on their solar car beauty, eVe. With eVe nearing completion, the Sunswift team holds high hopes for their solar sports car to be a true contender in this year's new Cruiser class. It is nothing short of hectic in the Sunswift workshop as the WSC 2013 approaches, but the team is excited, focused and doing all they can to ensure that eVe's revolutionary design hits the road.

Sunswift is not only looking to enter WSC 2013 with all guns blazing, but also to illustrate the amazing possibilities of solar energy in the car industry. Their solar-powered innovation hopes to strike an uncompromising balance between efficiency and practicality. The great progress that Sunswift is making would not be possible without the endless encouragement and aid of their sponsors and supporters. The team won't be resting until the elegant and environmentally friendly eVe is unleashed!

TAFE SA

Vehicle: Solar Spirit 3
Class: Cruiser
Our vehicle has seen major progress in recent months and is on schedule to be on the track at Darwin in good shape for the World Solar Challenge. We have altered our previous vehicle, Solar Spirit Mk-I, to comply with the new Cruiser category but we've been able to retain most of the previous configuration. The vehicle now has two motors working in tandem to provide more torque and higher efficiency. Road testing will be completed for this by mid August. A new set of batteries will be our most significant improvement.
Groups of students have been working on telemetry and body works since the start of 2013. Drivers are selected from our apprenticeship programs in electronics, electrical and metal fabrication. Team catering is assisted by the School of Hospitality and support vehicles are provided by the School of Recreation and Fitness. The construction workshop is buzzing several days a week and some evenings as various departments vie for access to complete their tasks on the vehicle. It's a lot of fun watching faces as we test drive the weird rolling chassis around the car park during the week.

Team Arrow

Vehicle: Arrow 1
Class: Challenger
Team Arrow is made up of both QUT students and companies with an interest in high technology engineering and motoring. Since the team has been in existence for less than 12 months we have been on a steep learning curve! Fortunately we have the benefit of having a number of experienced solar car builders in the team and one of the world's leading suppliers in this space, Tritium (www.tritium.com.au), working with us on the power systems.
The vehicle is currently undergoing assembly and will start on-road testing in mid August. The composite work was undertaken by our supporter LSM Advanced Composites (www.lsm.net.au) in Toowoomba.
The long-term goal for the team is to establish a platform to support and develop high-end student engineering talent in Queensland, backed by industry support.

Aurora

Vehicle: Evolution
Class: Adventure
We are running our successful Evolution vehicle in the Adventure class this year. We're looking at implementing a number of improvements including 2013 specification Michelin Radial X solar car tyres, new maximum power point trackers (MPPTs) designed and made in Australia by an Aurora team member, various electrical and electronic updates and another round of weight reduction.

Interesting!

In the revolutionary Cruiser class, Andris likes the look of both UNSW Solar Racing Team's eVe and the Hochschule Bochum Solarcar Team's PowerCore SunCruiser.

The road ahead

It may be that the Cruiser Class will drive developments ahead in driving options for practical passenger vehicles. Andris from the Aurora team says that the Cruiser class is a great first step, although their work on making their Solaris car fully road-legal has been driven more by the Australian Design Rules. (They haven't entered Solaris this year as they are relocating to a new workshop).

As Aurora's team manager Andris says: "our ultimate goal is to demonstrate a viable, solar-electric hybrid vehicle for everyday, off-grid use."

The path to a fully compliant road-going vehicle powered by solar power alone is a difficult challenge. It will be interesting to see this year's vehicles and the developments down the track. ✱

The World Solar Challenge begins in Darwin on 6 October 2013. www.worldsolarchallenge.org

See solar racing in your area!

The Model Solar Vehicle Challenge is a competition for school students to build and race model solar cars and boats: www.modelsolaraustralia.org

State events

Darwin Model Solar Challenge:
13 September 2013, Royal Darwin Showgrounds, Darwin NT.

Queensland Model Solar Challenge:
14 and 15 September 2013. Location TBA.

2013 SunSprint Challenge:
Dates TBA, UNSW Quad Lawn, Kensington Campus, NSW.

Western Australia Model Solar Challenge:
Dates TBA, The Esplanade, Fremantle WA.

Sunchase 2013 Alice Springs Challenge:
Dates TBA, Alice Springs NT.

Tasmanian Model Solar Challenge:
Dates and location TBA.

Victorian Model Solar Vehicle Challenge:
19 and 20 October 2013, Scienceworks, Melbourne VIC.

National event

Australian International Model Solar Challenge: 23 and 24 November 2013, Scienceworks, Melbourne VIC.

Josh's house and garden
Productive plans

Behind 10 Star Josh's House is a productive, water smart and shade-giving garden—and you can find the plans online, writes Jacinta Cleary.

AS a keen gardener in a dry spot like Perth, water has always been important to ABC's *Gardening Australia* presenter Josh Byrne. "From my late teens on we've always had water saving measures in place, and as a food gardener I'm always trying to come up with better watering systems." There was no doubt then that 'Josh's House' would be a water smart home.

Josh's House is the name of his ambitious building project in the Fremantle suburb of Hilton. Josh, an environmental scientist, runs a landscape and environmental design business while juggling a media career and a young family. As if not busy enough, he embarked on a "long-held dream" to build his own environmentally sustainable home and documented every step via the open-source Josh's House website, full of house and landscaping plans, fact sheets and videos to inspire anyone to build an energy and water saving home.

The two dwellings have been built in just six and a half months, with construction finishing in May. The project comprises two 10 Star homes on an 1160 m² block, with one for his family and another for his sister-in-law. As tends to be Josh's way, there have been no delays creating a common productive garden around the homes, with an impressive water harvesting and recycling set up.

Image: Joel Barbitta

↑ Josh's home has a 10 Star sustainability rating and features passive heating and cooling and advanced water recycling systems.

Water cycle

"All in all we will use less than a third of the typical Perth water scheme consumption while maintaining a beautiful and productive shady garden," says Josh. To do this, he's designed an integrated water system around what he calls his "water priorities", with rainwater capture and use at the top of his list, followed by greywater and bore water. One water source feeds into another helping to keep as much water as possible for reuse or infiltration within the property.

Rainwater tanks and beyond

With rainwater collection a priority, an efficient rainwater system has been installed. Each home has a wet system rainwater tank, where the collection pipes run underground to connect multiple downpipes from different gutters. This makes the most of the 200 m² roof space available on each home. An underground diversion valve is fitted so that water that sits in the pipes for too long, possibly becoming stagnant, can be flushed into an underground soakwell to seep into the surrounding soil.

Josh estimates mains water backup will be needed just a few months of the year. His house has a 20,000 litre poly rainwater tank and the other has a 12,000 litre tank, both plumbed to all areas inside and some parts of the garden. The first rain of the season that might contain roof debris and dirt is also flushed into the soakwell, and drinking, cooking and bathing water is filtered through sediment and carbon filters.

↑ Greywater is fed to the garden via a series of drip-feed lines. Here they can be seen before being covered in 100mm of mulch.

↑ The 20,000 litre rainwater tank, tucked into a corner, is one of two on site.

The rainwater plan goes beyond just tanks. "You've got to think of the whole property as a catchment to make the most of rainwater. It doesn't have to all go into a tank, you can include swales and rain gardens," says Josh. Along similar lines to the soakwell, rainwater from the carport and front verandah downpipes goes into a native damp land soak feature, similar to a drain wrapped in geotextile fabric. This water infiltrates the soil and helps to recharge the groundwater, while creating a zone for water loving plants such as native rushes and sedges.

Greywater direct to garden

Josh decided to install a direct-diversion greywater system with water that requires little treatment, such as laundry and shower water, delivered quickly to the garden. "Greywater-ready plumbing is pretty straightforward provided it is done and thought through at the beginning of the build," he says, with the 'builders kit' of a sump and dual interceptor unit put in during the initial plumbing works. One reason he chose this system, the Grey Flow by Advanced Wastewater Systems, is that the filters are cleaned automatically with a filter back-flush device: "Even the most enthusiastic greywater user can get tired of cleaning filters all the time," he says.

The system diverts bathroom and laundry water before it enters the sewer, flowing through a set of filters into a buffer tank. The tank water level rises and triggers a float switch, with a pump then pushing the water through pipes to a drip-flow irrigation system. The purple irrigation hose sits above the soil but is covered with around 100mm of mulch to keep the greywater contained, in line with WA Health Department guidelines on greywater reuse. The system pumps bore water if no water is being used in the home, such as when the households are away.

The garden benefits from around 300 to 400 litres of household greywater every day, used in particular on the fruit trees and shrubs. Greywater is an integral part of the garden's water supply so well worth the investment according to Josh. "All up the drainage plumbing cost about $1200 per house for the additional drainage pipe work. Then the greywater system itself including the pumps, filters and irrigation system cost around $2500 for supply and installation. So that's close to $4000 all up for a complete greywater system. As well as providing savings on my irrigation water use, my garden will have a regular supply of water every day from an unrestricted source," he says.

Josh wants to see more greywater systems in new homes so he's showing how it's done. He's produced a short video on the installation of his greywater system (see Feature Video 2 on the Josh's House website) and helped develop a guide to greywater installation. The detailed guide *Greywater-Ready Plumbing Guidelines* has been released by the Water Corporation in conjunction with Josh's environmental design business, Josh Byrne & Associates, to assist householders and plumbers select and install greywater systems.

Bore water and stormwater

Large sections of the garden are irrigated with bore water instead of "precious and constrained scheme mains water," including the vegetables and grass, with $6000 to $7000 spent on the bore. While some bore water use can be controversial due to the use of finite groundwater reserves, this bore taps into the superficial aquifer 30 metres below, which is recharged every year by the winter rainfall.

Stormwater runs into the soakwell, damp land and permeable surfaces as a way of putting back what's been used from groundwater. The soakwell, deliberately near the bore, is an underground modular tank made from recycled plastic drainage cells and wrapped in a permeable geotextile fabric. Water soaks into the ground while the fabric stops silt and soils from washing into the tank system. The soakwell takes overflow from the rainwater tanks as well as water flushed from the tanks' underground pipes and first flush systems.

Solid surfaces have been kept to a minimum to increase rainwater infiltration. The driveway is a permeable gravel surface so that rain can penetrate the soil; recycled plastic drainage cells over a geotextile fabric are underneath the driveway to drain excess water. The modular cells in the soakwell and driveway drainage system are made by Global Synthetics.

Water saving measures

Water use is controlled as much as possible, both inside and out, to make the most of what's available.

The house has high performance WELS-rated low-flow showerheads and taps, while the toilet features a water saving design, with a hand basin on top of the cistern so that hands can be washed with the water that fills the cistern.

Water saving in the garden includes basic measures right through to high-tech irrigation systems. The soil has been improved to hold more moisture and garden beds are mulched to reduce evaporation. And the predominantly native garden won't need water once established.

The garden is split into seven different hydrozones for more efficient watering, with plants grouped together based on their common water needs. The dripline irrigation system to the hydrozones uses both soil moisture monitoring and weather monitoring to maximise water efficiency. "The scheduling of the irrigation controller will be as efficient as possible with the station run times, watering days and watering volumes determined by the hydrozoning of garden beds," says Josh.

Dismantled then rebuilt

Recycled and salvaged timbers have been used extensively in the garden, although a major source of materials was unexpectedly trucked away. Josh had planned to reuse some of the original home on the block in the landscaping. Instead, one of the construction team, a wood worker, asked if he could move the house to his bush block south of Perth. It was packed up, window frames and all, with a set of plans for reference and given a new lease of life elsewhere. Josh searched the salvage yards for landscaping timbers instead.

Cooling garden

With the integrated water system underpinning it, the garden is like a 10 Star version of the houses—an urban environment for healthy living. As well as being water smart, the beautiful garden also plays a very important role in passively cooling the homes. Deciduous plantings such as the grapevines growing on the north-facing pergola will shade the living areas in summer and allow sunlight inside when the leaves are lost in the cooler months. The homes are further protected by evergreen plantings on the east and west such as the vines over the

↑ The Grey Flow builder's kit greywater system is mostly underground.

↑ Advanced trees give the garden an instant established look and will provide shade in summer.

↑ Laying the Nero Drainage Cell to create an even surface that will drain excess water.

front car bay. The decking on the northern side has been built with lightweight materials to reduce radiant heat, and removable shade sails will be put up in the hotter months.

Shared sustainable garden

While the garden has been designed with sustainable water use and biodiversity in mind, it's also a place for play and relaxation. "Our garden is great for kids' dexterity, intrigue and interest," says Josh, with large rocks and sensory plants throughout, as well as a climbing net and sandpit.

The wide front verge is planted with natives that anyone out walking their dog can appreciate, and the front yard is a perfect spot for neighbourhood get-togethers with a fire pit and stone wall seating. There's no fence between the two homes allowing for a large shared vegetable garden. Joint fruit trees, a chook pen and composting bays help the two households be more self-sufficient. ✳

Jacinta Cleary is on parental leave from *ReNew* magazine until next year. She says that countering the increase in household consumption associated with having a family is a large, interrupted project.

More info:
Josh's House: www.joshshouse.com.au
Greywater industry group for greywater guidelines: www.gwig.org

A 10 Star home at $1200/m²

Josh Byrne was "on a mission" to build a resource-efficient home that can be replicated by industry and the wider community. The result is a home with a 10 Star NatHers rating that cost only $1200/m² to build. With the house and landscape plans online, is this a prototype for more affordable energy efficient homes?

Josh would certainly hope so it seems. "To me, choosing to build a home that's thermally comfortable, energy and water efficient, as well as healthy to live in just makes sense. Furthermore, there are no reasons why a home that performs well should cost more, or be more difficult to build. I hope this project helps facilitate this change, through demonstration, information and inspiration."

The houses were designed by WA passive solar design specialists Solar Dwellings, with a brief to use conventional building materials and construction methods. The 10 Star rating was achieved through good orientation, reverse brick veneer construction to increase internal thermal mass, high insulation levels, appropriate window sizing, placement and glazing and the simple inclusion of curtains, pelmets and shade sails.

The houses run along the block's long east-west axis to maximise the north-facing living areas. Concrete slab floors are flooded with winter sun, while other internal thermal mass includes double-brick and reverse brick veneer walls to absorb winter sun and help keep temperatures stable in summer.

Only one double-glazed window was needed to achieve the 10 Star rating, in the kitchen, where a curtain couldn't be used. All other windows are made from low-e glass with a coating on all external glass to reflect heat.

The surrounding garden shades and cools the home (see main article) along with an array of windows on the south and southwest to capture cooling breezes and flush out hot air in summer. The white roof reduces heat gain as it reflects more solar radiation.

With these passive cooling features there's no need for air conditioning, nor is there heating. During the recent winter months the house warms naturally over the day and retains this heat. Josh says that the temperature gets up to 24 °C inside during the day and rarely drops below 20 °C, even when it's a particularly frosty 2 °C over night.

Bills are further reduced with a 3 kW photovoltaic system comprising REC 250 W polycrystalline silicon panels and a Chromagen gas-boosted solar hot water system. The Solatube, a tubular skylight, brightens darker zones in the house, and most other lighting is LED.

Watch how it performs

With only a handful of Australian homes holding a 10 Star Home Energy Rating there's a lot to learn about their construction and environmental performance. Josh's next project is a postdoctoral fellowship where he will scientifically monitor the homes over the next three years for the Low Carbon Living CRC. Josh's House will be one of their Living Laboratories, with data loggers and a weather station already installed during construction to collect energy use data. The information will be shared via the Josh's House website.

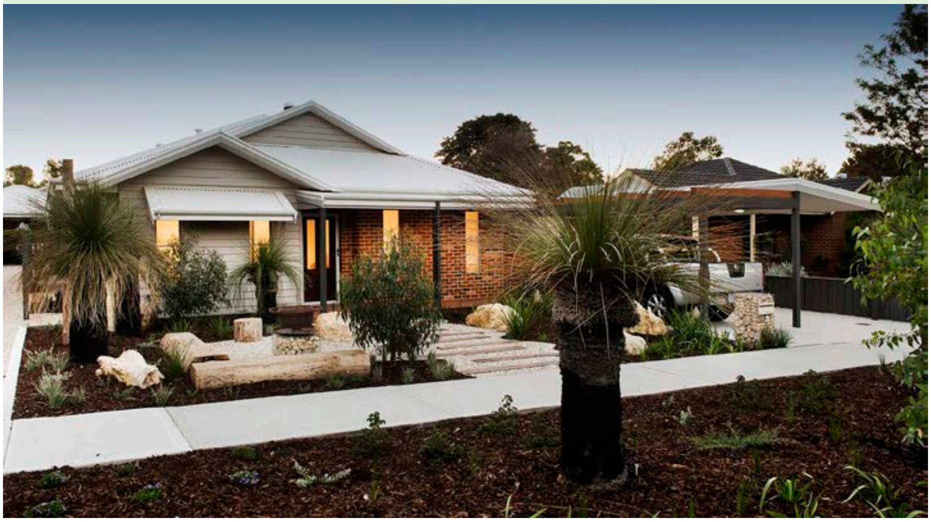


Image: Joel Barbitta

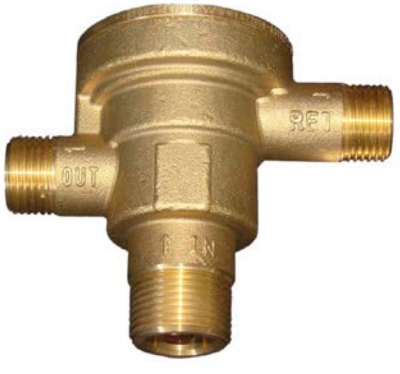
Practices and plumbing
Water saving ways

Water saving doesn't have to be expensive or difficult. Jacinta Cleary reviews the best practices and latest technologies to help save water around the home.

MOST water-conscious householders have befriended a bucket or two in the last decade to save water around the home, with Australian Bureau of Statistics figures showing household water use dropped 8% in 2011. With water bill increases and more dry spells on the way, water is still as precious as ever, so how can you save even more water around the home?

Diverters

Hot water taps that are slow to warm can mean cold water goes down the drain. Hot water recirculation systems help by diverting the cold water in the hot water line back to the hot water tank or another use, such as into a rainwater tank, until the water hits the right temperature. The easy-to-install Redwater Diverter is a simple brass valve that diverts cold water, while another retrofit option is the Act D'Mand Kontrol System, a pumped system that recirculates the water (and is available from the ATA shop). Or simply collect the cold water in buckets to save thousands of litres of water each year.



↑ The Redwater valve simply diverts otherwise wasted cold water from the hot tap to another use.

↑ The Every Drop Shower Saver lets you shut off the water while soaping up, reducing shower water use.

Bathroom

Around 20% of household water use is in the bathroom, according to SA Water, so improvements to showers, toilets and taps can help save water. The Every Drop Shower Saver is a paddle-like device retrofitted to the shower that quickly switches the water flow on and off while soaping or shaving. With a flick of the paddle the water comes back on at the same temperature and flow, stopping water going down the drain unnecessarily and saving energy from water heating.

Save more water in the bathroom by putting flow restrictors and aerators on the taps and install a low-flow showerhead. Place a brick or water bottle in the toilet cistern to reduce how much water it holds. Or install a dual-flush toilet with a hand basin where you can wash your hands while the same water fills the cistern; for more details see the water saving toilet feature in this issue.

Greywater

A household can produce up to 400 litres of greywater a day and there are a number of simple ways to get this water to the garden. The Hughie Sink is a plastic bucket moulded to fit the shape of most kitchen sinks. Wash the vegies in it, pick it up by the handles and tip it on the fruit trees. The Solar Bathtub Greywater Pump takes bath or laundry water outside in around 10 minutes, and best of all it's powered by the sun. Or send greywater to the garden by attaching a wastewater diversion valve to the laundry or bathroom drainage pipes. Find out about more advanced greywater systems in the Greywater buyers guide in *ReNew 102*.

↑ The Hughie Sink lets you capture water used for many tasks for later use on the garden.

← The AquaTrip can detect leaks and prevent water damage and drained water tanks.

Garden

The garden is the place to save litres and litres of water, with up to 40% of household water used there. Mulch or use water crystals to keep water in the soil, and control when the garden is watered with a soil sensor that measures moisture, or a rain sensor that suspends irrigation after rainfall. And make the most of those buckets or diversion systems this summer to keep the garden around your water-wise home thriving. ✱

Easy steps to save water

- Buckets! Collect water in the shower, kitchen and laundry
- Take shorter showers
- Fix dripping taps
- Run the dishwasher and washing machine only when full
- Place a brick in the toilet cistern
- Mulch and improve the soil to hold water
- Plant drought-tolerant natives
- Reduce evaporation: water to the roots or at night
- Cover the pool to reduce evaporation
- Wash your car in the rain

Next steps to save water

- Install a dual-flush toilet with integrated hand basin
- Insulate hot water pipes to keep water warm
- Install a cold water recirculation system
- Install flow restrictors and aerators on taps
- Install a low-flow showerhead
- Collect rainwater: in a tank or DIY with wheelie bins
- Create a DIY greywater diversion system or invest in a greywater treatment system
- Buy WELS-rated appliances—and check for rebates!
- Attach a weather monitor to the irrigation system

Clever water saving devices

Leaking or burst water pipes damage buildings and waste precious water. An Australian electronics design engineer has invented an early detection device for water faults, after his bathroom had to be rebuilt due to a small but unknown leak in a pipe fitting. The AquaTrip (www.aquatrip.com.au) is a water safety trip switch that turns off the water supply when a leak or burst water pipe is detected.

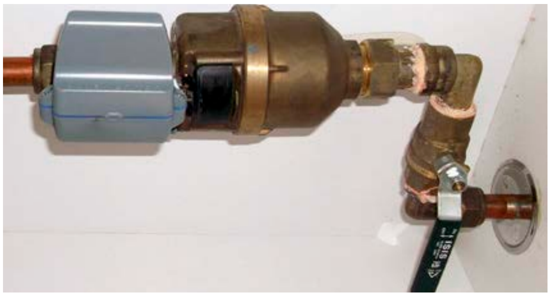
The electronic device, fitted to the incoming water supply by a plumber, monitors water flow into the property and can differentiate between normal water use and an actual plumbing failure. Leaks that would go unnoticed until real damage or expense is incurred are detected early on.

Starting at around $150 it's an affordable water saver for households, but can really make a difference in offices, schools and even parks and campgrounds, where a tap can be left running for hours. It can detect an irrigation leak on the other side of a farm or simply monitor precious rainwater supplies.

The AquaTrip won best Product Innovation at the Savewater Awards last November. Also nominated was the Wobble-Tee (www.wobble-tee.com.au), a water-efficient sprinkler that delivers water at two angles; one as widely as possible, and a lower angle that works better in the wind. The droplets are larger than usual so there is less chance of wind drift or evaporation. See www.savewater.com.au for more on the Savewater Awards.

Smart water monitoring
Add a monitor to your water meter

Andrew Stewart from Aquamonitor explains how smart water monitors can hook into our mechanical water meters to help reduce water consumption—and make a building manager's life easier.



↑ The Aquamonitor wireless sensor unit simply mounts onto a pipe and the sensor unit is fitted to the meter. Different meter models require different sensor fitment, but most standard meters can take a sensor that allows them to become part of a wireless water monitoring system. Two meter models are shown at right with the reed switch fitted.

USING mains water has financial, community and environmental costs. Hidden from everyday life the water we use is collected, treated, pumped and distributed. After the water is used it is often processed in some way or flows as wastewater into our waterways and oceans. No matter where water is used there is usually an energy cost associated with water heating, washing machines, pumping and water treatment.

As electricity consumers we have become more aware of the need to reduce usage, use more energy-efficient appliances and to limit wasteful usage such as standby power. Along similar lines, as responsible consumers we diligently consider water efficiency when choosing fittings and appliances.

But what about water monitoring? Wireless water monitors have also become available that display real-time usage and so enable us to track the main users of water and uncover wastage through leaks. Even better, they can even be used with existing mechanical water meters.

The humble water meter gets smarter

Most homes and buildings are connected to a mains water supply through a mechanical water meter that is routinely read by a local authority for billing purposes and for water supply management.

In Australia there are many different models of installed meters, the most common supplied by Elster, RMC and Itron. Mechanical water meters have a register with dials that display total water usage. Typically the meter comprises two physically separate sections that are linked using a magnetic coupling. A wet section connects the water inlet and outlet and contains moving parts that move in proportion to the water flow. A separate second section contains the register which turns in unison with parts in the wet section, via the magnetic coupling.

The majority of mechanical water meters also have provision for fitting a reed switch to a recess in the body or face of the meter. As water flows through the meter the magnets within the meter turn and cause the contacts of the reed switch to open and close. Electronic equipment can sense and total the reed switch closures to determine the volumetric flow of water. Each contact closure represents a fixed measure of water volume that has passed through the meter. There are some meters that are designed for an optical sensor rather than a reed switch to indicate water flow.

Smart water monitors typically have a wireless module that connects to the meter using a reed switch or optical sensor, depending on the meter type. Fitting the reed switch or optical sensor is usually a simple DIY task not requiring any changes to the plumbing nor requiring the water to be turned off. With the wireless module fitted, the meter is transformed and data can be regularly sent to a wireless monitor or to a data collection device for display and analysis.

Better submetering

Water monitoring can also make a big difference in commercial buildings. A common practice in commercial buildings is to install water meters at key points within the building or site. These meters are termed 'submeters' as distinct from the main meter which measures the total volume used by the building. Facilities such as hotels may

→ Using a PC with the Aquamonitor display unit (right), hourly readings can be downloaded into a CSV file that the user can then graph or analyse as they like.

have submeters installed in areas such as the laundry, kitchen and pool. By tracking each submeter, a proportion of the total mains water consumption can be apportioned to each area. Submeters also enable improved ability to locate and isolate faults and leaks.

However, depending on the size and layout of the building, the manual reading and recording of submeters is a task that, at best, is good exercise.

Using wireless monitors makes the meter reading task much easier by providing automated recording and alarming, with a display of the real-time usage and periodical totals available on a remote computer or smartphone. The result is an easier life for the building manager along with the potential for reduced consumption. ✱

Aquamonitor website: www.aquamonitor.com.au
Water meters and meter reading equipment: www.bit.ly/reliancemeters and www.bit.ly/flotechmeters and www.watermeters.com.au
Smart meter for residential usage: www.bermad.com.au/iperl/

Smart water meters on trial across the country

Regular water meters are made smarter by connecting them to a data logger that can send information back to a computer. A program can then look at the rate of flow of water to tell you how much water you use and when. It can even break down the day into the moments when you took a shower, washed a load of clothes or even used a tap.

Smart water meter trials are happening all around Australia. Dr Cara Beal, a Research Fellow at Smart Water Research Centre and School of Engineering at Griffith University, says that after surveying water utilities around Australia for a study undertaken by the Water Services Association of Australia, they estimate that there are around 150,000 smart water meters installed or being installed in Australia. She adds that this number is probably quite a conservative estimate and there could be more.

Water utilities are realising that having an intelligent water network system, with smart meters telling them where and how much water is being used, has the potential to not only improve water saving but also be cost efficient. For example, if peak water-use times can be flattened out, the result will be a saving on electrical pumping costs.

Cara says that for the consumer, having smart meter information is empowering as they have more feedback on their water use, including leaks, and this can motivate behavioural change (and save dollars). Smart water metering research shows that inside the house, on average, showers use around 30%, clothes washers use 20 to 25%, toilets use 15 to 20% and taps make up 20 to 25%. "If you want to save the world—have short, cold showers!" says Cara. When asked about dishwashers she added that they are not big water users and are the least of your water worries.

Saving water in the suburbs
A water self-sufficient home

Richard Stanford describes his son's rainwater collection and greywater treatment system in suburban Sydney which makes the house 96% water self-sufficient.

MY son Ralph and his family undertook a major renovation of their small, semi-detached federation house in Randwick, Sydney, three years ago. Their aim was to create more space and transform the building into an energy-efficient one.

They endured more than a year of very slow progress but were finally able to return to a home transformed with a modern interior and much enlarged first floor, which still retains the original yard and heritage front. The frontage disguises the fact that the roof and walls now contain modern insulation, the windows are all double glazed and there is a 4.8 kW array of photovoltaic panels and a solar hot water system on the roof. Most interestingly though, the house is now 96% self-reliant for water.

The original plan to have a rainwater storage tank under the house was deemed impractical because of the unknown state of the foundations, built on sand. Excavating close to them could have been disastrous, so the second option of excavating for a smaller tank under the garage floor, at the rear of the property, had to be adopted. There is no room for surface tanks.

Knowing the roof area and the local rainfall average, my son estimated that a 10,000 litre tank, combined with recycling of greywater, might provide approximately 80% of water requirements. In the event, the builders managed to make the tank very close to 15,000 litres. It is a concrete structure with a heavy-duty flexible liner. It is trafficable, with a cast-iron manhole cover. A sealed rim outside the main cover with an aluminium cover over it prevents any spilt liquids seeping in through the manhole.

→ The reed bed treats greywater before final sterilisation. It measures just 2250 mm long x 820 mm deep and 1660 mm high, and contains around 900 mm of soil on 600 mm of gravel.

Between the roof and the tank, simple enough in themselves, there is an amazing and mystifying collection of tanks, pumps, filters and pipework. The gutters and downpipes are designed to be self-cleaning. The 200 mm half-round gutters, their outer edges lower than the inner edges, are arranged with the maximum fall possible within the confines of the fascias; the outlets are fixed under the gutters and all rivets in the outlets and gutter corners are installed inside out. These measures ensure a fast flow of water, with no ponding and no obstructions for the movement of leaves out of the gutters.

Cleaning the gutters, or any leaf guards, would not be practical because of their height and the restricted access between buildings. The outlets are 150 mm, reducing to 100 mm downpipes. The down pipe returns from gutter outlets to walls are at 45 degrees. The leaf diverters have covers to keep out the sunlight,which would otherwise encourage algae to grow; they are accessible from ground level and are easy to clean. First-flush diverters are fitted to all downpipes.

The downpipes feed an underground pipe that leads to the rainwater storage tank. There is an electronic monitor that indicates

→ Most of the controls, filters and pumps are housed in a large cupboard in the garage.

how full the tank is and a submersible pump that sends water to the kitchen and the two shower rooms via a 1 micron, pleated fabric particle filter, a 10 micron pleated carbon filter and a single 80 watt UV steriliser. This is a simple 'light in water' design where water flows in a jacket around the UV light source.

There is a small pressure tank, to avoid the pump starting for every short water use. An automatic switching device turns over to town water when necessary. Each shower room has a cold water diverting valve that returns the cold water runoff from the hot taps to the rainwater tank. The solar hot water is gas boosted.

All used shower and laundry water goes to a 100 litre greywater buffer tank, from where it is automatically pumped to a reed bed. The reed bed is filled with sand (derived from mine slag) and planted out with reeds. It has a sump at one end and, after spreading out over the surface of the sand and filtering through to the bottom, the water fills the sump. The greywater from this sump is already crystal clear to the naked eye and is odourless.

Another submersible pump sends the water from the sump to a storage tank via a 130 micron disc particle filter and a sophisticated UV steriliser, in which microbes cannot be shaded by particles smaller than 130 microns that get through the filter. It has UV light sources around the perimeter and the water flows along the centre. This UV steriliser is normally off and is automatically switched on and brought up to operating temperature before treated greywater from the sump is passed through it. Yet another pump sends the greywater from the storage tank to the laundry and toilets on demand. Only the kitchen waste and toilets are emptied into the sewer.

Things can go wrong

With a project like this, the home-owner can have an uphill battle with architects and builders to find people to specify and to install things that are out of the ordinary. My son found himself having to do research and specify equipment.

By placing the shower rooms on the first floor instead of the ground floor, the rather low mains water pressure soon made itself apparent and necessitated a mains booster pump to be installed shortly after moving back into the house.

The submersible pump he specified for the rainwater tank proved inadequate and the plumber advised and installed a larger one.

Soon after commissioning the greywater reed bed, there was a plague of mosquitoes. The hole for the outlet pipe and submersible pump lead had not been sealed, allowing access for mosquitoes to the water in the sump. We fixed this ourselves, in the process finding that the cover for the sump did not fit properly and we corrected that too. Now there are no mosquitoes.

Another problem soon manifested itself—the sand from the reed bed was leaking into the sump and filling it up. We had to excavate the sand from that end of the bed, carefully removing the reeds, remove and replace the water permeable barrier between the reed bed and the sump properly so that it would not allow sand to pass through, then backfill the sand and replant the reeds.

Any rainwater system will be compromised if the gutters and downpipes are not carefully designed and installed to be self cleaning. It proved impossible to find anyone willing or able to install the gutters according to specification; in the end, the builder accepted, with alacrity, my son's offer for him and me to install them ourselves.

Soon after completion it became apparent that rainwater was not entering the tank. It transpired that during a period of crisis management, a stand-in plumber was employed in order to have the underground connections done in a hurry, before the paving contractor arrived to backfill the trench, concrete over it and then bed the

Table 1. Average daily water usage during the first year.

Daily usage	Town	Rainwater	Greywater	Greywater in house	Greywater in garden	Total
Litres	17	237	131	112	19	385
Percentage	4%	62%	34%	29%	5%	

The greywater buffer tank.

"There was even some greywater to spare and subsurface drip irrigation is now in use in the front garden."

An Aquameta water tank gauge displays the tank water level—important for an underground tank.

The submersible pump is located inside the underground rainwater tank.

backyard paving in sand. The stand-in plumber had piped the rain water out to the street, as normal! The paving had to be removed and the trench re-excavated.

In addition, the overflow from the rainwater tank had been positioned such that water from the street could back flow into the tank. My son had to devise and install a new outlet to avoid this.

In the end though, the results are worth it. Table 1 shows the breakdown of average daily water usage in the first year, with just 4% coming from mains water. There was even some greywater to spare and subsurface drip irrigation is now in use in the front garden. ✸

Richard Stanford has been a member of the ATA since 1999 and an environmentalist for 65 years. In 1982, he took a degree course in Design in Wood and became a furniture designer and maker, until retirement in 2002. He first retrofitted a family home to be energy efficient in 1970, built one from scratch in 1994 and retrofitted another in 2004.

Flushed with pride
Water saving toilets

Beth Askham takes us on a tour of some water saving loos.

TOILETS can flush away litre upon litre of potable water, with up to 25% of our home's water going down the toilet.* It used to be worse; before 1982 when dual-flush toilets were introduced, toilets in Australia had an average flush volume of 11 litres. Now, the most efficient toilets use around 3.3L per flush and to use less water than this we might need to radically change toilet design. New water-saving toilet designs in the pipeline incorporate air assistance, vacuum piping or urine separation.

How low can we flow?

Dual flushing is the standard for water-efficient toilets in Australia. The most efficient dual-flush toilets use 4.5L for a full flush and 3L for a half flush, with an average flush volume of 3.3L. These toilets are rated as 4 stars under the WELS rating scheme (the more stars, the more efficient the model). Some models with an integrated hand basin that flush with greywater reach 5 stars, but there are no 6 star toilets available at this stage.

Indeed, we may be at the limit of the minimum amount of water used for flushing. Too little water in a flush can create drainage problems as it's the water that pushes the waste along sewer drainage lines. Ways to get around drainage issues and still reduce the amount of potable water used includes flushing with greywater, using a Drainwave that releases water from your house in stored batches (see www.drainwave.com.au) or using another type of toilet that doesn't depend on water-such as those that use air pressure to flush or composting toilets.

Image: Caroma

↑ Caroma integrated hand basin and pan. Caroma and Roca (W + W) make integrated hand basin toilets that use basin greywater to flush. Royal Flush produces a cistern and hand basin retrofit.

Urine separation toilets

Urine separation toilets reduce the amount of flushing required. They are more common in Europe but there are some examples of their use in Australia. The University of Technology Sydney (UTS) Institute for Sustainable Futures is working to divert urine from their sewerage system by installing dual plumbing at its Barangaroo development and in their new UTS Broadway building in Sydney. They plan to reuse the urine's nutrients as agricultural fertiliser. "It could easily be argued that 'taking a leak' is our most apt description for going to the toilet as it literally involves leaking valuable resources into the waste stream," says Professor Cynthia Mitchell, who is leading the project.

Vacuum toilets

Vacuum toilets are increasingly being used in offices, public buildings and portable toilets, but it's still early days for them in residential dwellings. Vacuum toilets use less than one litre each flush and it's only to wash the pan. They essentially use atmospheric pressure to push waste into toilet piping that's kept at a lower pressure.

Pumps keep the piping network at a 55% vacuum and when a toilet is flushed, this drops to 35% before it builds back up. All waste is macerated and then sent to the sewer, avoiding any drainage issues. An advantage of vacuum toilets is that you can place them anywhere in the building layout without needing to account for gravity-fed piping, as the vacuum piping can remove waste vertically if needed. Managing Director John Neskudla of Vacuum Toilets Australia

Image: Vacuum Toilets Australia

↑ Behind a vacuum toilet.

Image: Nature Loos

→ Nature Loo makes council-approved composting toilets that are, as they say, "works of art". They also claim that these composting toilets need less than an hour a year to maintain.

says, "Vacuum toilets are the future; we cannot continue to flush our most precious resource down the toilet."

Flushing with air

Air-assisted toilets such as the Propelair toilet use an electric motor driving an air pump to essentially flush the toilet with air. The Propelair toilet uses only 1.5 L of water per flush and needs to be connected to a power source to run the air pump. When flushing, the toilet lid needs to be closed to create an airtight seal. These toilets have just been launched in the UK but are not yet available in Australia.

Image: Propelair

↑ The Propelair toilet cistern.

Composting

Composting toilets in general use no water at all and also produce useful compost. They really come into their own where there is no or limited mains sewerage. In Christchurch, NZ, a group called Relieve have found that composting toilets can provide a safe and effective toilet for households after an earthquake. At big outdoor festivals, groups such as Compost Toilet Systems and A Natural Event use composting toilets to manage the waste of thousands of festival goers.

Andy Tannahill from Compost Toilet Systems says that composting toilets are a "very, very, very positive thing with the festival punters". They also save festivals a huge amount of water. In these systems all the waste stays on site, initially in the bin for 300 days or more and then in big worm farms, where it sits until it's used as compost for trees on site. Andy says that they need to add extra sawdust to counter the extra nitrogen from urine as these systems don't have urine separators.

There are two main types of dry composting systems—continuous and batch systems. Continuous systems have a single sloped chamber. Waste moves from the top of the slope to the bottom, composting on the way. The final compost is removed from the bottom of the chamber. The original Clivus Multrum, commercialised in the 1960s, is a good example of this system.

Batch systems use a series of chambers. Each chamber is used until full and then put into storage for six to twelve months. The Australian Rota-loo is a good example of this type of composting toilet. In a batch system, the compost process occurs over time after the batch is put into storage. This ensures that the isolation periods for any pathogens can be maintained. It also reduces the size of the infrastructure required as a batch can be as little or big as you want.

Fans are often used in composting toilets, drawing air from the room into the toilet pedestal and then outside via a vent. This both aerates the pile and makes sure any smells from the compost don't reach the internal room. ✱

More info:

**Analysis of Australian Opportunities for More Water-Efficient Toilets* (2008) for the Australian Government Department of the Environment, Water, Heritage and the Arts. Authors: Anna Schlunke, James Lewis and Simon Fane, Institute for Sustainable Futures, UTS, 2008.

Humanure Handbook (3rd edition), Joseph C Jenkins, 2005.

Watch your water use

If you are looking to change over to a dual-flush system, see if your state government, local council or water utility offers rebates for water-efficient products.

It's worth checking for leaks in your toilet. A leaking toilet might be running up to two tablespoons of water a minute that quickly turns into 40 litres a day and 280 litres a week. One way to check is by putting food colouring into the cistern and waiting 15 minutes to see if any colour leaks into the bowl.

DIY composting toilet

By Good Life Permaculture

A simple, robust and effective batch composting toilet can be made out of a wheelie bin. There are five key design elements in this toilet system—the seat, false floor, drainage, ventilation and using it.

The seat: Can simply be made from plywood or planks and cut with a jigsaw. The seat is made to sit into the depression that's in the plastic moulding of the bin. When you're not sitting on the toilet, close the lid. This stops flies from visiting.

↑ The wheelie bin composting toilet before being placed in the shed-with-a-view. The painting and hole shape of the seat are all creative choices!

The false floor: The principle behind the false floor is that you want to drain away excess wee, keeping the compost from going anaerobic (decomposing without air). To create a false floor that is permeable but will keep the composting waste above, you can use some old steel reinforcing bar (reo), chicken wire and shade cloth. You can wrap the wire around the reo and the shade cloth around them both. This is propped about 100 mm above the bottom of the bin using four flower pots (bricks would work too).

↑ The false floor

Drainage: This can be made from off-the-shelf plumbing parts, namely a stop valve and hose fitting drilled into the bottom of the toilet. Making a sock or filter of shade cloth over the internal end of the drain can also reduce the chance of blockage. The next question is where do you drain to? In country areas, some councils approve subsurface drainage into a trench. See if there are any drainage options approved by your council.

Ventilation/aeration: Using mesh and ag-pipe is one option for keeping a composting toilet smell free. In this toilet, a round hole was cut in the side of the bin and a 12 V computer fan added in an old drain pipe to extract any odours from the pile. The fan is powered by a small solar power system that also lights the outhouse.

Using it: With the wheelie bin type of composting toilet it is recommended to avoid weeing in it too much. Not to say you can't, but it's good to avoid getting the compost too wet. When your business is finished add a good handful of dry organic matter. Rotted sawdust seems to work well.

When the bin is full (6–12 months depending on how often it's visited), the bin is unhooked from the drainage and set out to rest. Milkwood Permaculture estimates that it will take one person 150 days to fill a wheelie bin. After 12–18 months it is composted.

Once you've filled the loo, you can add compost worms (red wrigglers and tiger worms are the ones you can get most commonly). These worms are gold in how quickly they help process your humanure. You can add compost worms in much earlier; they'll happily live in the compost loo while it's in use.

↑ Remarkably after about four weeks of composting you wouldn't know it was ever poo.

Note: These toilets are subject to council approval—check with your local council first.

Good Life Permaculture is a permaculture business based in Tasmania.
www. goodlifepermaculture.org.au

The best way to save water? Waterless toilets.

Not long ago sustainable products were seen as a luxury item. Now with the cost of utilities going up and the initial outlay for sustainable products coming down, the question facing families is not whether they can afford to be sustainable but whether they can afford not to be.

With water prices increasing by 18% from 2010-2011 and bulk water costs and sewerage connections predicted to rise by 47% to a yearly average of $1,346 per household by 2017, saving water suddenly makes a lot of sense both economically and environmentally.

Waterless toilets are also known as composting toilets and are well regarded for their sustainable credentials.
A system from one of the leading composting toilet suppliers in Australia - ECOFLO Water Management - reduces the average household's water consumption by around 35,000 litres per year.

This means that as well as saving water, with the predicted increase in bulk water charges, a waterless composting toilet will pay for itself within just five years.

The common alternative to a waterless composting toilets is a septic system. However, at around $6,000 incl GST, your cheapest septic system is very similar in price to an Australian Standard certified waterless composting toilet and grey water system, yet does not reap the same water-saving or cost-saving benefits.

An ECOFLO composting toilet requires no water and allows you to re-use your bathroom, kitchen and laundry waste water. There is no need for extensive plumbing, ground works or maintenance contracts.

Whether remodelling or building a new home, choose a waterless toilet and start saving for the future.

Rooftop diversity
Beneficial uses of rooftops

From farming to education to biodiversity, Brod Street considers the many and varied uses of rooftops.

↑ Brod's native rooftop garden, built on the west-facing roof of his 1890s terrace home, provides a year-round display of botanic beauty as well as cooling for his home.

IN THE past, building practices embraced the use of rooftops for all sorts of beneficial uses—for food production, aesthetics, education and recreation.

The capital of rooftop variety must be New York where flat roofs once supported libraries, school sports, a school for the visually impaired, playgrounds and roof gardens. Today New York embraces green roofs as a cost-effective way to deal with a host of urban problems. For example, they help manage peak stormwater flows into the city's only sewer, which has to cope with both stormwater and wastewater. Reducing the volume of stormwater helps avoid the discharge of sewage into rivers and oceans (resulting in beach closures) when the sewer can't cope.

London has had a variety of roof uses, too. In 1921, a Mr Thomson used the Institute of Engineers roof, near Big Ben, for a farm of 200 rabbits and 36 chickens (60 eggs per week!), with the birds allowed to roam about the roof garden during less windy days.

In 1941, *The Argus* reported that Collins House in Melbourne possessed a large lawn on its roof, used for sitting on and eating lunch, or playing golf: "Collins House can provide rather a big surprise. On the roof is a well-kept lawn which is just a shade smaller than a tennis court. It has been there since the building originated with a group of enthusiastic golfers decided that their lunch hour could be well spent in the city if they could find somewhere to practise putting."

Green roofs today

Nowadays in urban Australia, most green roofs contain a low diversity of plants, usually introduced succulents and sedums. They are typically installed on a flat roof with between 100 and 150 mm of planting substrate over a drainage layer and a waterproof membrane, with the planting substrate consisting of 80% mineral and 20% organic mix.

It is not advisable to use general garden soil for green roofs as it is too heavy and too rich in nutrients. Most mineral mixes are a blend to achieve the desired outcomes. Scoria mixes often contain some crushed tiles, brick rubble and coarse sand in addition to the lightweight volcanic rock. Other mineral mixes might use waste ash from power stations for its water-

↑ The green roof at the University of Melbourne, Burnley, designed for biodiversity with logs and rocks for habitat and water retention.

Mineral + organic mix		No plants	Plants
		% of rain held in mix	% of rain held in mix
Fine pine mulch	80% Clinka + 20% pine	29%	26%
	60% Clinka + 20% pine + 20% poly	20%	26%
Coconut fibre (coir)	80% Clinka + 20% coir	Technical problems	31%
	80% Clinka + 20% coir + water retention layer	Not tested	53%
	60% Clinka + 20% coir + 20% poly	15%	33%
Rice hulls	80% Clinka + 20% rice	31%	Not tested

↑ Table 1: In his primary school science project, Moss Cowcher is comparing different growing media for use on green roofs. Here are the water retention results for 14 July to 6 August 2013 when 71.8 mm of rain was recorded.

holding capacity. Expanded clay is another good mineral product, formed by subjecting 'popping' clay particles to 1100 °C to create lightweight particles up to 10 times their original diameter.

The key reason for only using 20% organic content is due to the risk of oxidation of the organic content over time, which could result in massive shrinkage of the growing medium and increased maintenance.

Possible organic mixes include coconut fibre (coir), pine mulch and rice hulls. Coir is an excellent green roof organic material given its ease of wetting, as shown by Moss Cowcher's research (see box). It also doesn't collapse when dry and won't become hydrophobic (repel water), which can be a problem with some types of pine mulch. Tests by horticultural consultant Dr Geoff Cresswell also show coir is biologically active and supports a diverse population of micro-organisms.

Engineering

Green roofs need to be engineered for the fully saturated load of soil and plants, maintenance equipment and any traffic, which means they are primarily built on new buildings.

As an idea of what is involved when installing on an existing roof, I recently worked with a structural engineer inspecting a roof for possible conversion to an open-air classroom green roof. The engineer required two sections of the building's footings to be exposed and two inspection points cut into the ceiling. He determined that the existing clip-lock metal roof would only support a temporary weight of 120 kg/m². For a trafficable green roof it would require 250 kg/m² load (of which 60% would be the weight of people). He assessed that the outer walls were structurally able to support a green roof built over the top of the existing roof.

The predominance of smaller freestanding buildings with pitched roofs in our cities are challenging for the construction and safe maintenance of green roofs—but my house project, outlined overleaf, offers DIY people some hope for greening their shed or part of a house roof.

Primary school science project

As part of the Science Victoria Science Talent Search, Moss Cowcher, from Erasmus Primary School, has been examining different growing mixes for use on green roofs. Erasmus Primary is considering a 100 m² native plant green roof as an open-air classroom for nature studies.

The research was mindful of the need for a growing medium to be lightweight, have good water-holding capacity and air permeability, and provide the nutrients needed by the plants. The air permeability requirement is to avoid any water logging that would result in plant failure because roots are unable to respire. Most substrates try to achieve around 20% air-filled pore space.

Moss tested nine different growing media, see Table 1 above, with the common material in all test beds being expanded clay from Clinka. The test plastic containers were filled to 28 litres at a depth of 250 mm.

The addition of 20% by volume polystyrene balls in four planters was to see how very light mediums compare. The different organic mixes were fine pine mulch, coconut fibre (coir) and rice hulls. These were all kept to 20% by volume.

Moss also introduced a water retention layer in one of the planters. This was made out of 60 recycled milk bottle tops which could store about 0.9 litres of water or 8 litres/m². The boxes with native plants each had two common everlastings and two small leaf eutaxia.

Moss's recent findings showed that from 14 July to 6 August, when 71.8 mm of rain was recorded, the test beds with plants retained between 26% and 53% of rainfall. Those without plants retained between 13% and 31% of rainfall.

The best performer based on water-holding capacity was the planter which had the water retention layer, coir and plants, with 53% retention of rain.

The research showed that adding 20% by volume of polystyrene balls reduced the load by 16%, or 18 kg/m² for 250 mm depth, but also reduced water-holding capacity by 9%.

Moss also confirmed that a fully saturated mix at 250 mm deep was easily below the maximum desirable loading of 135 kg/m².

Biodiversity

It is my passion to see more biodiversity in green roofs in urban areas, on all sorts of buildings and roof alignments. I consider that true living roofs are ones that have abundant beneficial insects and other species that help maintain botanical health and are far more inspirational than a monoculture. We should make more use of local natives which have adapted to low nutrient soils and limited rainfall—two characteristics important in selecting the plants for a green roof.

There are some good examples in Melbourne.

The recently completed 400 m² green roof at the Minifie Park Childcare Centre in Balwyn North uses local indigenous plants and is one to watch for its ability to provide habitat for invertebrates and birds. It is a flat roof viewable from parkland overlooking the sunken building.

The University of Melbourne, Burnley, has a green roof designed with biodiversity in mind, complete with tree branches, rocks and capacity for some surface water retention. Where there is surface water this supports insects, birds and even a gecko or two. The Burnley roof is particularly interesting as it is on a heritage-classified building: it's often problematic to introduce changes while keeping historic features intact. Other than a perimeter safety fence there are no visual changes to this building when viewed from the ground and this was deemed acceptable.

What I really like about both of these examples is that there are no stairs or structures to allow unwanted predators such as cats, foxes or dogs to reach these 9 m high structures. Permanent internal access is available at the Burnley facility whereas a ladder is required to maintain the Minifie Park green roof.

↑ The rooftop garden on Minifie Park Childcare Centre requires a ladder for maintenance, which means this habitat for invertebrates and birds is free from unwanted predators.

My native green roof

I built my experimental green roof on the sloping west-facing roof of our 1890s terrace home. Commencing in 2010, it took me three years to install a 200-tray system.

The green roof was built after strengthening the original roof with timber stretching from the top of internal brick walls to the roof struts. To hold the system in place I used galvanised L-shaped brackets fastened to the roof. Each tray simply sits in place.

It was a safe place for construction as the roof was joined with the neighbour's, so the risk of falls was minimised, other than from ladder climbing. It's also located in a private space hidden from view by neighbours.

Each tray actually consists of two aluminium BBQ-sized trays placed inside each other. Horticulural consultant Dr Geoff Cresswell notes that aluminium is a good choice as it inhibits plant root tip growth thereby preventing roots from penetrating the tray. Aluminium is also compatible with a zinc-coated roof and is lightweight, strong and flexible. The downside is that it is high in embodied energy.

I built the green roof to help cool the house and this has worked well with the inside roof space up to 10 °C cooler than in previous summers. I also wanted to see how a native grassland concept would work on a sloping roof with a hot, dry west orientation and using a shallow 100–112 mm of native potting mix.

One thing I found is that the roof slope is an advantage, not an obstacle. With my tray system the bottom-most edge of the tray does not have drainage holes and this allows up to 60 litres of rainwater to be held in the 15 m² roof system, with more held in the growing media and plants. The higher sides of the trays drain to the underlying original corrugated metal roof. The trays do not inhibit the original roof drainage ability.

To help create water-retention pore space I used either small pebbles or lightweight perlite. An interesting aspect of this water retention is that the native rushes have randomly spread across the green roof trays into these 'wells'. The knobby club-rush look great and help create a wind break and shade for the more sun-sensitive plants, such as the scarlet running postman.

The trays are topped with broken terracotta roof tiles, scrounged from demolition sites. These help break the impact of rain and hail and prevent soil erosion. Some larger tiles were spread around, along with sticks to create spaces for spiders and insects.

A botanic beauty

I have successfully established 20 native species common to southern Victorian grassland and woodland understorey habitats. The edge section which is in partial shade contains a row of non-native bromeliads. Together with a small gutter planter of native rushes that receives water from a higher gutter (including over-pressure water from our solar water heater), this helps create a humid micro-climate.

One of the most pleasing aspects is the enormous array of species visiting or breeding on the roof. The native Australian painted lady caterpillars eat the common everlasting. You also see the colourful nectar feeder the common hoverfly, which is beneficial as its larvae feed on aphids. Spiders are usually a good indication of biodiversity and I have noted up to 12 different species. The largest visitors are the ringtail possums which graze the carpobrotus (native pigface). This is helpful as otherwise the pigface would get out of control. My strong advice is to avoid pigface on a green roof.

My top five species for all year botanic beauty and their ability to deal with wind, high temperatures and limited watering are small leaf eutaxia (40 cm high), common everlasting (25 cm high), tall blue bells (20 cm high), matted pea bush (low) and, if semi-shaded, scarlet running postman (ground cover). ✱

Brod's short YouTube clip gives more info: www.bit.ly/HGRvideo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On the roof
A rooftop vegie garden

What do you do if your garden is a bit too blessed with shade? Grow your vegies on the roof, of course. Andrew Marsh describes his rooftop garden project.

↑ A trapdoor and ladder (above) lead to Andrew's rooftop garden (right), He says it's like having another room and is "an enduring curiosity for all who see it". A great way to get up close to admire the solar panels as well!

I HAD the idea to build a roof garden many years ago when, despite my best endeavours, my vegetable crop continuously failed through lack of sun. Our block in the eastern suburbs of Adelaide is blessed with plenty of shade from some very large trees and we struggle to grow anything that needs much light.

The rear of the house was renovated in 2006 and one of the features retained from the original was a large corrugated iron skillion roof, which sits between two gables. This roof is roughly north facing and has been useful for locating a couple of series of frame-mounted solar collectors, used for heating water for both the house and the swimming pool. It also proved handy for my roof garden plans.

Design

I wanted to do as much as possible of the construction work myself and so set about designing the structure to suit both my ability and available tools. I should point out that I am a mechanical engineer and so had a fairly good idea of the issues to be considered. I started by deciding how I wanted to use the completed garden and from that extrapolated the maximum load that the structure was expected to bear.

The basic design was for a timber deck, something that I am familiar with as I've constructed these before. How this was to be supported 3.5 m in the air was less obvious and needed careful thought, especially as it was to be located directly above two of our bedrooms.

The skillion roof is 6 m wide by 8 m long, but because of the pitch of the roof it would have been impractical to build a deck on much more than half of its length. However, the rear of the house lent itself to extending the deck beyond the roof, which would double up as a cantilevered porch and so the dimensions for the deck could be 6 m by 5 m ($30 m^2$). Plenty big enough.

With that amount of space at my disposal I decided to use approximately a third of the area ($10 m^2$) for vegetable planters and so based my design on that load. The four planters would each need to be about 400 mm deep and so would contain a total soil volume of $3.6 m^3$. The density of wet soil can be as high as 2 tonnes per m^3. Added to that the mass of the deck structure itself, plus transient loads such as people and wind gusts, meant that the total load consideration was far from trivial.

Another consideration was soil movement in our area. Much of Adelaide is built on highly reactive clay, which causes huge movements in walls and foundations as the soil expands and contracts throughout the seasons. The newer part of the house was built on a single footing and so would move uniformly; however, part of the deck would need to be attached to two older walls, one of which was built in

1970 and the other in 1898! Allowance for independent movement here was essential. In addition, any steel beams used would need to have a clearance for thermal expansion. A 6m universal beam sitting in full sun can grow by 5mm in length—plenty enough to crack a wall.

In consultation with a structural engineer, the design was based on three 200mm universal beams, which would run laterally across the roof and would be attached with welded brackets to the brick walls at each end.

The beams were cut midway to introduce a 15mm gap to allow for thermal expansion and seasonal wall movement. This made the installation much easier as the beams were only 3m long instead of 6m, but meant that additional supports were needed within the span. Three tubular steel columns were used which pass vertically down through the roof and internal stud walls and are then secured to the floor slab at the base. Flexible pipe flashings seal the column penetrations through the roof iron. All up, the structure is designed to take a total load of 15 tonnes.

The decking structure itself is similar to one that would be built at ground level, using treated pine trusses which were each bolted to the steel beams through welded angle brackets. The decking planks have a 6mm gap between them and were conventionally fastened to the trusses using Dektite nails. Rainwater freely drains through the deck onto the skillion roof below.

Access and safety

One of the practical issues with a roof garden is the need to climb up onto it. I considered creating a spiral staircase within the house but this had a number of practical problems, not least of which was making the whole assembly weather tight.

In the end I opted for an aluminium loft ladder which I installed through the cantilevered overhang. This can be folded up and stowed as you would an access ladder inside the house. These are designed for internal use though, so I had to spend a bit of time weatherproofing the timber.

To stop anyone toppling off, I installed a tubular steel fence across the front of the deck and around the ladder hatch, strung with tensioned stainless steel cables. I have placed some planter boxes just inside the fence and in a couple of years I'm hoping that the climbing plants will create a thick green wall.

Vegetable planters

I plan to eventually have four vegetable planters, which will be positioned to evenly spread the load through the structure. I'm trialling just two for now to see how they perform.

These are made from Colorbond roofing sheets which I cut down the length using a cutting disc in an angle grinder. The four sides are bolted together with Dexion slotted angles. I was concerned that reflected heat from the surrounding roof might overheat the soil and so decided to insulate the planters with a 75mm layer of rockwool. This is sealed from the soil and the weather with a sheet of tarpaulin, which is held in place with automotive edge trimming.

Once complete, the planters were like mini swimming pools and so needed provision for drainage. This was done by adding a length of PVC pipe with multiple holes drilled in the upper side and then wrapped in coarse shade cloth to act as a screen. The pipes extend out from the base of each planter and surplus water is allowed to freely drain onto the skillion roof below. The location of the drain holes 50mm above the base means that they will never totally drain and any residual water will wick up as the soil above dries.

The first summer crop was very successful, although it was necessary to create some shading for the tomato plants as the weather got hotter. This was done by using 3m lengths of PVC electrical conduit, anchored on the deck at each end and hooped over to create a framework for shadecloth; very cheap and extremely effective. As can be seen from the photo, the winter crop is doing quite well too.

Another room

We have had the roof garden for almost a year now and it is an enduring source of curiosity for all who see it. In fine weather it's a great place to sit and read or have a beer and we have even taken to serving cocktails up there before a dinner party.

In essence it is like having another room, albeit an outside one. Even better, I can finally grow a leek! ✱

↑ The garden beds under construction. They were first insulated with a 75mm layer of rockwool and sealed from the soil and weather with a tarpaulin. The drainage pipe can also be seen in the top photo.

Andrew Marsh is a mechanical engineer who has worked extensively in solar thermal design. He is also the author of a handbook on sustainability in older houses.

Water recycling

The image of the garden also shows a 200L black plastic pickling drum located behind the solar collectors, which is worth a mention given this is the water issue! The toilet cisterns have dual plumbing and can be gravity-fed from this tank, which is topped up daily from the swimming pool during the eight-month non-swimming period, using a little pump normally used to circulate pool water through the solar collectors. This pump runs for a few minutes a day on a timer switch. Over the course of a year this saves approximately 35,000 litres of mains water.

The swimming pool itself has a winter cover, which is held in place by recessed fasteners. This eliminates the need to run the filter pump for most of the year as, due to the absence of light, there is no algae. The swimming pool has a stormwater diverter valve fitted so that it can be replenished with rainwater from the roof all the year round.

Communal water harvest
Healthy estate

Sharing water management among the houses on this estate makes sense in many ways, not least for the health of nearby Duck River, writes Mark Liebman.

Photo: Mark Liebman

↑ The parkland serves as both a public recreation space and a huge water tank for the residents.

ASHGROVE Estate is a housing estate in Sydney's west designed using the principles of 'new urbanism'. New urbanism principles include having smaller house lots with larger communal areas, designing for passive surveillance (for example having houses front parkland), and integrating water-sensitive urban design.

The estate was developed by Mirvac in 2006 and was awarded a NSW government's Green Globe Award in 2008 for its innovative water-management system, which is now saving 10 million litres of water a year.

Ashgrove was probably the first estate in NSW to harvest stormwater from the local road network. The treated stormwater is used to irrigate the estate's parkland and is also reticulated via a 'third pipe' to each house on the estate for toilet flushing, car washing and watering gardens. In effect, the stormwater system acts as a huge water tank for the estate, removing the need for rainwater tanks for each house.

Stormwater is more abundant and easier to collect at the estate scale than rainwater, but there are risks with using stormwater, compared to rainwater. Unlike rainwater from roofs, stormwater is carried in drains and comes into contact with the ground so, before using it, effective filtration and disinfection are required to remove sediment and pathogens. Suitable uses of stormwater include non-potable uses such as car washing, garden watering and toilet flushing.

Reviving Duck River

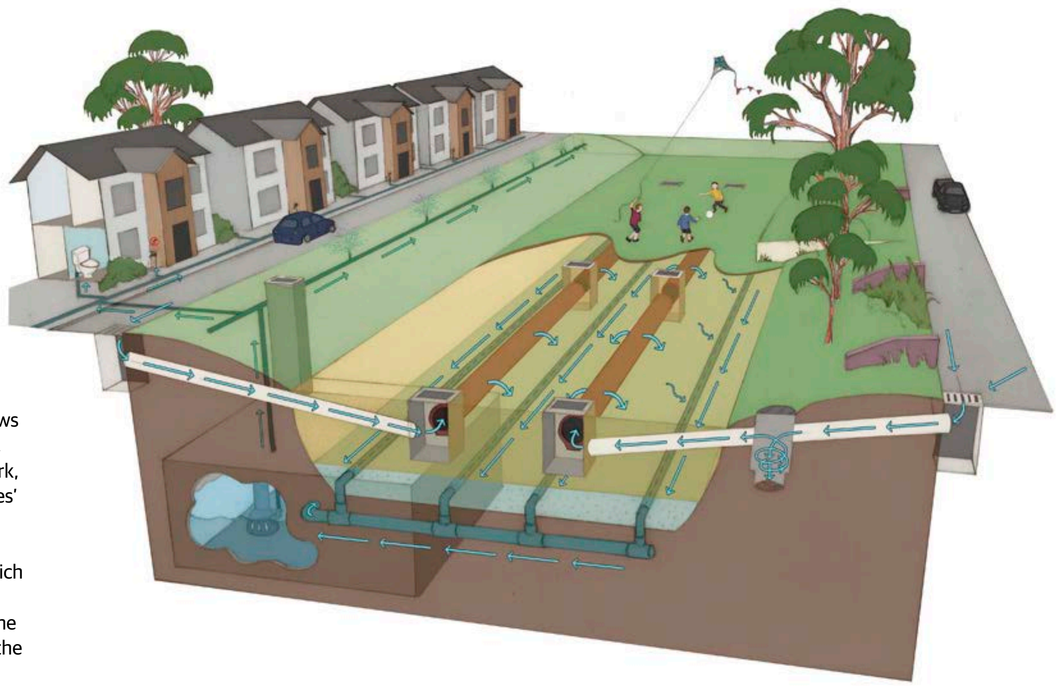
After filtration, excess stormwater runoff from the estate is discharged to the Auburn golf course, from where it makes its way into Duck River. Duck River's ecological health declined severely with development of its catchment post-WWII, but it is slowly being revived. This estate is certainly making a contribution.

Approximately 70% of the Duck River catchment is covered by impervious surfaces (which shed water almost every time it rains) and most of this is directly connected by gutter and/or pipe to Duck River. The estate has reduced stormwater flows by 10 ML/year which actually helps to protect the river from excessive levels of urban runoff.

The export of suspended solids has reduced by 80% and heavy metals are down to levels that protect the most sensitive macroinvertebrates (small creek insects). The system also retains 45% of nutrients which would otherwise cause algal blooms. Through stormwater harvesting not only are we reducing potable water demand we are also reducing excessive volumes and frequencies of stormwater runoff.

Treating the stormwater

The estate occupies 12 hectares, nine of which contain a mix of townhouses and



→ Figure 1. Illustration of the hybrid bioretention system used at Ashgrove Estate, showing the flows into the system from stormwater, and out of the system into the park, storage tank and the estate houses' 'third pipe' for toilet, car washing and garden use. The large brown pipes are the HydroCon pipes which filter water through the pipe wall. The cutaway at front left shows the 800 kL buried storage tank with the submersible pump visible.

Illustration by Sarah Laborde, Designer & Illustrator

houses. Nearly three hectares (25%) is public parkland which has multiple uses, one of which is to contain the stormwater and water infrastructure that serves the estate.

The estate uses a unique hybrid bioretention system to treat the stormwater to ensure that it is fit for its intended use.

As shown in Figure 1, the treatment train starts with gross pollutant traps which use centrifugal separation to remove large pollutants such as plastic bottles, litter and coarse sediment. The water is then directed into a series of hybrid bioretention basins. We call them 'hybrid' because they use a combination of treatment systems.

The runoff from typical smaller rainfall events passes through the walls of permeable concrete pipes. Normally pipes transport water from point A to B, but, instead, these pipes are designed to exfiltrate water through the permeable wall of the pipe and outward into a surrounding filter media. Produced in Australia by HydroCon (www.hydrocon.com.au), the pipes remove phosphorus, heavy metals and sediment from the stormwater as it permeates through the pipe wall. Several processes happen in the pipes including settling of sediment, adsorption and ion exchange.

After the water leaves the pipes, it passes into a filter system where biological processes facilitate the removal of nitrogen and additional phosphorus and sediment.

Larger flows from intense rainfall are not treated by the HydroCon pipes; instead, these flows are directed up to the ground where they pond on the surface and then seep down through the filtration media.

After passing through the filtration media the water is soaked up by a traditional agricultural drainage pipe, which allows water to come into the pipe through the slotted pipe. The filtered water is then stored in a 800 kL buried concrete tank and is UV-disinfected prior to use to ensure compliance with recycled water regulations.

Walking on water

There is a growing awareness of such bioretention systems, which are normally covered with reeds, sedges and water-tolerant plants. This system, however, uses grass instead of reeds and sedges.

This makes the space above the filter completely accessible to the public. Were it not for the flood hazard warning signs, most people who use the open space would never know they are walking on a stormwater filtration system.

The grass provides a solid vegetative mat with a good rooting depth and density, which is vital to maintain the porosity of the system and prevent it from clogging.

> "In the future new estates might also include communal food growing areas, and use the abundance of stormwater to irrigate their crops."

Using this approach, we were able to subtly weave water-sensitive urbanism into the fabric of the estate. Its use means that we did not need to segregate any land with reeds and sedges and we could maximise the opportunity for accessible public open space.

The bioretention basin also performs a flood-control function, helping to store floodwater during extreme storm events and thus solving an ongoing localised flood problem. In this sense it functions just like any other detention basin—an area of land set aside to allow the temporary storage of floodwater and so prevent uncontrolled flooding downstream.

The three-hectare investment in open space has thus had maximum impact. It serves to limit flooding and treat stormwater from the site and the surrounding catchment, and it houses the stormwater harvesting and reuse infrastructure. And importantly, it provides a vibrant, usable landscaped park.

Communal versus individual

NSW BASIX legislation mandates new houses reduce their water demand by 40%. In response, rainwater harvesting using rainwater tanks and pump systems is now largely standard for new houses in NSW, but communal systems such as this are still considered alternative technology.

During the design phase, a lifecycle cost analysis (LCA) was undertaken to compare two options: 1) the communal stormwater harvesting system (with 800 kL tank, pump system, 'third pipe' to deliver the treated water to all the dwellings on the estate and a parkland irrigation system) and 2) a rainwater tank on each lot, each with its own dedicated pump, and a separate irrigation system for the parkland.

The cost-based LCA showed that, despite a marginally higher capital cost per dwelling for the communal system, after just four years of operation it would become the cheaper option and savings would accrue thereafter.

It is also much easier for the body corporate to manage a single system rather than for each household to manage their own. Maintenance can be scheduled and the costs apportioned to the community as strata levies. In return, householders get treated stormwater and do not have to worry about maintenance. Often individuals undertake maintenance of their rainwater tanks and pumps only when they fail and this can be costly in the long run, necessitating replacement of key components. From a regulatory perspective, a single system, without any manual overrides and with body corporate responsibility is also much simpler.

The estate provides a great example of sustainable urban design and development. It shows how common spaces and common infrastructure can enhance community living. In the future new estates might also include communal food growing areas and use the abundance of stormwater to irrigate their crops. The strata-titling provides an innovative way of managing communal infrastructure. The residents get up to 10 million litres of cheap water a year and an impressive, well-irrigated parkland. The fish and frogs that live in Duck River are enjoying a better quality of life too. ✱

Mark Liebman is a civil and environmental engineer and a water-cycle innovator. He is director of the Sustainability Workshop, a civil and environmental design consultancy. He led the team that designed the roads, drainage and water reuse infrastructure at Ashgrove Estate. For further information, email mark@sustainabilityworkshop.com.

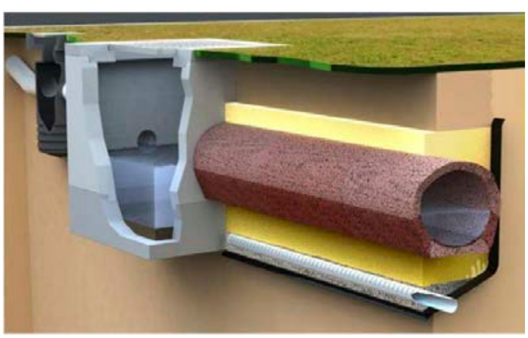


Image courtesy of HydroCon

← Profile of a permeable HydroCon pipe used to filter out phosphorus, heavy metals and sediment from the stormwater.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The aquaponics cycle
Organic matters

Geoff Wilson, director and editor of Aquaponics Network Australia, explains the recycling inherent in aquaponics systems.

AQUAPONICS is the 33-year-old name for symbiotic cultivation of plants and aquatic animals in a recirculating environment. It mimics natural systems originating in ages-old food-production practices in Asia, central and south America and the Middle East.

Organic aquaponics is now being pioneered in Australia in integrated systems to produce fresh organic food, including fish, crustaceans, molluscs, many vegetables, most herbs and some fruits. The systems have very low water use—usually about one twentieth of standard agriculture's water use (and sometimes much lower)—and can make use of solar energy for water and air pumping, and LED lighting.

In the best organic aquaponics systems the main regular input is just organic fish feeds, plus management time. Organic fish feeds can be produced in a home garden, via worm farming, insect larvae culture and algae production, for example.

Then, as a by-product of keeping fish in a closed system or tank, fish waste accumulates and the effluent-rich water becomes high in plant nutrients. This is toxic to the fish, but microbes convert key wastes to plant food. Plants then take up the nutrients and reduce or eliminate the water's toxicity for fish. Cleaned water is returned to the aquatic environment and the cycle continues.

Aquaponic systems do not discharge or exchange water. Water is only added to replace water loss from absorption by the plants or evaporation into the air.

Systems vary in size from small indoor to large commercial units. They use fresh or salt water depending on the type of aquatic animal and vegetation, though most are fresh water.

Aquaponics systems could provide 'protected cropping' next to home kitchens or restaurants. Brisbane-based Qponics is proposing aquaponics use for production of omega-3 oils, along with algal fish feeds. (Disclosure: I am a shareholder of Qponics.)

Photo: Charlie Vinz, Chicago. www.flickr.com/photos/vinzcha/

↑ A basic portable aquaponics system growing watercress, which shows the technology's simplicity. Other home-based designs cost more but can also grow more.

Sydney-based Urban Ecological Services is leading the way on large-scale production of fresh fish, vegetables, fruit and herbs. Another Australian company, Perth-based Algae-Tec, is pioneering lower-cost harvesting of algae for producing both energy and food. Its ideas have great relevance to more efficient aquaponics on a large scale.

A new Australian innovation is reducing water use even further, via solar-powered air moisture harvesting which condenses air moisture at a much lower cost than supply of municipal water.

Producing fish feeds from the recycling of organic matter has the added benefit that these wastes do not go to waste dumps and create methane gas. Aquaponics is also expected to produce little nitrous oxide—the greenhouse gas from agriculture which has 300 times the greenhouse effect of carbon dioxide. ✱

Geoff Wilson is a retired agribusiness journalist who runs Aquaponics Network Australia as a hobby, after 33 years writing about aquaponics from its 1980s start in the USA.

Know your renewables
Solar hot water system basics

Solar hot water systems are steadily becoming more popular in Australia. Lance Turner explains the types and how they work.

SOLAR water heaters have been around in their modern form for almost 100 years. However, there is a lot of confusion between solar water heaters and solar photovoltaics, the common 'solar panels' that generate electricity directly.

Solar hot water (SHW) systems are what's known as a solar thermal technology. They use the sun's heat to heat water, either directly or indirectly. There is generally no electricity involved, except for the use of circulation pumps and backup boosting in some systems.

The basic design is that a flat panel that contains tubes for the water to flow through is connected to a storage tank. Water flows from the tank, is heated in the panel by the heat of the sun and flows back to the tank as heated water. However, there are a number of different configurations of tank and panels, and each has a different method of getting the water to the panels and back to the tank.

→ A close-coupled evacuated tube solar water heater. The steep mounting frame is designed for placement on the ground or a flat roof.

Photo: www.chinasangli.com

The simplest type is the close-coupled direct heating system. In this, the solar collector is mounted on the house roof with the water tank mounted directly above it. Water flows from the tank into the collector where it is heated by the sun. As warm water is less dense than cold water, the warm water rises up through the collector tubes and flows back to the tank as heated water, drawing colder water from the tank into the bottom of the collector for heating. This system is called thermosiphoning and is the most reliable and simple of the solar thermal water heating systems.

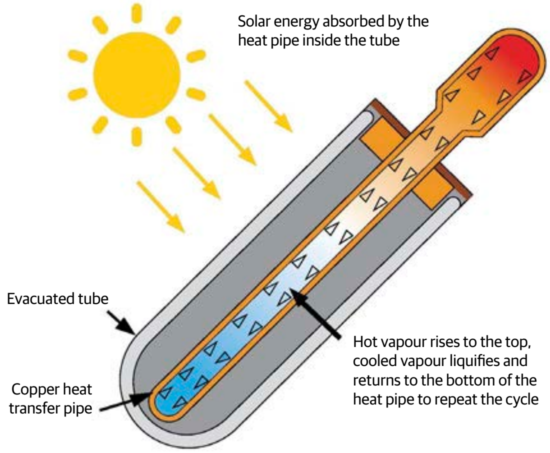
The other common system usually has the tank mounted at ground level, either inside or outside the house. A pump circulates water from the tank up to the collector, where it is heated and then flows back to the tank. A pump is needed in such systems as thermosiphoning only works when the tank is mounted above the panels. The pump is controlled by a special controller that has multiple temperature sensors in the tank and the collector.

This type of system is known as a remote-coupled or split system. It is more complex than a close-coupled system due to the added complexity of the pump and controller.

Panel types

While there are two main types of systems, there are also two main types of solar collectors. The first is the flat-plate collector, which is a flat, insulated box containing an array of pipes connected to a metal sheet, all painted black. The metal sheet absorbs incoming solar heat and transfers it to the attached pipes and hence the water inside them.

The second type is an evacuated tube collector. These consist of an array of glass tubes. Inside each of these tubes is a second, smaller tube, which has a black coating inside it, and the two tubes are sealed together at one end. The space between them is evacuated of most of the air, hence the name. Incoming solar radiation passes through the outer tube, heating the inner tube. Because there is almost no air between the two tubes, heat isn't lost back out of the tubes by convection/conduction. Inside the inner tube there can be a number of different systems for gathering the incoming heat. Some systems use U-shaped copper tubes which contain the water to be heated. Others use special devices called heat pipes, which absorb the heat and transfer it to their top end. The top of each heat pipe is connected to a dimple in the collector top manifold (a pipe with multiple apertures for making connections), or tank, for a close-coupled system, and heat is transferred from the heat pipe to the water in the manifold or tank.



→ Some evacuated tube collectors heat the water directly whereas others use heat pipes (seen here) to transfer the heat to the tank.

Frost protection

Even in Australia there are many places where the overnight temperature can go below freezing, and thus, for any exposed pipes containing water, there is the danger of freezing. If this happens, the water in the pipes expands as it changes to ice and, if there is no room for this expansion, pipes can be split by the force.

A number of systems have appeared over the years to combat this problem. Originally, most systems used anti-frost valves. These were mounted at the bottom of collector panels and would open when the water temperature approached 3°C. Water would flow out of the panels, drawing in warmer water from the tank and thus preventing freezing. The problem with these valves were that they were prone to failure—either failing to open, resulting in burst collectors, or sticking open, resulting in the loss of all the heated water.

The solution was not to use water in the collectors, but a food-grade anti-freeze solution instead, similar to that used in car cooling systems. The anti-freeze, commonly called glycol as it is mainly a propylene glycol solution, runs in a sealed system, transferring collected heat to the water in the tank via a heat exchanger (basically a big coil of copper pipe) in the tank. This eliminated the valves, but it did introduce another problem: the glycol used in the anti-freeze is more able to get past rubber seals in the system, and so glycol loss was common, resulting in the need for regular checks—something that was rarely done on most systems.

The advent of the split system solved this problem. Some split systems still use glycol while others run water directly from the tank to the collectors. When the water in the collectors approaches freezing, the pump controller starts up, circulating warm water from the tank into the collectors.

System pressure

Most solar water heaters operate at mains pressure, just like a regular water heater. However, there are some systems that operate at a reduced pressure or even no pressure in the tank itself. Non-pressurised systems have the tank 'open vented' to the outside air, and use a heat exchanger coil inside to pass the stored heat to the mains pressure water—the mains pressure water is contained inside the coil, so there is never any mains pressure in the tank.

One advantage of a non-pressurised system is that the tank is less likely to leak. You can also connect uncontrolled heat sources to the system as any boiling of the water just results in steam being given off through the open air vent. Also, there are a number of companies importing open-vented systems directly from China, resulting in system prices not much more than a regular water heater.

Failure modes

With close-coupled systems, there is not much that can go wrong apart from a stuck frost valve (on older systems) or loss of glycol. With split systems, there are quite a few failure modes, including glycol loss and pumps refusing to run or running at inappropriate times. Indeed, this latter complaint is quite common and usually due to poorly installed or failed temperature sensors.

Evacuated tubes can suffer fracture or leakage from seals, but unless the tubes have water directly inside the inner tube instead of in a copper pipe, there will be no water loss and the system will continue to run, just with reduced capacity.

Boosting

When there's insufficient sun, some form of boosting of the tank water temperature may be required. This is often done with a simple electric element inside the tank, often running on cheap off-peak electricity. Other

SHW safety and maintenance

As solar input is an uncontrolled heat source, it is important that overheat protection on solar water heaters is in good condition. The most common safety valve that is required on all systems, solar or otherwise, is the pressure/temperature relief valve, or PTR valve. These will open if the tank temperature approaches boiling point or the pressure in the tank exceeds its rating. This causes hot water to be expelled, drawing in cold water and cooling the tank.

Non-return valves are also usually fitted to the cold water inlet to prevent hot water entering cold water lines due to expansion, and tempering valves to the outlet—these mix cold water with the hot water from the tank to limit the temperature of the water supplied to the home to prevent scalding.

Solar water heaters require some maintenance. For systems with glass (enamel) lined mild steel tanks, the sacrificial anode (which corrodes away instead of the tank) should be changed every few years. Stainless steel tanks don't require the use of anodes, but should not be used where the water pH is below 6 as this will be too acidic. This means stainless steel tanks are usually not used with bore water.

You should also check that circulating pumps are cycling on and off at correct times and that boosters are operating correctly.

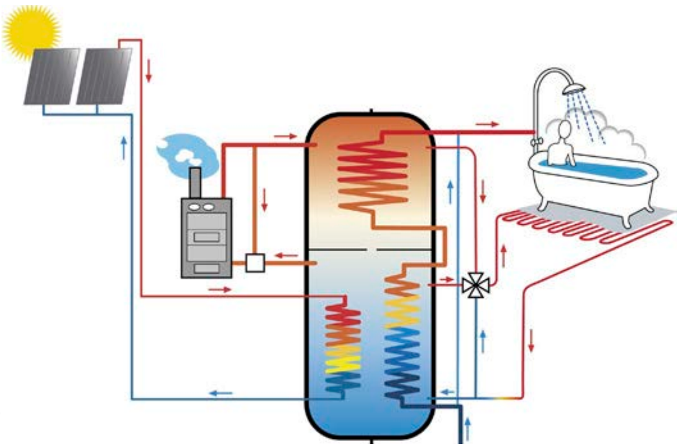


Diagram: www.akvaterm.fi

↑ A typical combined solar hot water and hydronic heating system, with wood heater backup.

Photo: www.sunbather.com.au

↑ Solar pool heating collectors are simpler than solar water heating units, consisting of grids of rubber pipes. This unit, from Sunbather, is the same colour as the roof to make it less conspicuous.

methods include gas boosting directly to the tank, like a regular gas water heater, or the use of a separate instantaneous water heater as a booster.

Open-vented (non-pressurised) systems can even be boosted from solid fuel heaters such as a wood stove. The stove contains a heat collector panel known as a wetback and the hot water is circulated by a pump, or by thermosiphon if the tank is located higher than the heater.

Combined hot water and home heating

As the heading suggests, some systems are quite large and can provide both hot water for the home as well as for a hydronic heating system, allowing you to at least partially heat your home with the sun.

These systems can be quite expensive to install, with extensive plumbing required for the hydronic radiators, and so are best installed when a house is being built, unless there is good under-floor access or you are willing for pipes to be visible on outside walls.

Solar pool heating

Swimming pools are one area where solar heating has become quite popular. A correctly set up system can extend the use time of a pool well into autumn.

Such systems usually use low temperature collectors which consist of grids of rubber and/or plastic piping mounted on a suitably oriented house or garage roof. Water from the pool is pumped through the collector, where it is heated and returned back to the pool. In effect it's like a giant split system, but the temperature rises are much lower.

Most solar pool heater collectors are unglazed—there is no cover or insulation to reduce heat loss. This is mainly due to the temperature differential between the pool water and ambient air being quite low, so heat losses are not great. However, when roof space is limited or maximum efficiency is desired, glazed collectors, such as the SunX system from Heliocol, are often used.

Solar pool heating systems are also available as DIY kits, allowing pool owners to reduce installation costs by doing it themselves. ✸

Resources:
Solar hot water rebates: www.ata.org.au/rebates
Your Home: www.bit.ly/yhtm-solar

Other 'solar' hot water options

Hot water heat pumps

These work on a refrigeration cycle and absorb heat from the air, concentrating it and dumping it into the water tank (like a fridge, but in reverse). While not strictly a solar water heater in that they generally don't have solar collectors, the heat they absorb from the environment mostly comes from the sun, so many consider them to be solar water heaters.

A heat pump can often be the ideal solution where solar access is limited but reduced running costs for an electric water heater are desired, or where excess PV output is available.

Direct PV water heating

Earlier we explained the difference between solar photovoltaic panels that generate electricity and solar thermal hot water systems. Just to confuse matters, there are solar hot water systems that do use photovoltaic panels. Some DIY systems use a PV panel to directly drive the circulating pump, so that the pump runs whenever the sun is out. This can work quite well, but combined with a simple controller that runs the pump only when water is adequately heated, can work even better. At this stage, this is still in the realm of DIY systems only, as far as we know.

In addition, with the huge reduction in prices of PV panels in recent years, it is now economical to install a direct-to-tank PV system, with an array of solar panels feeding electricity directly to the element in a standard electric storage water heater. There are no pumps, no pipes up to the roof and very little to go wrong.

To improve efficiency of such systems, a maximum power point tracking (MPPT) controller is usually fitted between the panels and the element. This provides the most output from the panels into the element, as well as giving the option of an electronic thermal cutout when the tank reaches the desired temperature. This is an option for competent DIYers with reasonable electrical knowledge.

Another option is to install a relatively small electric water heater and PV array as a pre-heater for any existing water heater, eliminating the need for complete system replacement.

→ A Sanden CO_2 heat pump water heater.

Saving water for a (non) rainy day
A rainwater tank buyers guide

A rainwater tank is one of the best ways to become more water self-sufficient, but which tank is right for your home? Lance Turner looks at the options.

RAINWATER tanks come in almost any size, shape and colour you can imagine, with a variety of materials to suit different preferences or usage requirements. So what should you look for when buying a tank?

The first decision you have to make is where the tank will be located. Where you place the tank will determine its size and shape, and possibly even its colour if it needs to blend into the surrounding vegetation or dwelling walls. A large yard offers a number of options. You could place it next to the house or shed, or even under the house.

You also need to consider how the water will get from the roof into the tank, as well as overflow piping. However, there are a number of different systems for plumbing a tank to a home's gutters that allow a tank to be situated some distance from the home, so this should probably not be an overriding consideration.

→ Slimline tanks can squeeze into otherwise unusable spaces.

Photo: PJT Green Plumbing

Tank materials

The six most common rainwater tank materials are concrete, fibreglass, plastic (usually polyethylene, often just called 'poly', or PVC, used in flexible bladder tanks), Aquaplate Colorbond (thin sheet steel with a colour coating on the outside and a waterproof coating on the inside), galvanised steel and stainless steel. Each of these materials has advantages and disadvantages, so let's look at a few of those.

Durability

A water tank can be a considerable expense, even after a rebate, so you want it to last as long as possible. The expected lifetime of any tank should be at least 20 years, and indeed, many tanks come with a 20 or even 25 year warranty. However, a number of factors will determine just how long the tank actually lasts, and that includes water quality, maintenance and positioning of the tank.

For example, plastic tanks are relatively immune to damage from salty water, so if your tank is regularly topped up from a bore or dam, then a plastic tank might be the best solution. However, if your tank only needs to hold rainwater, then any tank material should be suitable.

The tank's location can affect the lifetime of the materials. Ideally, the tank should be located in shade if possible, not just to keep the water temperature low and reduce evaporation, but also because some materials are degraded more rapidly by direct sunlight.

Most poly tanks will slowly degrade over time with exposure to the sun, despite having UV inhibitors added to the plastic. Because the plastic is being used to hold water, there are limits to how much UV inhibitor and other chemicals can be added to the polyethylene, so eventually the tanks will suffer some degradation.

Metal tanks come in three common materials. Corrugated galvanised steel tanks have been popular in both rural and urban situations for a long time.

Another steel tank type, Aquaplate, is a derivative of Colorbond steel. It has the colour coating on one side and a waterproof coating designed specifically for tank manufacture on the other. Provided the coating is not damaged during the tank manufacturing process and seams are correctly formed and sealed, the tank should last a great many years.

Stainless steel tanks are known for their durability and strength. They are generally small modular tanks for urban use, but large stainless steel tanks are also available. These are made from corrugated stainless steel that looks much like corrugated iron, just a lot shinier. While stainless steel tanks can be more expensive than other types, they have a number of advantages which we will look at later.

Concrete tanks can be quite durable, but they do tend to sweat if they don't have a plastic or rubber liner. If you look at a concrete tank that has been around for a while, it is not uncommon to see white powdery 'salt' residue on the outside.

→ The Water Cube from Flexi Rain Tanks comes as a flatpack kit. It holds 800 litres and will fit anywhere you have a spare square metre or so of space. Multiple units can be linked to make larger tanks.

Photo: Flexi Rain Tanks

Repairability

The material used in the tank will also determine how easy the tank is to repair. Tanks are large obstacles and they often suffer damage by vehicles, trailers, ladders, falling branches and many other large objects found in the average yard. Even children throwing rocks can cause enough damage to penetrate protective coatings on steel tanks, though this sort of damage is easily fixed if caught early.

Poly tanks are generally weldable by any plastic fabricator with the right equipment; most manufacturers will provide a repair service for their tanks. Some even have 'on road' repair services or can provide a good local contact to help you. It is difficult for adhesive compounds to attach to the surface of polyethylene, but small repairs may be performed using a suitable sealant such as Scotch-Weld DP8010 or Scotch-Weld DP8010NS by 3M.

Any attempt to weld galvanised tanks will compromise the galvanising. If welded, the damaged zinc must be replaced with either a galvanising coating or a waterproof sealant. Galvanised tanks can be soldered with a suitable lead-free solder. High-temperature solders such as plumber's 'silver solder' will definitely require resealing from the inside of the tank.

Stainless steel tanks are probably the simplest to fix. A stainless steel fabricator can weld small holes and patch larger ones with new stainless steel. The repairs generally need no additional treatment, as the corrosion resistance is in the steel itself, not a coating. They can also be repaired with waterproof sealants.

Many concrete tanks are underground and are unlikely to sustain damage, but if an above-ground tank is damaged it may be difficult to repair effectively, depending on the level of damage.

Fibreglass tanks are relatively easy to repair, for a skilled fibreglass worker.

Of course, any tank that has a separate flexible rubber or plastic liner will only need repairing if the liner itself is damaged, which is much less likely to happen as the liner can flex away from any penetrating objects.

Material sustainability

There are other factors that need to be considered when looking for a tank. For a start, the tank will eventually need to be scrapped, and you must consider what to do with it at the end of its useful life.

Galvanised and lined mild steel (such as Aquaplate) tanks will generally be quite corroded by the time they start to spring leaks, so they may not be easy to dispose of. Whether a scrap metal dealer will want a tank that is a large percentage iron and zinc oxide is debatable, and at the very least you may have to pay them to take it.

Stainless steel tanks generally don't corrode to the level that coated steel tanks do, so when it comes time to scrap them, most scrap metal dealers will actually pay you for them, as stainless steel is quite valuable. What's more, all of the material in a stainless steel tank can be recycled, whereas the zinc and/or plastic coatings of mild steel tanks are removed from the steel during recycling.

Poly tanks pose an interesting problem in that, if they have degraded to a point where they can no longer hold water, the plastic has reached a point where it can only be recycled into a limited range of other products. Unless the manufacturer/supplier has some sort of recycling system available for them, they will usually end up in landfill.

Fibreglass tanks are generally not recyclable, and being a composite material will most likely end up as landfill.

Most tanks can be put to other uses when they will no longer reliably hold water. Tanks can sometimes (depending on their condition) be turned into storage sheds, animal shelters or storage bins, provided they are given adequate structural bracing.

Concrete tanks are fairly benign disposal-wise, but they do represent quite a large volume of materials. Some companies can recycle concrete but it is not a service available everywhere. Moving an old and disintegrating tank is often a job for heavy machinery, so the cost of removal may be considerable.

The toxicity of the material must also be addressed. Even if a metal tank ends up in landfill, it is a relatively benign material. Although Colorbond tanks have plastic coatings, these will eventually break down into various chemicals. The amount of toxicity per tank is small, but it is still there.

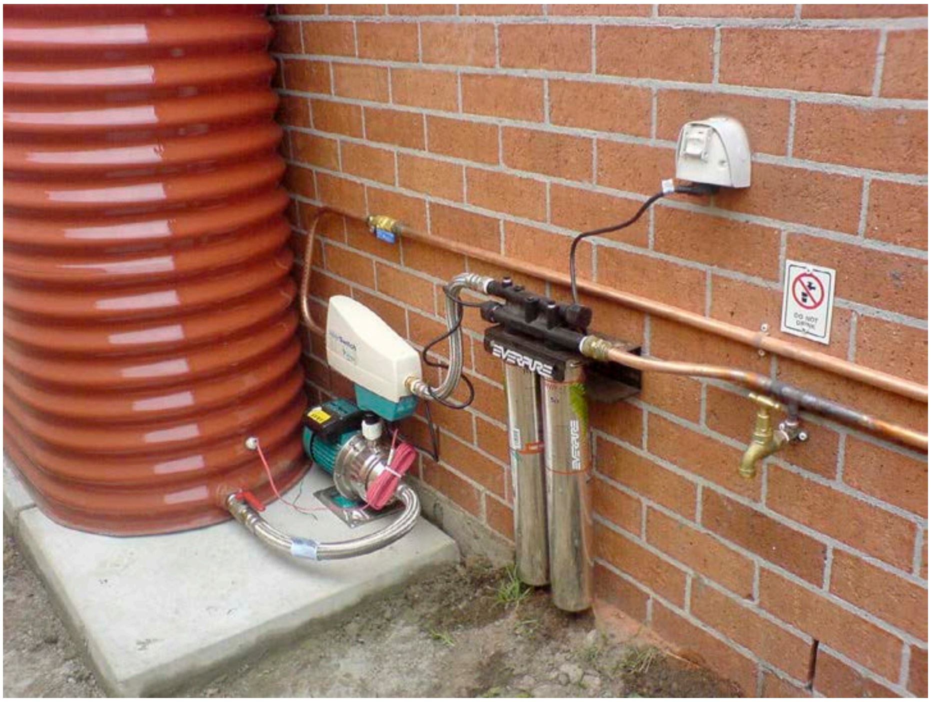


Photo: PJT Green Plumbing

↑ This system has a slimline tank feeding a mains pressure pump. The output of the pump goes to a water controller which switches back to mains water when the tank gets low (note the water-level switch in the tank just above the outlet). The vertical metal cylinders are water filters.

Fibreglass tanks contain quite a lot of polyester resin and small amounts of some rather nasty substances, such as the catalyst used to make the resin set. This will all be released as the tanks break down in landfill.

The embodied energy of a material is another consideration. Stainless steel has quite a high embodied energy, but being fully recyclable offsets most of that. Steel is similar, but with a lower embodied energy but also often less recyclable due to corrosion. Plastic and fibreglass tanks have more embodied energy than you might think. The actual volume of material in them is a great deal more than for a metal tank because they have much thicker walls.

Water quality

This also begs the question, do plastic and plastic-lined tanks leach chemicals into the water?

All water tanks sold in Australia have to comply with AS/NZS4020:2002. This standard specifies requirements for the suitability of products in contact with drinking water, with regard to their effect on the quality of water. These products include all items such as pipes, fittings, components, and materials used in coating, protection, lining, jointing, sealing and lubrication applications in the water supply and plumbing industry. Polyethylene tanks also have their own manufacturing standard, known as the AS/NZS4766:2006, which covers all aspects of the tank's design and manufacture.

So, if a tank fully complies with the requirements, it should be safe. However, plasticised PVC, such as used in some bladder tanks, is considered unsafe in many countries due to the potential hazard of the plasticisers, which can possibly leach out into the water, so it's something to be aware of.

Another potential problem with bladder tanks is that they have no air/water interface. Unless the water is of good quality and regularly turned over, the water may stagnate.

Tank accessories

The greatest risk of contamination comes not from your tank, but from your roof and gutters. There are a number of tank accessories that can help avoid any contamination problems, as well as other accessories that can make owning a tank that much more useful.

FIRST-FLUSH DEVICES

Between downpours, the average roof collects contaminants from sources such as bird and other animal droppings, pollution from vehicles, stoves and heaters, and roof coatings and sealants. All of these wash down into your tank with the first flow of rainwater—unless, of course, you have fitted a first-flush device. These divert the initial flow of water from the roof to the stormwater drain, thus preventing most contaminants from entering your tank. Many water tanks are supplied with these devices as part of the package, but if not, then make sure you fit one, even if you are not intending to drink the water, as it will reduce the build-up of sludge in the tank.

Some first-flush diverters include a leaf screen and other functions. The Supadiverter (www.supadiverta.com.au) is a good example of a unit that does everything.

PUMPS

Rainwater pumps should be selected with three things in mind: application, reliability and noise.

For your application you need to know the pressures and flows you will require. For example, running a shower and lawn sprinkler together requires 15 litres per minute (lpm) at 140 kPa pressure. However, running an irrigation system might need 60 lpm at 400 kPa. Work backwards from the number of appliances you want to run at the same time. Add them up and this will give the

Bushfires and water tanks

If you live in a rural area, or even the urban fringe, you should take into account the effects of bushfire on your water tank. Contamination of tanks from floating ash can be a big issue, and a first-flush device can reduce this problem considerably. Residents in bushfire-risk areas will also need to attach fire-brigade fittings to their tanks and ensure that fire tankers can access the rainwater tank.

Of course, fire doesn't just produce a lot of ash, it also has a habit of burning things. Poly tanks can melt down to the waterline if a bushfire gets too close, but in severe fires even metal and concrete tanks can become unusable. If you live in a fire-prone area then underground tanks might be your best bet. A 2007 Bushfire Cooperative Research Centre/CSIRO report titled 'Research into the Performance of Water Tanks in Bushfires' details the effect of fire on different tanks.

required flow rate.

Stick to 25mm or larger pipe and you won't run into problems around the home. The pressure required is determined by the pipe size used and the length of the pipe. Multi-stage pumps deliver the highest pressures. A pump professional (not necessarily the local pump salesperson) will be able to guide you in your selection once you have a clear idea of your application.

Reliability can be determined by several factors such as suitability to the application, construction materials, quality of the installation, water quality and pump and controller quality. If you are going to use the pump regularly and will depend on it working well, don't buy a cheap unit.

Jet pumps will handle grit and sand well. Multi-stage pumps offer efficient performance. Look for a controller that offers 'dry run protection'—dry running is the most common way to destroy a pump.

Noise on domestic pumps is governed by EPA guidelines that set out time blocks and maximum noise levels at the closest point to your neighbour's house. A pump's noise depends on its type. The noisiest to the quietest are: peripheral turbine, jet pump, multi-stage pump, and the quietest (virtually silent) a submersible pump. Incorrect installation can also make for noisy operation—again, large pipework will reduce the chance of this happening.

→ Traditional leaf strainers have a tendency to clog, resulting in a number of other designs entering the market. This is the Rain Guardian (www.rainguardian.com.au), and combines leaf screen and first-flush diverter in one unit.

WATER-LEVEL GAUGES

One very handy device for your water tank is a water-level gauge. These range from a simple dipstick, to mechanical float/stick devices (the higher the stick is above the tank, the more water you have), to wireless electronic sensors which send the water level information to a receiver in the house. As with many such devices, simpler is usually better.

LEAF GUARDS AND TANK SCREENS

Leaf guards can be fitted to the full length of your house gutters, but add-on leaf guards may not work effectively for very long as they can get clogged. Gutters made to exclude leaves, or leaf diverters (often called rain heads) fitted to the downpipes before the tank's top meshed inlet, are a better option. Rain heads often come as part of the tank package, but if not, they really are a must as leaves can quickly block downpipes.

Tank sizes and styles

Once you have decided on the tank's material, you then have to work out the size (capacity) and shape, and whether you want it underground or above ground.

Above-ground tanks are usually of the traditional round variety, or of the flat-sided oval or rectangular 'slimline' style for narrow spaces. There are even tanks that are so narrow they can be used as walls, and others that consist of small modular tanks that can be assembled into larger tanks of almost any shape.

If you highly value aesthetics, then poly tanks may well be your first choice as they have clean, smooth lines and come in a huge range of colours and styles.

For high-density living, underground tanks can often be the solution, and these are available as poly tanks or concrete, which is often cast in-situ. Concrete tanks are usually reinforced internally and as such can support heavy loads, so they can be placed under driveways. Some underground poly tanks are also well reinforced and can withstand considerable loads.

If your house is mounted on stumps, or you have a post-mounted deck, you could consider a bladder tank. These consist of a metal frame around a flexible plastic or rubber bladder. As the bladder fills it expands to its maximum size.

Be aware though that some bladder tanks use PVC bladders. If you intend to drink the water from a bladder tank, make sure the bladder is rated as a potable water bladder. If

Photo: PJT Green Plumbing

↑ Large tanks, like this Rhino Tank corrugated Colorbond unit, can provide water for an entire home.

Photo: PJT Green Plumbing

↑ What does a truck have to do with rainwater tanks? This truck is sitting on one! Underground tanks can withstand high loads without damage.

you are only using the water on the garden then this most likely won't be an issue.

Wet or dry systems?

The terms 'wet' and 'dry' refer to the type of downpipe system between the roof collection area and the tank(s).

In a dry system, water flows downwards from the gutter through a sloping pipe to the top of the tank. When the rain stops, the pipe empties into the tank and becomes 'dry'. Dry systems work in many situations where the tank is on the same side of the house as the guttering and is close to the house.

With a wet system, part of the pipework between the tank and the guttering is lower than the top of the tank, and is usually buried in the ground. This may be required if the tank and gutters are on opposite sides of a house, requiring the pipework to run under the home to reach the tank. Other obstructions such as a driveway can be a reason for this setup. When the tank is a long way from the home, a wet system is often used to get the pipes out of the way and eliminate the need for pipe supports, as would be required if the pipes were suspended above ground.

There are a couple of disadvantages with wet systems: the pipes need to be insect-proofed to prevent mosquitoes and similar bugs breeding in them, and the first-flush device in the system must flush not only the first flow of water from the roof, but all of the water that has remained in the pipe as well.

Proper mesh screens solve the first problem and indeed are generally a requirement with wet systems. In-ground first-flush devices can solve both of these problems. They are buried in the ground along with the pipework and have a drainage outlet that is lower than the tank and pipework. In effect, they can be used to convert a wet system into a dry system, as when the rain stops, the first-flush device will drain the pipes completely.

However, in-ground first-flush diverters need to drain the wet system pipes if they are to work. They also have drippers that can block, they retain debris, the ground needs to be on a slope and the drippers can reduce rainwater yield.

Ideally, the first-flush diverter should always be at the downpipe. Many plumbers fit first-flush diverters on the vertical riser at the tank. This means that the flush chamber fills with the settled water from the riser while the first flush is still in the downpipe and so this ends up flowing to the tank!

The Supadiverta uses a modified wet system and has siphonic outlets that use small PVC pressure pipes to divert fast-flowing water to an inlet fitted 100mm above the bottom of the tank. This eliminates air inside the pipe, resulting in fast flows between the diverter and the tank, completely flushing the pipe each time it rains.

Maintenance

Water tanks can slowly build up a layer of sludge in the bottom. This is caused by dust and debris entering the tank, which will happen no matter how good your filtering is.

Check your tank for sludge every two to three years. If it becomes too much of a problem you may need to get in there (if the tank has an access hatch) and clean out the goop.

You may want to consider installing a tank cleaning overflow system. These work by having an internal overflow pipe that draws water from the base rather than the top of the tank. They can be simply homemade using suitable lengths of downpipe and fittings. One commercially made system, the Tankvac (www.tankvac.co.nz), uses perforated pipe along the tank's floor that sucks in anaerobic water and debris. It is a siphonic system that flows much faster than the inflow, which is ideal if several downpipes supply the tank.

If you are concerned about bacterial contamination and need to drink the water, then you may need to occasionally use a

Energy use and water pumping

Energy use of pumps will vary depending on efficiency. The more efficient a pump, the less energy it will use to move a given volume of water.

If you are thinking about installing a rainwater tank but are concerned that you will need to use energy to power a pump, think about this: the mains water in your home gets there by being pumped through the mains water system. This water is pumped great distances and is delivered to homes at a much higher pressure than generally needed. Because of these factors, the embodied energy in mains water is quite high, relatively speaking. Using a small pump to move water out of a rainwater tank will generally use far less energy than drawing that same volume of water from the mains.

To get an idea of how little energy is needed to push water around, have a look at a pumping calculator at www.bit.ly/PumpPower. Using this calculator it can be seen that to move 2000 litres an hour up to a five-metre head using a 60% efficient pump, the pump will require a shaft power of just 50 watts. Using the average electric motor to drive the pump would result in an energy consumption of under 100 watt-hours.

↑ The Rain Harvesting dial tank water-level gauges come in a simple mechanical model (left) and a wireless version with a digital display for inside the home.

product such as Davey Acquasafe Rainwater Purifier. This should only be done if absolutely necessary. To avoid this, use other methods of treatment, such as UV sterilisation.

Councils and rainwater

Like all permanent structures, there are rules and regulations that apply to rainwater tanks. Each council has their own requirements for sites and installation, so before you do anything, talk to your council and find out what they require.

Rebates

Water tanks can cost quite a bit of money, but fortunately rebates are available for tank installation in some states. While tanks do not have to have AS/NZS4766:2006 certification, if you want to claim a rebate then the tanks must be certified. This is permanently marked on the side of the tank with the manufacturer's name, tank capacity, date of manufacture, serial number and the AS number. For more information on the rebates available, go to the Savewater website www.savewater.com.au

About the table

The table gives an idea of the range and types of tanks available. It is impossible to list all of the tanks on the market so shop around and get a number of quotes before you decide on a particular system.

The RRPs listed in the table should be taken with a grain of salt. While we asked suppliers for GST-inclusive prices, some companies tend to quote ex-GST prices, so check the final price with the manufacturer. ✱

Resources:
Australian Rainwater Harvesting Association: www.rainwaterharvesting.org.au
Green Plumbers: www.greenplumbers.com.au
Bushfire Cooperative Research Centre: www.bit.ly/WTBIBF
Master Plumbers Association of NSW: www.enviroplumber.com.au
ATA rainwater tanks page: www.ata.org.au/sustainability/rainwater-tanks
ATA rainwater tank size calculator: www.tankulator.org.au

Brand/contact details	Model	Capacity (litres)	Type	Material	Warranty	RRP $	Comments
All Poly Products Stawell VIC 3380 Ph: (03) 5358 5858 sales@allpoly.com.au www.allpoly.com.au	APS600	600	Slender tank	UV-stabilised food-grade polyethylene	10 year	POA	Pump kit, pressures switches etc.
	APS1000	1000					
	APS1000PT	1000	Pressure tank				
	APS2300	2300	Slender tank				
	APS2300PT	2300	Pressure tank				
	APR600	600	Round tank				
	APR1000	1000					
	APR2250T	2250	Tall tank				
	APR2250S	2250	Squat tank				
	APR3360R	3360	Round tank				
	APR4500T	4500	Tall tank				
	APR4500S	4500	Squat tank				
	APR7200R	7200	Round tank				
	APR10200	10,200					
	APR13700	13,700					
	PCR22500	22,500					
	PCR25000	25,000					
	PCR3000	30,000					
Ausdrain Cammeray NSW 2062 Ph: (02) 9929 7650 www.ausdrain.com	R2000	2000	Underground tank	Polypropylene	10 year	1,750	Price includes EnviroModules, liners, EnviroSump filtration unit and inlet/outlet. Prices do not include delivery and are exclusive of GST. Tanks are not limited to the sizes shown and can be tailored to any capacity and dimensions.
	R2500	2500				1,950	
	R3000	3000				2,150	
	R3500	3500				2,350	
	R5000	5000				2,850	
	R7500	7500				3,475	
	R10000	10,000				4,025	
	R20000	20,000				6,550	
	R50000	50,000				14,500	
Aqualine Water Tanks ph: (02) 6355 6257 Mobile: 0427 611 861 bigtank@westnet.com.au www.aqualinetanks.com.au	Above-ground corrugated iron rainwater tanks	15,000 to 400,000	Above-ground round modular tanks for domestic, rural or industrial use	Corrugated galvanised iron with polyethylene liner and geofabric protective insert. Powder coating optional	20 year	POA	Australian Bluescope steel, any colour options, domed roof. Optional extras include additional fittings, pumps and filters. Site preparation also available if required. Aqualine tanks are erected on site by our own team, anywhere in NSW, VIC and QLD at no extra cost.
Bushmans Tanks Qld - Dalby NSW - Orange VIC - Terang SA - Cavan ph: 1800 008 888 www.bushmantanks.com.au	T10500	46,400	Above-ground tank	Polypropylene	10 year	POA	Price is GST inclusive and includes delivery within the Bushmans free delivery zone. Fittings include overflow, leaf strainer, ball valve and flexhose kits on larger tanks.
	T8400	38,000					
	T6500	30,000					
	TS5500	25,000					
	TS5000	22,500					
	T3300	15,000					
	T2300	10,000					
	TS2200	10,000					
	T1100	5000					
	TS910	4200					
	T660 Slim	3000					
	T650	3000					
	TT560	2500					
	T440 Slim	2000					
	T350	1500					
	T230 Slim	1100					
	T220 Slim	1000					
Clark Tanks Pty Ltd Ph: 1800 88 7979 Moama NSW, Bathurst NSW, Dalby QLD www.clarktanks.com.au	CT 10,000	46,817	Round tank	UV-stabilised food-grade polyethylene	25 year	POA	Pumps and accessories also available
	CT 7,000	32,822					
	CT 5,200	23,639					
	CT 5,000	22,730					
	CT 3,000	13,638					
	CT 2,200	10,000					
	CT 2,000	9092					
	CT 1,100	5000					
	CT 1,100 Sq	5000					
	CT 1,000Sq	4546					
	CT 660	3000					
	CT 440	3000					
	CT 225	1022					
	440 SL	2000	Slimline tank		10 year		
	660 SL	3000					
	ST 5,000	5000					
Elmich Australia Newington NSW 2127 Ph: (02) 9648 2073 australia@elmich.com.au www.elmich.com.au	VersiTank 550	Any	Underground tank	Polypropylene	10 year	POA	Price varies depending upon configuration and ompressive strength specification requirement.
	VersiTank 840						
	VersiTank 880						
Flexdrive Tank Solutions New Gisborne VIC 3438 Ph: 1300 353 937 tanks@flexdrive.com.au www.flexdrive.com.au	1100 Slim	1100	Above-ground tank	Polyethylene	10 year repair or replace	POA	Designed, manufactured and owned in Australia Tanks are certified to AS/NZ4766:2006 by SAI Global. Cert No. SMKP21695. Full range of colours to match Colorbond. Fast delivery to SA, NSW, ACT and VIC. Also available pump enclosures, pumps and tank/mains switches.
	2000 Slim	2000					
	2100 Round	2100					
	2200 Modular Slim	2200					
	2500 Slim	2500					
	3000 Slim	3000					
	4000 Modular Slim	4000					
	4000 Slim	4000					
	4100 Slim	4100					
	5000 Modular Slim	5000					
	5000 Round	5000					
	6000 Modular Slim	6000					
	8000 Modular Slim	8000					
	8200 Modular Slim	8200					
Flexi Raintanks Ph: (03) 9304 4498 info@flexiraintanks.com.au www.flexiraintanks.com.au	Water Cube	800	DIY above-ground tank	Galvanised steel frame, flexible water bag, mesh cover.		495	Options available. Shipped anywhere in Australia.
	Water Cube starter pack	800				625	Includes tank, smart diverter, inlet pipe, fittings and double tap outlet. Options available. Shipped anywhere in Australia.
Freewater Super-Slim Rainwater Tanks, PO Box 1995, South Plympton SA 5038 Ph: 0414 556 520 info@freewater.com.au www.freewater.com.au	FW1-B/ FW1-RG	220	Super slim rainwater tank	HD0840 copolymer food grade polyethylene	Lifetime	260	Freewater slimline tanks can be easily connected together to increase water storage needs using the supplied installation kit.

Brand/contact details	Model	Capacity (litres)	Type	Material	Warranty	RRP $	Comments
Global Roto-Moulding Irymple VIC 3498 Lot 3 Nan's Road Helidon Spa QLD 4344 ph: 1800 666 333	GR-2000RW	2000	Above-ground	UV stabilised polyethylene	10 year	POA	Full range of colours. All tanks are made from heavy-metal-free polyethylene.
	GR-3000RW	3000					
	GR-5000RW	5000					
	GR-5000RWS	5000					
	GR-10000RW	10,000					
	GR-10000RWS	10,000					
	GR-14000RW	14,000					
	GR-23500RW	23,500					
	GR-28000RW	28,000					
	GR-C2200 Urban	2200 Slim					
	GR-C3000 Urban	3000 Slim					
Heritage Water Tanks Australia Ph: 1800 115 552 PO Box 3382 Malaga DC WA 6090 www.heritagetanks.com.au	HGT 55	55,000	Above-ground	1mm Bluescope steel, 0.75mm polyethylene liner	20 year conditional warranty	POA	Heritage Water Tanks are proudly built here in Australia. We use the highest quality materials for every tank we build. Supplied with 50mm brass outlet with metal ball valve, leaf basket, overflow pipe, lockable access hatch. Zincalume and Colorbond available.
	HGT 90	90,500					
	HGT 110	111,500					
	HGT 135	135,000					
	HGT 160	160,500					
	HGT 220	220,000					
	HGT 250	251,000					
	HGT 285	285,000					
	HGT 375	375,000					
Landscape Tanks Park Orchards Vic Sales/technical enquiries Ph: 0414 308123 www.landscapetanks.com.au	Standard unit	2000	Water tank/retaining wall/raised garden bed	Reinforced high grade 50 MPa concrete for lifelong performance	1 year	POA	Landscape tanks are a multi-purpose unit that may be used for several tasks around the home at the same time. Water tanks, retaining walls, front fences, detention systems, pool surrounds and raised garden beds.
	Large unit unit	3000					
Nanango Tank Makers 13894 D'Aguilar Highway Nanango Sth QLD 4615 Ph: (07) 4171 0556 sales@ntm.com.au www.ntm.com.au	Round corrugated	485 to 30,000	Above-ground	Bluescope steel Aquaplate Colorbond	5 year manufacture, 20 year materials	Check website for product details and price list	Options include household water pressure pumps: Orange Pumps (1 yr warranty). Tanks come with standard fittings. Can make make custom tanks to order.
	Slimline corrugated	550 to 5400					
	Round poly	750 to 22,400		Polyethylene	15 year		Includes standard fittings (25mm outlet).
	Slimline (modular incl) poly	1000 to 3000					Includes standard fittings.
	Rural tanks	55,000 to 375,000		1mm zincalume or Colorbond steel, 0.075 mm hydro 1000 polyethylene liner. RHS hot-dipped trusses covered with corrugated roof sheeting	20 year		Upgrade kit available - gutter system, removable ladder, second 50mm outlet for firefighting connectors.
Ozzi Kleen Water & Waste Water Kunda Park QLD 4556 Ph: 1800 450 767 info@ozzikleen.com www.ozzikleen.com.au	RW5000	5000	Underground rainwater harvesting tank - pool and garden system	Food-grade roto-moulded polyethylene	15 year	POA	Full harvesting system upgrades available with mains diversion or top-up option on all above-ground tanks as well. Available from distributors Australia wide who can give accurate prices including shipping. Find your local agent online or phone. RRP prices are ex factory prices. Prices do not include delivery or GST.
	RW5000 Delux	5000	Underground rainwater harvesting tank - diversion system				
	RW5000	5000	Underground rainwater tank - slave tank				
	SL3000	3000	Slimline above-ground				
	RT5000	5000	Round above-ground				
Pioneer Water Tanks Bellevue WA 6056 ph:1800 999 599 www.bluescopewatertanks.com.au	GALAXY™ Tanks	12,000 to 2.6 million litres	Lined steel water tank	Zincalume or Colorbond. Heavy duty 5-layer Aqualiner liner.	Up to 20 year conditional	POA	Rural, domestic, agricultural, commercial, industrial, mining, municipal applications. Liner certified to Australian, American and British standards for contact with potable water.
Plastek Water Products Ballarat West Vic 3351 Ph: 1800 065 356 plastek@bvci.com.au www.bvci.com.au	495L Tank (Slimline)	495	Slimline	Food-grade UV-stabilised rotomoulded polyethylene	10 year fix or replace	POA	Large range of tanks for domestic, rural and industrial applications. Full range of colours and profiles. Manufacturers of polyethylene stock troughs and small cartage tanks. Tanks are only for above-ground installations.
	2100L Tank (Slimline)	2100					
	3500L Tank (Slimline)	3500					
	5000L Tank (Slimline)	5000					
	335L Tank	335	Round smooth				
	450L Tank	450					
	675L Tank	675					
	900L Tank	900					
	2,250L Tank	2250					
	2,250L Tank	2250	Round corrugated				
	2,250L Tank	2250	Squat smooth				
	3,000L Tank	3000	Round banded				
	3,200L Tank	3200	Round smooth				
	4,500L Tank	4500	Round corrugated				
	5,000L Tank	5000	Round smooth				
	5,000L Tank	5000	Round banded				
	9,000L Tank	9000	Round corrugated				
	10,000L Tank	10000	Round smooth				
	13,500L Tank	13500	Round corrugated				
	22,700L Tank	22700	Round smooth				
	22,700L Tank	22700	Round corrugated				
	27,250L Tank	27250	Round smooth				
Polymaster Swan Hill VIC 3585 Ph: 1800 062 064 www.polymaster.com.au	SLT600	600	Above-ground Slendaline	Polyethylene	10 year	POA	Tank and pump packages also available. Certified by SAI Global to the Australian Rainwater Tank Standard AS4766.
	SLT1050	1050					
	SLT2100	2100					
	SLST2000	2000	Above-ground Slendastyle				
	SLST3000	3000					
	SLST5000	5000					
	RWT200	200	Above-ground round corrugated		20 year		
	RWT600	600					
	RWT1000	1000					
	RWT1600	1600					
	RWT2270T	2270					
	RWT2270LP	2270					
	RWT3300	3300					
	RWT4500T	4500					
	RWT4500LP	4500					
	RWT7100	7100					
	RWT9000	9000					
	RWT13600	13600					
	RWT22500	22500					
	RWT31700	31700	Below-ground		20 year		Tank and pump packages available. Complies with Aust standard 1546.1 for septic tanks. Engineered by geotechnical experts including finite element analysis.
	URT2250B	2250			7 year		

Brand/contact details	Model	Capacity (litres)	Type	Material	Warranty	RRP $	Comments
Poly Water Tanks Fountaindale NSW 2258 Ph: 1800 077 178 info@polywatertanks.com.au www.polywatertanks.com.au	667r	667	Above-ground	Polyethylene	10 year	POA	All tanks are Australian certified.
	700r	700					
	750r	750					
	1000r	1000					
	1330r	1330					
	2500r	2500					
	3440r	3440					
	4000r	4000					
	5000r	5000					
	10000r	10,000					
	13500r	13,500					
	1334s	1334	Slimline above-ground				
	1400s	1400					
	1500s	1500					
	2000e	2000					
	2001s	2001					
	2100s	2100					
	2250s	2250					
	2660s	2660					
	2668s	2668					
	2800s	2800					
	3000s	3000					
	3000e	3000					
	3335s	3335					
	3990s	3990					
	4000e	4000					
	5000e	5000					
	5320s	5320					
	1800b	1800	Underfloor				
	2000b	2000					
	3000u	3000	Underground				
Polyworld Redcliffe QLD 4019 Ph:1300 888 654 info@polyworld.com.au www.polyworld.com.au	WT23000	23,000	Cylindrical	Food-grade UV stabilised polyethylene	10 year (option to increase if required)	POA	Options include removable mesh screened overflows; stainless steel strainers, pumps, first flush diverters, level gauges, mains water switchover units, water filters. Prices are ex factory. Delivery on application.
	WT16000	16,000					
	WT15000	15,000					
	WTT10000	10,000					
	WT10000	10,000					
	WT7500	7500					
	WT6000	6000					
	WTSQ6000	6000					
	WT5000	5000					
	WT3000	3000					
	WT2000	2000					
	WTSQ2000	2000					
	WT1000	1000					
	WT500	500					
	WT200	200					
	RT5000	5400	Slimline				
	SS3000	3000					
	RT3000	3000					
	RT2500	2500					
	AST1100	1100					
	AST700	700					
	AST300	300					
RainPac by Flexitank (Australia) Springvale VIC 3171 Ph: 1300 306 000 sales@rainpac.com.au www.rainpac.com.au	RW1.0 1000	1000	Flexible under house or under deck bladder tanks	Reinforced 750gsm food-grade PVC	10 year	949	Made-to-order customisation is available. Tanks can be joined together to create large hidden water storage systems. Tank supplied with a full installation kit plus first and second stage Silvan H2O filtration products ($150 RRP value) at no extra charge. Free delivery with every order. Available from all good retailers, visit website for a full list of retail distributors. Prices will vary from state to state.
	RW1.0 1500	1500				1069	
	RW1.0 2300	2300				1199	
	RW1.3 1700	1700				1109	
	RW1.3 2500	2500				1249	
	RW1.3 4000	4000				1459	
	RW1.6 2450	2450				1169	
	RW1.6 3850	3850				1339	
	RW1.6 6000	6000				1569	
	RW2.0 3400	3400				1369	
	RW2.0 5400	5400				1599	
	RW2.0 8600	8600				1829	
Rainmaster Technologies P/L Ph: 1800 733 020 Wyong NSW 2259 info@rainmaster.com.au www.rainmaster.com.au	RM3140	3140	Below-ground round	Reinforced concrete	15 year	POA	Concrete below-ground rainwater recycling systems for domestic, commercial and industrial applications. System consists of tank, submersible pump and changeover device. Optional extras are: leaf debris filter and excavation. All tanks can be modified/customised for on-site detention (OSD) or can be linked together to attain larger volumes.
	RM3850	3850					
	RM5000	5000					
	RM7500	7500					
	RM10000	10000					
	OSD5000	5000	Below-ground round OSD				
	OSD7500	7500					
	OSD10000	10000					
	RMTUB6000	6000	Below-ground rectangular tub				
	RMTUB8000	8000					
Rhino Water Tanks Ph: 1800 632 410 sales@rhinotanks.com.au www.rhinotanks.com.au	RT-25	26,000	Large domestic/rural/ industrial	Corrugated steel with polyethylene liner, optional Zincalume or Colorbond	20 year	POA	Price includes a 50mm outlet and ball valve, 50mm scour drain for cleaning, 100mm overflow, heavy duty lockable access hatch, sacrificial anodes for corrosion protection, leaf basket with lid, and removable internal/external ladder.
	RT-40	40,000					
	RT-60	58,000					
	RT-80	79,000					
	RT-100	104,000					
	RT-130	131,000					
	RT-160	160,000					
	RT-200	198,000					
	RT-230	234,000					
	RT-260	264,000					
Ri - Industries Ph: (08) 8445 7822 Fax: (08) 8268 2335 www.ri-industries.com.au	Above-ground rainwater tank	5000	Pre-cast round	Concrete	5 year	POA	Conical roof.
		9090					
		13,640					
		22,730					
	Below-ground rainwater tank	5000					Flat roof.
		9090					
		13,640					
		22,730					
Slimline Rainwater Tanks Ph: 1800 804 901 sales@slimlinetanks.com.au www.slimlinetanks.com.au	Slimline and round tanks Aquaslim and Aqualong	Custom sizes up to 7000	Rainwater tanks, retention tanks, pump kits	Colorbond Aquaplate	20 years	POA	The original manufacturer of slimline style tanks. Servicing Melbourne metro and Victoria-wide.
Stainless Steel Rainwater Tanks Logan Village QLD 4207 Ph: (07) 5546 8571, sales@stainlessrainwatertanks.com www.stainlessrainwatertanks.com	Slimline and round tanks	Up to 40,000	Custom-built tanks	Corrugated stainless steel	25 year	POA	Above ground tanks.

Brand/contact details	Model	Capacity (litres)	Type	Material	Warranty	RRP $	Comments
STRATCO www.stratco.com.au Queensland (07) 3451 4444 New South Wales (02) 8811 7200 South Australia (08) 8349 5559 Western Australia (08) 9455 1911 Northern Territory (08) 8944 2300	Aqua-Mod 1 module	500	Domestic above-ground	Galvanised steel	On application	POA	
	Aqua-Mod 2 module	1000					
	Aqua-Mod 3 module	870					
	Aqua-Mod 4 module	2000					
	Aqua-Barrel 500 Low	500		Aquaplate			
	Aqua-Barrel 1000 Low	1000					
	Aqua-Barrel 1000	1000					
	Aqua-Barrel 2000	2000					
	Aqua-Barrel 3000	3000					
	Aqua-Classic 3000	3000					
	Aqua-Classic 5000	5000					
	Aqua-Quad	2000					
	Aqua-Line 3000	3000		Polypropylene			
	Aqua-Line 5000	5000					
Sydney Water Tanks Smeaton Grange NSW 2567 Ph:(02) 4629 6688 sales@sydneywatertanks.com.au www.sydneywatertanks.com.au	SWT 3800	3800	Underground	Concrete	30 year	POA	Features include a variable turret height system, 40MPa steel fibre reinforced concrete, super strong access cover, non-return flap valve, mosquito mesh leaf filter, construction bypass. Optional extras include: first-flush diverter, Rainswitch (BASIX package) with a fitted submersible stainless steel pump.
	SWT 6100	6100					
	SWT 10000	10,000					
	SWT 11500	11,500					
Tanket Bayswater Vic 3153 Ph: 1300 826 538 www.tanket.com.au	1,700L Universal	1700	Above-ground or underground concrete tanks.	Concrete	Free from defects for 15 years	See our website for latest prices.	Tanks available in Class A, B or D for different traffic loads with lids to suit. Options include pit risers, light concrete covers, cast iron infill covers, grates, pits, soakwells, core hole drilling, pumps, rainbank, rainwater management systems, retention systems, brass tank outlet for CFA fittings, tank alert float switch.
	2,100L Universal	2100					
	3,800L Universal	3800					
	5,000L Universal	5000					
	10,500L Universal	10500					
	10,750L Uni. Tank Low Profile	10750					
	11,000L Universal	11,000					
	20,000L Universal	20000	Domestic, industrial or rural use				
	21,500L Universal	21500					
	32,000L Universal	32000					
	42,500L Universal	42500					
	52,500L Universal	52500					
Tank Heaven Seaford VIC 3201 Ph: (03) 9786 1511 www.tankheaven.com.au	730R	730	Above-ground round	Polyethylene	10 year	See website for latest prices	Available in all popular tank colours. Options include pumps, connection kits and tank/pump packages. Standard fittings/accessories include leaf strainer, overflow fitting, threaded outlet. Altered or additional fittings at no charge.
	1250R	1250					
	2100R	2100					
	3000R	3000					
	4200R	4200					
	6000R	6000					
	10000R	10,000					
	1700S	1700	Above-ground slimline				
	2000S	2000					
	2000SQ	2000	Squat model				
	2500S	2500					
	3000S	3000S					
Tankworks Australia Blacktown NSW, Somerton VIC, Crestmead QLD Ph: 1300 736 562 www.tankworks.com.au	Made to measure	Round up to 30,000L, Slimline up to 7000L	Above-ground slimline and round corrugated steel	BlueScope Aquaplate® steel	20 year materials, 10 year construction	Various	Full range of colours. Flexible fitting locations. WaterMark approved. Delivery service to slab. Serving greater Sydney, Melbourne, Brisbane. Tank and pump cleaning and maintenance services.
	Rural / Industrial range	27,000 to 250,000	Large domestic / rural / industrial	Corrugated Colorbond or galvanised steel	10 year	Various	
The Aussie Bladda Tank Contact: Andrew Ph: 0431 722 989 www.aussiebladda.com.au	The Aussie Bladda Tank 33 standard sizes	1275 to 6000	Bladder tank	UV-stabilised reinforced polypropylene	10 year	Check website for prices	Custom-built sizes available to 45,000 litres. Standard fittings include 50mm inlet, 25mm outlet and breather. Can store drinkable water. No frames required. Supplied boxed for easy transport
WaterPlex Artarmon NSW 2064 ph:(02) 9113 5593 or 1300726670 info@waterplex.com.au www.waterplex.com.au	eco sac	1400 to 10,700	Flexible bladder tank, galvanised steel frame.	Flexible potable-grade PVC with galvanised steel frame	10 year	POA	Comes in 89 different sizes, protective covers for each size. Stainless steel option for frame. Widths from 1100 to 2100mm and lengths from 3000 to 8000mm.
	reo sac	1150 to 8800	Reinforced bladder tank with mounting plate for pipework	Reinforced PVC potable-grade bladder			Comes in 66 sizes: widths from 1100 to 2100mm and lengths from 3000 to 8000mm.
	Aquaclad	390 to 21,150	Flat-pack steel slimline tank in 4 widths, 2 heights and 16 lengths.	Steel frame,PVC liner with geotextile protection.			Raw zincalume, any Colorbond colour. Clad with any finish you desire. 54 size combinations. Comes in 880 or 1670mm heights, 465, 755 or 955mm widths and 9 lengths (1200–6000mm).
	Liquidity VLS	Almost any size	Void and tank liners in any shape or size	Flexible geo membranes	-		-
	Round and Slimline Steel	Thousands of sizes	Round and Slimline	Galvanised steel or Colorbond	20 year materials, 10 year construction		Full range of colours, flexible fitting locations and sizes.
WaterStore Poly Tanks Ph:1800 654 610 sales@waterstore.com.au www.waterstore.com.au	225 litre poly	225	Round poly tank	UV-stabilised polyethylene	10 year	390	WaterStore are based in Bendigo, Central Victoria and have 1400 agents all over Victoria, and some in SA & NSW. All tanks come with standard outlet & ballvalve, overflow and strainer. All fittings fitted on delivery at customers request. Heavy duty options available. Options include pumps, first flush diverters, level gauges, mains water switchover units, pump covers. A range of water troughs and feeding troughs in various sizes also available.
	335 litre poly	335				520	
	400 litre poly	400				415	
	900 litre poly	900				495	
	1000 litre poly	1000				665	
	2000 litre poly round	2000				730	
	2000 litre poly slimline squat	2000	Slimline poly tank			970	
	2000 litre poly slimline	2000				960	
	2250 litre poly round	2250	Round poly tank			750	
	3000 litre poly slimline	3000	Slimline poly tank			1115	
	4000 litre poly slimline	4000				1499	
	4500 litre poly squat	4500	Round squat poly tank			1250	
	4500 litre poly tall	4500	Round poly tank			1190	
	5000 litre poly round	5000				935	
	5000 litre poly slimline	5000	Slimline poly tank			1760	
	9000 litre poly	9000	Round poly tank			1590	
	10000 litre poly	10000				1650	
	22700 litre poly	22700				2395	
	33750 litre poly	33750				3750	
Wet Earth ph:(02) 6062 3300 sales@wetearth.com.au www.wetearth.com.au	Domestic Bladder	1120 to 11,400	Self supporting bladder tank	UV stable reinforced flexible PVC material	10 year	725 to 2300	Width 1.1m to 2.8m. Length 3m to 8m. Made to order so all tanks customised
	Large Bladder	11,000 to 200,000			5 year	3000 to 15,000	Width and length to 14m. Height to 1.5m.
	Aquaplate Steel Tank	340-28,950	Round and slimline	Polymer-lined corrugated steel tank	10 years	799–3,967	Width from 0.55m to 3.5m Length from 1.1m to 3.3m Height to 3.0m

Delivering less pollution
A Citroen Berlingo electric conversion

Rhys Freeman describes the successful conversion of a delivery van by the EV group at CERES in Melbourne.

FOLLOWING on from a direct current (DC) conversion of a Citroen Berlingo van over 2007–2009, CERES in Melbourne decided to convert a second van to electric drive, this time an AC conversion.

Alternating current (AC) motor conversions are not as common as DC conversions, due to higher costs and poorer knowledge of the technology among the conversion community. This is despite the fact that current commercial vehicles use AC brushless drive trains, either induction or permanent magnet.

The CERES project was to be a conversion of a Mercedes Sprinter, but it was first necessary for the conversion team to gain some knowledge about the process. This came from the conversion of another van to AC drive, a Citroen Berlingo. That conversion is described here, along with the lessons learnt for the Mercedes Sprinter conversion.

Contributors to the conversion

The Citroen Berlingo project was fortunate to have a team of technical experts with excellent knowledge of many of the fields required for a conversion:

- Bryce Gaton (electrician and ex-head of Electrical Trade and Renewable Energy department, Swinburne TAFE, Wantirna)
- Rhys Freeman (coordinator of previous CERES conversion)
- Simon Dodd (aircraft maintenance engineer at Qantas)
- Andy McCall (electrician and qualified motor body builder/repairer).

Funding and budgets

This project was not funded by CERES, but by an external source, Grow Lightly South Gippsland. The total budget was $35,000, though in the end the cost was closer to $40,000. Most of the extra costs were due to minor component/wiring costs.

Image: Jennifer Hamilton, *Milk Magazine*, Gippsland

↑ EVs are suitable in rural areas and for delivery vans, so long as you work within their range limits.

Components and choices

The van chosen was a 2002 Citroen Berlingo. It had a damaged gearbox with significant oil leaks, and a noisy engine, also with persistent oil leaks. The vehicle had obviously been involved in an accident in the past, though the body had been adequately repaired, and it was apparent that the vehicle had been run without oil for months.

We believe that this vehicle would have been destined for the scrap heap if we had not purchased it—repairing these problems would have cost more than the vehicle was worth.

The existing engine did not matter at all and was removed. However, the gearbox was another matter. Simon pulled the gearbox apart and replaced the bearings and seals. This seemed to repair the leaks and removed the noise. He also completely removed the reverse gear, as reversing in the EV would be performed by reversing the motor direction.

The coupling, which connects the motor to the existing gearbox, was to be a clutchless design. A clutchless system enables one to shift gears without a clutch, which normally works well with a DC system. However, this has proved problematic for our vehicle as it uses regenerative braking, which makes it difficult to match speeds between the motor and gearbox, and therefore shift gears.

Fortunately this is rarely needed due to the high rotational speed available from the AC motor. It is possible to drive the majority of the time in third gear without using other gears at all.

However, this knowledge meant that we decided to install a clutch in the later Mercedes Sprinter project to enable much easier gear changes when needed.

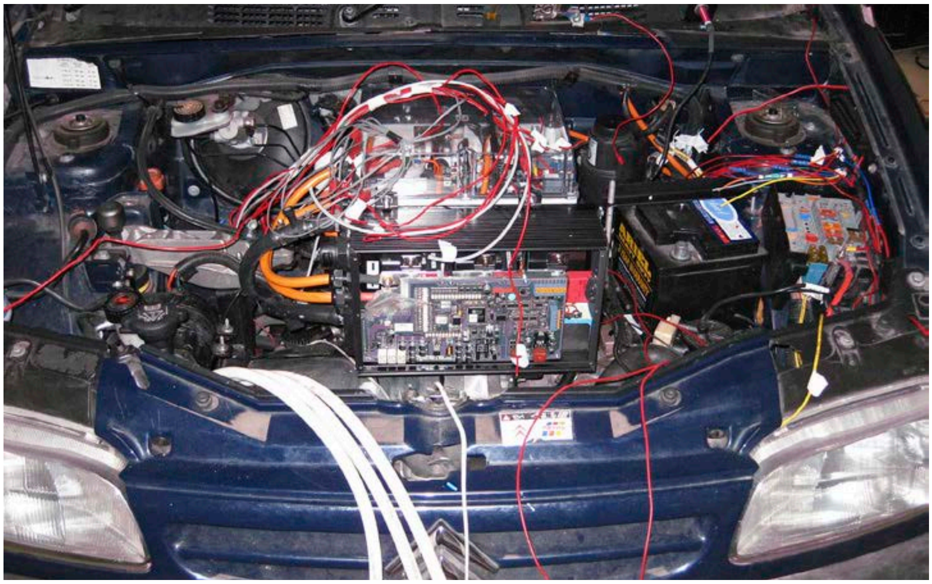
At the time of this conversion, AC motors and controllers were very expensive. We decided to go with a system from a company in Italy, Electro Vehicles Europe. The chosen system included a 30 kW Fimea AC induction motor and a Tim 600 controller (both water-cooled) from Mes-Dea. The price for this system at that time was about $7000.

The battery pack is a 25 kWh Winston Battery lithium iron phosphate pack made up of 90 amp-hour cells. These came from EV Works in Western Australia.

The structure of the rear of the Berlingo van (as found from the first CERES DC conversion) was not very conducive to an efficient arrangement of the battery pack. In consultation with the VASS (Vehicle Assessment Signatory Scheme) engineer, it was decided to rework the rear area to provide greater storage space.

The power steering uses an electro-hydraulic Citroen Saxo pump running off the existing 12 volt system. A high-voltage motor to drive the old pump was deemed to be risky and unnecessarily complex. This was borne out by later work on the Mercedes Sprinter, which used a separate electric motor to drive the power steering pump—this arrangement has been difficult and has required repeated modifications.

The VASS engineer was anxious that our pump run with the same pressure and flow rate as the original. The early Citroen Berlingo Electriques (the commercially made electric version of the Berlingo) also used this model of pump. Our first effort at using a secondhand power steering pump was a failure—the pump failed due to a manufacturing fault. However, a new version of the same pump proved to be effective, although noisy. The pump noise was later significantly improved using rubber vibration dampeners.



↑ The engine bay during the conversion—lots of new cabling required!

The choice to use this pump was also backed up by the production versions of the Citroen Berlingo in the early 2000s. These had an identical electro-hydraulic system.

Because EVs are efficient and so their motors generate little heat, they don't have lots of hot coolant for use in a heating system, so an alternative heat source must be supplied. We used a Mes-Dea Rm4 4 kW water heater. This model can be fitted to the existing water pipes that run into the heater core in the vehicle.

Activating the heater is a matter of flicking a switch—no restructuring of the dashboard or additional safety circuits are required. The alternative, a ceramic heater, would require safety mechanisms to prevent the element from turning on without the fan, a potential fire hazard.

For energy monitoring, an EVision battery monitor was sourced from Metric Mind in the USA. This monitor, although expensive, was viewed to be a good option as it provided useful automotive statistics and figures which other monitors did not, such as watt-hours used per kilometre, kilometres travelled per kilowatt-hour and instantaneous kilowatts.

A battery management system (BMS) is required to keep track of the voltage of individual cells in the battery and cut power if any cells drop below a certain cell voltage. It also prevents overcharging. Our BMS was obtained from EV Power in Western Australia.

Some EV users are of the opinion that if the charging process is managed properly, a BMS is not required. We do not subscribe to this view. The original DC CERES vehicle has this same BMS and, although simple, it has saved the battery pack many times.

A DC–DC converter is required to supply power to the vehicle's original 12 volt electric system. It converts the high voltage from the battery pack to about 14.4 volts to run the lights, windscreen wipers, radio and other equipment. The model chosen was a Meanwell power supply, a PSP600. This is not an automotive component and had a problem with in-rush currents (the high current that flows into the power supply to charge its main filter capacitors when power is first applied). The first model malfunctioned after several months; however, the replacement incorporated a soft-start process and has been fine ever since.

A vacuum brake unit is required to provide appropriate brake pressure. In a standard petrol vehicle, the vacuum is usually provided from the original internal combustion engine. In an electric vehicle, the vacuum must be derived from a pump. Our model was a Taiwanese model—effective and cheap.

The batter charger chosen was a Zivan charger, modified to charge the lithium cells we were using.

The existing throttle in the vehicle was unsuitable for use, therefore we obtained a throttle from an old Mitsubishi Lancer. Fortunately the Tim 600 controller allowed us to program the parameters for using this throttle, which has proved reliable. We are not convinced that typical non-automotive throttles used in conversions will handle the dust, grease and vibration of a vehicle without requiring regular cleaning.

The process

The conversion took two years to complete, with the elapsed time mostly due to members of the team having to fit it around their paid jobs. At times work would proceed rapidly, other times it would be a month or two between visits.

The structural preparation of the vehicle (battery box, adapter plate and coupling) took just under a year to complete and was performed by Simon Dodd.

The electric wiring of the vehicle took another year, with input from both Bryce and Andy. Andy also performed bracketing work and regular welding modifications.

Our main concern about the vehicle was the motor–controller combination. Experience from Swinburne University Engineering department (which had a very similar system for their electric racing vehicle) showed that the combination was problematic. The motor and controller were not matched, and settings were not provided by the manufacturer. Our advice for any future purchases is to obtain a guarantee that your motor–controller system is matched at the factory!

Unlike the Swinburne experience (they had a series of major hardware disasters), the most worrisome moment (firing up the motor and controller) proved to be a non-issue. The motor rotated even at low currents and without significant heat.

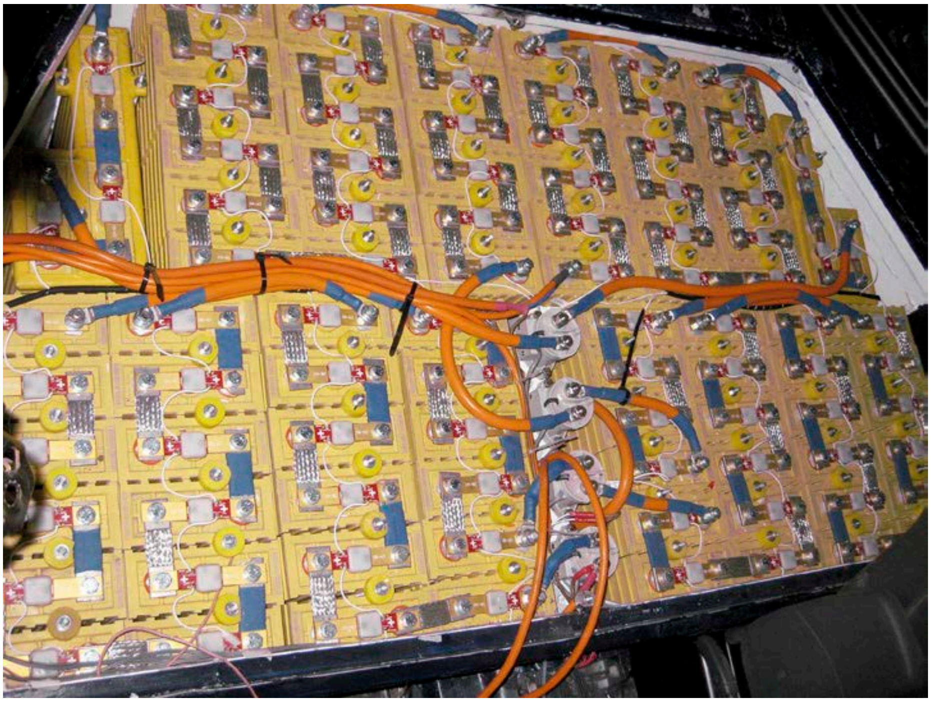
The coupling between the motor and gearbox did provide some headaches, as it was moving along the shaft. After removal and modification, it now works well.

After all this work to fix the problems that arose, we were able to take the vehicle down to the engineer and get it approved for roadworthiness with almost no alterations.

Performance

The car did not work well initially, however. Torque was very low and acceleration poor, with a stream of controller errors of various sorts. After a process spanning several months, the torque was improved and the errors were identified and eliminated.

After this, the AC motor proved to be ideal, providing continuous acceleration and sustained torque. It is now possible to accelerate from 0 to 110 km/h entirely in third gear, with very low noise and current draw maxing out at 150 amps.



↑ The lithium battery bank during conversion. Note the four contactors that break the pack into lower voltage sub-packs for safety.

Regenerative braking (both on the brake pedal and throttle) provides consistent energy to the battery pack during braking. We estimate that it adds up to 10% extra range to each journey. The regenerative braking has worked so well that the brake pads have become glazed due to light usage.

The high voltage of the vehicle compared to most EV conversions has led to lower currents, low waste heat and little maintenance of components.

The range has not been proven but we suspect that it is at least 110 kilometres. A more streamlined vehicle would have a greater range—vans are poor aerodynamically, which is not conducive to efficient energy use.

The car performs very well on hills and with the water cooling does not overheat, even in hot weather. It has travelled well over 11,000 kilometres in the past year.

The future

Going on an analysis of the current usage patterns and battery characteristics, it appears likely that this vehicle will continue to drive well for many years, probably between 8 and 10 years, without battery pack replacement.

The owners are very happy with it and the vehicle has introduced many people in the country to alternative fuel vehicles. Petrol driving has been reduced by 90%, as most of the driving has been in the 100 km range around the Grow Lightly headquarters in Korumburra.

If we were to convert another Berlingo today, we feel that we could achieve a range of between 130 and 150 kilometres due to battery improvements.

The CERES Mercedes Sprinter

The Mercedes Sprinter conversion, modelled on the Citroen Berlingo conversion, has proceeded through about 90% of the conversion process, but the same issue which caused some problems for the Berlingo has halted the Mercedes project: the motor and controller were not matched at the factory, and this time it has not been possible to get the system working. With both components and funding doubtful, it's not possible to say when this problem will be resolved, but we are still hopeful. Stay tuned! ✷

Rhys has a strong interest in sustainability, particularly in electric vehicles, having been involved in five electric vehicle conversions, all delivery vans, since 2007. He has worked in IT for most of his career and has qualifications in sustainable energy and horticulture.

Revealing heat loss and energy waste
Monitoring a rooftop solar hot water system

David Gobbett used a Netduino microcontroller to monitor the temperature fluctuations in his rooftop solar hot water system. He describes the setup and what he's learnt.

FOR decades, the first or only solar appliance installed by many Australian households was a rooftop solar hot water system. My parents installed one on our family home in Adelaide in the mid 1970s. In my current home we installed a conventional 300-litre rooftop system in 2006. Superficially at least, the design seemed to have changed little over the intervening years. In both cases an electric booster was connected to off-peak power, which is switched on automatically by the power meter from midnight to 7am each day.

To reduce our energy consumption over summer, we turn off the electric booster at the main switch during late November to late March, and we still have adequate hot water most of the time. However, occasionally we unexpectedly get caught short of hot water, and at those times it's been frustrating having no way of knowing how hot the water in the tank actually is.

Another concern with switching off the booster is that there are potential health issues when hot water system temperatures are allowed to drop below 60 °C. Lévesque et al. (2004) indicate that Legionella bacteria can grow in water temperatures up to 45 °C, but that growth stops above 55 °C, and over 60 °C the bacteria are killed. Even in hot water systems with the thermostat set to 60 °C, the lower part of the tank can remain at temperatures that are optimal for Legionella growth. It would be nice to avoid this—but that would entail having a way to sense the temperatures in the tank, which is high up on the house roof.

A project idea was sparked when a friend showed me that he was using a small microprocessor board to log solar PV power

The well-studied solar hot water system.

outputs. He had also connected a sensor on his water meter so he could log household water consumption. This inspired me to start on my own project to get a better understanding of what the temperatures in my solar hot water system were doing.

My interests in this project were to:

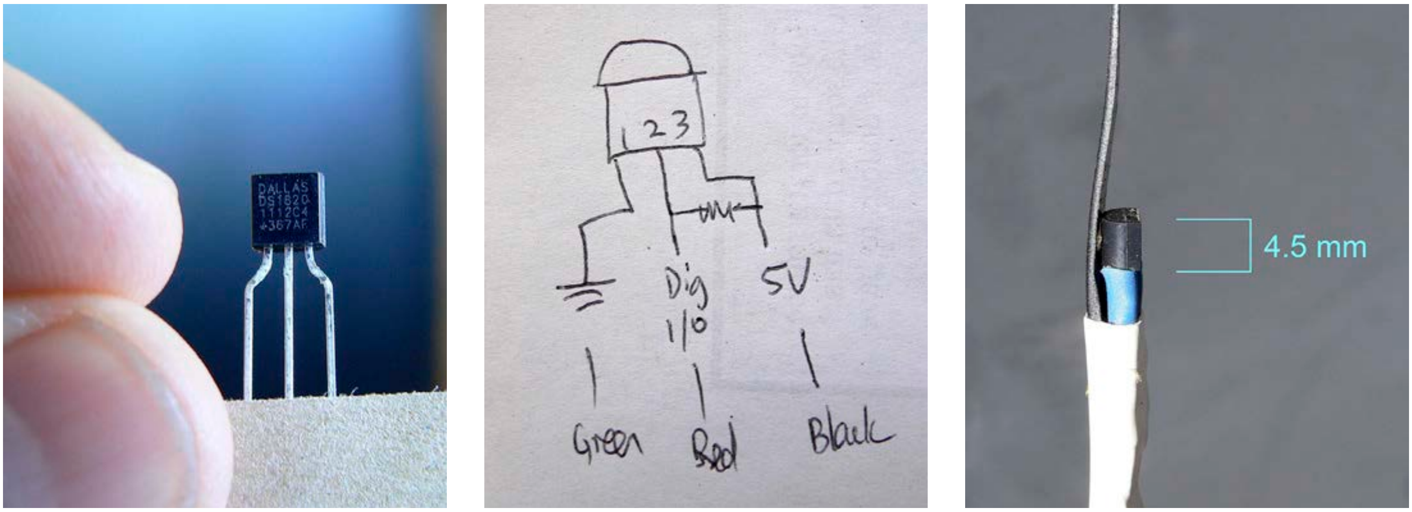
- minimise unnecessary power usage
- know when we're running low on solar hot water, so the booster can be turned on
- minimise any risk associated with Legionella.

Setting up the temperature logging

Although I have experience as a computer programmer, I had never programmed microprocessors or worked with such things as temperature sensors. After some internet research I decided to use 1-wire devices (1-wire is a technology by which sensors and other devices can communicate). I took the plunge and purchased:

- 1-wire temperature sensors (DS18S20; 10 of these cost $18). These sensors operate over a temperature range of -55 °C to +125 °C. Several of these sensors can be connected to a single cable to form a mini network where each sensor has its own unique identification.
- a USB to 1-wire adaptor, to allow me to connect the sensors to my PC for testing (DS9490R; $28)
- a Netduino Plus microcontroller (US$70) which included a network socket and micro SD memory card slot. (See side box 'Arduino style microcontroller boards').

I proceeded to build the system in small steps. First I soldered three of the 1-wire



At left is a one-wire temperature sensor. In the middle is my sketch for wiring the sensor to the telephone extension cable and at right is the finished sensor with shrink tubing covering the connectors. The pointy end of a cable tie is included to help with sliding the sensor under the hot water system insulation.

sensors to a length of old telephone extension cable and then used the 1-wire to USB adaptor to connect them to my PC. Using free software (from www.maximintegrated.com) I was reassured that I had wired them correctly (phew!). Then with some extra lengths of phone extension leads, I inserted the sensors under the insulation at one end of my hot water tank and immediately saw big differences between the top, middle and bottom of the tank, as well as temperature changes in response to hot water use in the house. This was encouraging since it showed that I could get useful temperature readings from the outside of the tank.

Next I worked out how to connect the sensor cables to the Netduino board, and created a small program that would read the sensors every minute and save the readings to a file on the SD memory card. There were some challenges in writing the code to do this, but online examples and tips on web forums meant I was not starting from scratch. When I had that working, it was relatively straightforward to start sending the data to www.xively.com (see side box 'What is Xively?') where I can now view temperatures online at www.xively.com/feeds/56826. Finally, I set up the wiring to the hot water system in a more permanent manner and connected the Netduino directly to my internet router and set it running. While wiring it all up I added an extra temperature sensor inside the roof space, and one inside the house too.

It is possible to observe the data on Xively via a web browser or an app on my phone, but the ability to compare and analyse is limited. I subsequently developed an Excel spreadsheet that would allow me to download data from Xively so I could graph and analyse in more detail.

What have I learnt?

I have been surprised by some of the things the logging has revealed. Apart from realising that my morning showers are far too long, our household of four rarely uses even half of the hot water in the system.

Heat loss

The normal rate at which the tank loses heat is much higher than I expected. Even in warmer weather, and when we're not using hot water, the temperature of the upper section of the tank drops by about 1 degree per hour (see Figure 1). That is despite having installed extra foam insulation on all the exposed external pipework. However, some shrinkage of the insulation has occurred which means it is not providing as good cover as it could. I also wonder whether some reverse circulation might be occurring and that the solar panels are accelerating the rate of cooling when the sun is not shining.

Energy waste while we sleep

I record our household electricity consumption each month (Figure 2), and have observed that in winter months the hot water system is responsible for using up to 46% of our total household electricity. In summer, when the booster is turned off, we use no electricity for hot water for three to four months.

The temperature logging reveals quite a bit of energy wastage. The off-peak power turns on at midnight and off again at 7am. If the hot water temperature is low, the heating element switches on immediately at midnight, and quickly heats the upper two thirds of the water. The rate at which the tank loses heat during the night means that before the power

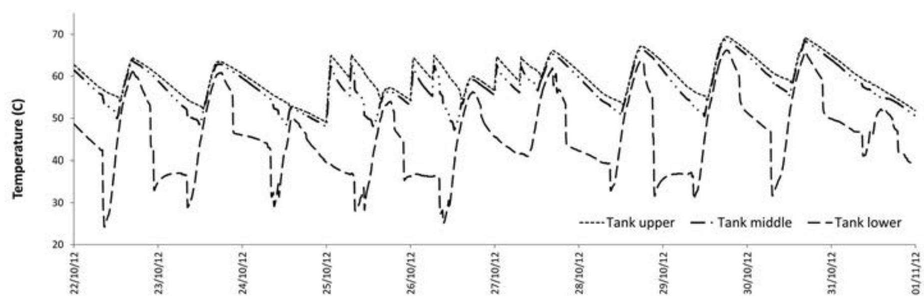
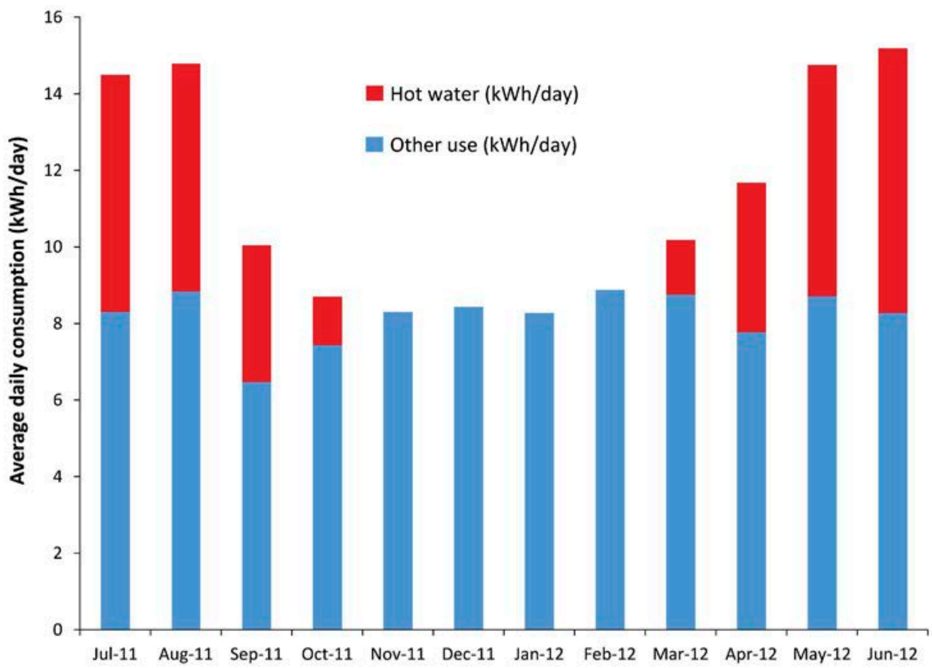


Figure 1: Ten days of temperature logging. Temperature drops due to consumption are visible in the lower part of the tank, but the middle and upper mainly show cooling due to heat loss.



↑ Figure 2: Summary of the amount of energy (kWh) used by our household and hot water system over a year.

switches off again at 7am, a large amount of that heat is lost and it is not unusual for the booster to come on again later in the morning to re-heat water that has already cooled (Figure 3). This must be leading to significant wastage. I expect this wastage is much worse during the colder winter months when the temperature differential between the air and hot water are much greater.

I am also puzzled about the claimed benefit of the off-peak power system in smoothing out grid electricity demand during the night. From my observations, if thousands of hot water systems across the grid all turn on at midnight, this might cause a huge spike in demand over a short time, quite the opposite of the smoothing of consumption that I thought the off-peak system was intended to produce.

Legionella potential

The electric booster only heats the upper section of the tank. This leaves the lower part of the tank often lower than the recommended temperature for Legionella control. However, since hot water for usage is drawn from the top of the tank, and also noticing that even the lower section of the tank gets above 60 °C every few days in mid-season October, I am not too concerned about the Legionella risk. Without the electric booster on over summer, the upper section of the tank exceeds the Legionella-killing temperature of 60 °C about half of the time.

Winter performance

The 2013 winter is the first chance I have had to look at performance when insolation is at its lowest. The key thing I have realised over the recent months is that solar heating during winter is minimal. In my case there are two exacerbating factors which are the western orientation of the hot water panels and the presence of tall gum trees growing to the north-west of our house. It takes a really sunny winter's day to show much heating of water during the day. Neither the trees nor the orientation of the system are factors that can readily be changed.

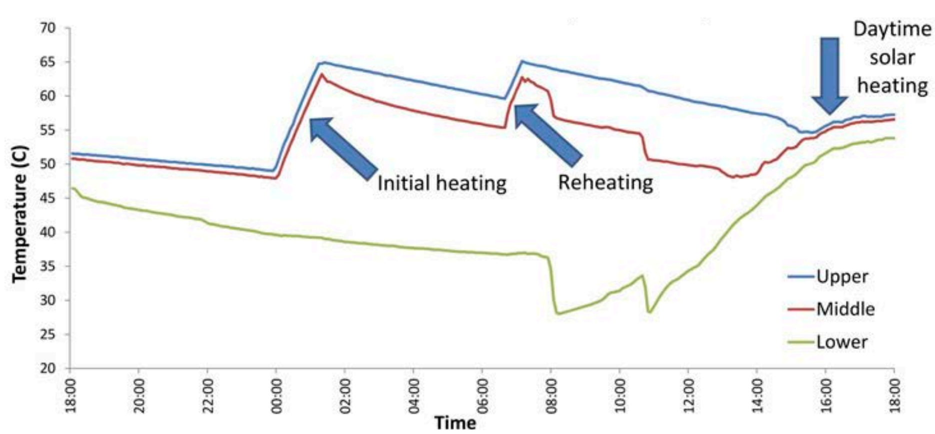
What could be improved?

Two interconnected problems my monitoring has revealed are the high rate of heat loss and the energy wasted by the electric booster. If it was possible to reduce the rate of heat loss, then the electric booster would be less likely to re-heat the water twice within a few hours. However, apart from improving the insulation on exposed plumbing, there is no obvious way to improve the situation. I plan to use an infrared thermometer to scan the exterior of the hot water system to try and identify places where the heat loss is worst.

I also plan to look into whether it is possible to restrict the time at which the heating occurs, so as to reduce total energy consumption.

What is Xively ?

Xively (www.xively.com; known as Cosm until recently) is a web platform which provide simple APIs (programming interfaces) that allows the public to securely upload and use real-time data. The data can be graphed on the Xively website or accessed via other services. For example I use the Xively viewer app on my Android phone that allows me to monitor my hot water system temperature data from anywhere with an internet connection.



↑ Figure 3: One day of temperatures with the electric booster turned on. A second period of electric heating occurs before the booster switches off at 7am. A drop in the lower tank temperature around 8am and 10.30am are from morning usage. Heating water at midnight for daytime usage seems a bit like putting on the kettle before going to bed at night to have hot water for a breakfast cuppa.

Optimally the water should be heated:

- closest to the time it is used, so heat loss is minimised prior to use
- at the end of the day when the opportunity for solar heating has been maximised, and therefore the amount of electrical energy required to heat to 60 °C (for Legionella safety) is minimised. However, since this is in the late afternoon/early evening when other power demands are high, this might not be such a good thing if we're considering impact on grid power demands.

If using off-peak power, a timer might enable some improvement. It takes about 1.5 hours to raise the tank temperature by 15 °C. If a timer were added to turn on the hot water system a couple of hours before the end of the off-peak cycle, the double heating of water would be prevented.

Over the past few months my temperature logging setup has revealed quite a bit about how my hot water system works. The challenge now is to find cost-effective ways to improve on the energy wastage. ✱

David Gobbett is an Adelaide home-owner who enjoys tinkering, learning and exploring practical ways to analyse and reduce his household's energy use.

References:

Lévesque, B, Lavoie, M and Joly, J (2004) Residential water heater temperature: 49 or 60 degrees Celsius? *Canadian Journal of Infectious Diseases*. 15(1): 11-12.

Also see www.bit.ly/Lh5GAz

A note on safety

If your solar hot water system has the tank on the roof then you will need to climb onto the roof to install the sensors. Take all necessary precautions to prevent a fall, we want our readers to stay safe!

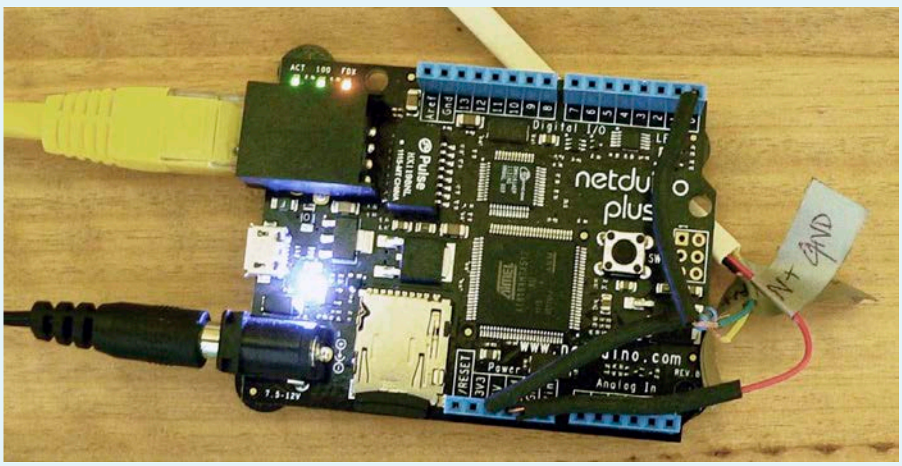
Arduino style microcontrollers

Arduinos are small microcontroller boards suitable for hobbyists, designers, artists and researchers. A wide variety of hardware can be connected as add-on modules known as 'shields'. There are shields for many more functions than can be listed here, but they include ethernet, wi-fi and GSM networking, LCDs, GPS, SD cards, MP3 players and even voice boxes (for producing robotic-sounding speech). Free software enables programs to be coded and run on the microcontroller to log data and control hardware and displays.

There are boundless ways in which Arduinos can be used. Examples include controlling motors, robots and lights; sensing, logging and displaying temperature, light and humidity; and monitoring and controlling irrigation. With a network connection, the boards can also act as a mini web server and send SMS messages or tweets. As an example, Air Quality Egg (airqualityegg.com) is a community-funded project that has developed an Arduino-compatible shield with air quality sensors on board.

There are many variants of Arduino and compatible boards, with different levels of compatibility with the shields and programming software. Wikipedia is a good place to start to get a sense of the range of options available. One important consideration is your programming skills, since it should be quicker and easier programming in a language you're already familiar with. Access to advice and code examples will also be an advantage when it comes to solving technical problems, so I'd recommend choosing a product with an active on-line community.

Netduino microcontrollers (such as used in my temperature logging project) have the Microsoft .NET Micro Framework installed. This means they can be programmed with .Net languages that many programmers are familiar with. There are also reasonably active Netduino forums (forums.netduino.com). In addition, a Netduino Plus was available for under US $70, and came with a network connector and a micro SD card socket on the main board, so I didn't need to purchase additional shields.



↑ The Netduino Plus connected to the sensors and my ADSL router.

Food production in a drying city
A bumper greywater harvest

Tim Frodsham explains how his household uses greywater and rainwater to offset mains water use for food production.

CLIMATE change modelling carried out over the last 30 years has indicated a distinct drying and warming trend for southwestern Australia. At the same time, the gutless sandy soils of Perth, Western Australia, make gardeners work hard to build up soil fertility for non-native food plants, with copious amounts of water required. As a result, we've become increasingly dependent on imported produce with its embodied energy of many food 'miles', as well as adding strain on surface and groundwater resources for what is grown locally for a rapidly expanding urban population.

I sought to develop a project to address these issues. My project brief was to cultivate a domestic garden of 12 m² that could yield up to 3 kg of food per square metre at peak summer production and source no more than 20% of its water from mains water sources, with the bulk of the water coming from rainwater and greywater.

I also wanted to look at ways to make the watering system itself more efficient. One water utility study found that no strong relationship exists between irrigable area (lawn, garden and verge) and total ex-house water usage, suggesting it is likely that many householders are watering inefficiently.

I opted for a carefully designed watering plan, using sub-surface dripline reticulation, mulch and a 'troika' of three different water sources to offset conventional mains water:

- greywater from bathroom and laundry sources to sub-surface slotted pipe
- rainwater from tank storage to sub-surface driplines
- opportunistic diversion of stormwater from the roof into the sub-surface slotted pipe.

↑ After about two months, the plot was at peak growth. Pomegranate and lemon trees in each corner are also on the way to producing. The larger plants also served to keep the soil cool.

I also installed mains water reticulation in parallel sub-surface driplines.

To enhance water retention, all reticulation lines would be covered by a mulch layer consisting of shredded sugar cane waste and pea straw, between 100 mm and 250 mm thick.

How much water?

An audit estimated that my household's greywater output (from shower and laundry) was around 280 L/day. We would supplement the greywater with rainwater and mains water, to reduce the impact of salts in the greywater and to cover periods of low greywater production, such as when we were away from the house. With a 3000 litre rainwater tank, we decided to budget for 36 litres of rainwater per day, and 24 litres of mains water.

Preparing the plot

I needed to drop the level of the ground to enable a gravity-feed greywater system to be installed, so a friend and I excavated the plot by hand to a depth of 0.3 m, removing about 4 m³ of dirt. We then spread about 1 m³ of 'veggie mix' soil, supplemented with bentonite clay to improve water retention on the hydrophobic Perth sands, and pelletised fertiliser to boost nutrients. I also added lime to the soil to buffer against any drop in pH from the slow-release fertilisers and reduce their impact on young plant roots.

↑ The pre-project area.

↑ Addition of topsoil and bentonite clay soil amendment to the excavated plot.

↑ The reticulation grid is installed. The lilac lines are for rainwater, the larger 'ag-pipes' for greywater and the smaller brown lines are for mains water.

↑ The initial planting was mulched with a mix of pea straw and sugar cane mulch.

Plumbing details

I followed the greywater guidelines from the WA Department of Health to build a system that was gravity fed and designed for sub-surface reticulation to the garden plot. The key compliance criteria were:

- adequate setbacks from the fences, paths and house wall
- adequate drainage line length to avoid pooling
- adequate sub-surface drainage by mulching over the top of the greywater dispersal lines.
- use of a valve to send greywater back to the mains sewer when not required
- use of low phosphorous and zero boron detergents in water released as greywater.

I used 100 mm slotted 'ag-pipe' for greywater dispersal, 13 mm lilac-coloured driplines to distribute rainwater and 8 mm in-line driplines (Netafim 'landline') for mains water. The greywater ag-pipes had a geo-textile cloth fitted to reduce the risk of blockage by plant roots and soil.

A slight downward slope of 1:50 (2% gradient) along the greywater dispersal pipe was required to encourage drainage and prevent any blockages in the system.

As an additional source of water, the excess water overflow from the solar hot water system was plumbed into the reticulation grid.

Plant selection and watering arrangements

Once the reticulation system had been laid out, tested and programmed, the most water-dependent plants (e.g. corn, pumpkin and squash) were planted closest to the greywater dispersal lines, with other less water-dependent plants (e.g. beans, eggplant and garlic) planted further away.

I used two off-the-shelf timers, one for the mains water and one for the rainwater. The latter was selected for its solenoid valve to handle lower-than-mains water pressures from the rainwater tank.

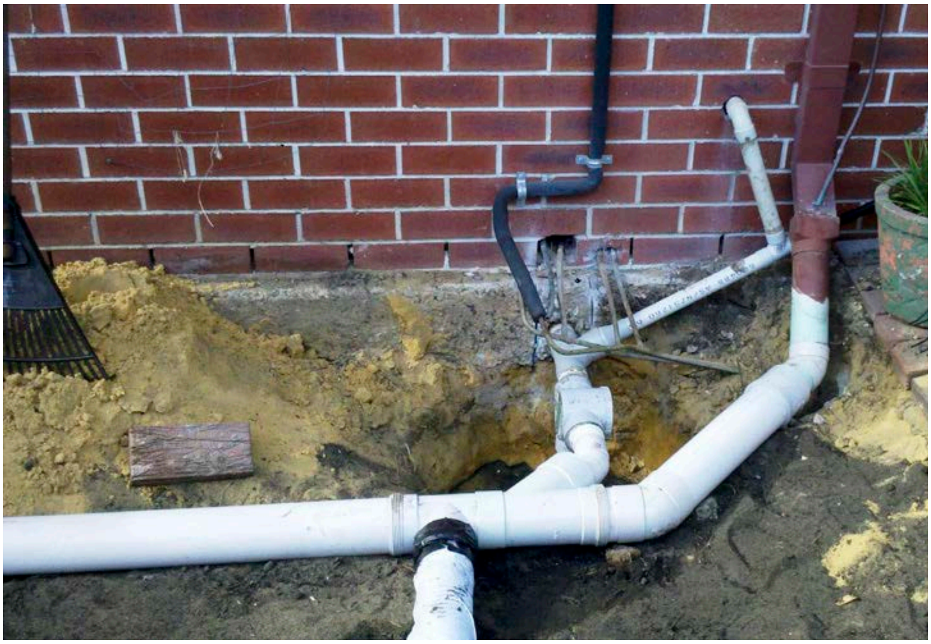
I programmed the timers to schedule use of mains water at sunrise (3 to 4 minutes) and rainwater at midday (5 minutes). The timing of greywater production and use was dependent, of course, on user behaviour. We aimed to do showering and clothes washing at night (sundown to 11 pm), providing maximum watering when it was cooler and the water would therefore be optimally used by the garden. Small volumes of greywater were also produced/used at various times due to handwashing.

It should be mentioned that, as with any greywater system used to water a garden, low sodium detergents and shower/hand washing agents should be used. More information on suitable detergents can be found at www.lanfaxlabs.com.au/laundry.htm.

Technical challenges

There were a range of issues requiring adjustments throughout the project. The 90 mm three-way 'swing' valve greywater diverter proved too leaky during initial tests. Adding a one-way ball valve on either side of the T-piece fitted at the greywater outfall proved more reliable, with manual switching of the valve in autumn.

I found that the 'ag-pipe' was only able to distribute water evenly at a range of 300 mm either side. However, this limitation was offset to some extent by the use of the mains



→ Profile of the gravity-fed greywater outfall. On the right is the brown downpipe carrying stormwater. To the immediate left, the smaller white pipe carries flows from the bathroom handbasin and the washing machine. In the foreground is the first of the three slotted ag-pipes, part of the reticulation grid. Outfall access was cluttered by 12mm mains water copper piping close by. The black lagged pipe is from an instantaneous gas hot water system (not plumbed into the greywater system).

and rainwater reticulation lines.

There were small amounts of leakage in connection fittings of the lines carrying mains water until these were sealed with silicone glue, as well as steel hose clips, rather than plastic ones.

I found it difficult to get accurate measurements of stormwater and greywater flows. Using expensive digital flow meters was outside my budget, but would have made that part of the project easier.

The yields would have been higher, perhaps greater than 5kg/m², if the loss of crops to rodents could have been reduced.

A larger rainwater tank would have boosted reserves, as at the end of this project, no reserve capacity was left in the rainwater tank.

Results

Table 1 shows the actual results for all types of water use. The table shows that greywater production/use was underestimated, as actual greywater production was around 490L/day. This was partly because of an increase in occupancy of the house.

Table 2 shows the food yields from the plot and the calculated supermarket value. On a water recycling and food production level, this project was a resounding success. It used around 41kL of water that would have otherwise gone down the drain, obtaining 95.5% of its water requirements from greywater and rainwater, while producing some 52kg of food. This was produced from a mere 12m² plot, at an excellent yield of 4.3kg/m².

The plot used around 896L of water to produce each kilogram of food. Many factors can influence this litre/kg figure, and obviously in this system all greywater was used whether it was required or not. The key advantage was that the water was used, rather than being released into the sewers, and that zero transport energy was required.

It would be interesting to determine how large a plot could be cultivated with this volume of water. Based on previous experience (mine and others) growing vegies during Perth's hot summers, I would have estimated that at peak growth periods the summer garden would need around 20L/m²/day, a total of around 240 L/day for my plot of 12m², This would suggest that a plot of at least double the size could have been supported, given the average of 556L/day that was available in this project.

I estimated that the value of the food grown was $154 (see Table 2). The cost of this project, including plumbing fixtures, plants, gardening products and consumables, but excluding labour, was $1100. Thus the value of the food produced was around 15% of the cost. As the system is still producing food, this is a reasonable return from one summer!

Total labour time was around 45 combined person hours—having someone else install the system would have added to the cost of the system.

Table 1. Actual volumes and ratios of reticulation water sources in project area—three month trial.

	L/day	L/week	L/month	Total (L)	%	Comments
Greywater	490	3430	13720	41160	88	Flow estimated using the method described in the WA Code of Practice for Greywater Reuse
Stored rainwater	36	252	1008	3024	6.5	Each 100m of low-flow 13mm dripline use is reported to allow 40 litres of flow per minute at a peak head pressure of around 25kPa. I used about 40m, which approximates to around 16L/min, or 960L/hr. The dripper flow rate was rated at 8.0 L/hr per dripper.
Mains water	24	168	672	2016	4.5	5L/hr per dripper. 25m of line equated to 480L/hr.
Stormwater				500	1	One summer rainfall event only
Total				46700		An average of 556L/day

Table 2. Food yields from the 12 m² plot over a three-month summer period.

Food type	Weight (kg)	Date	Comments	Supermarket value of food—Sydney prices, March 2013 ($)
Pumpkin	8.17	30/2	More on vine, but late ripening.	24.43
Corn	11.25	20/2	Some 20% of crop eaten by rodents. All harvested and consumed before this date.	45
Aubergine	2.99	3/3	Smaller 'finger' style variety as well as the round variety.	14.90
Tomatoes	8.37	1/3	Some lost to desiccation, and rodents.	25.05
Squash	2.22	5/3	Also some lost to desiccation and rodents.	8.9
Sunflowers	0.99	28/2	Giant Russian variety - seed head dry weight.	17.10
Cucumber	2.01	27/2	Lebanese variety.	12.05
Zucchini	9.49	28/2	Large dark green variety.	47.35
Rockmelon	5.41	29/2	Dark orange variety.	21.55
Chili	0.31	3/3		2.80
Lemon	0.65	5/3		2.60
Pomegranate	0.25	6/3		1.75
Total (kg)	52.12			
Food Yield (kg/m²)	4.3		Value of food produced	$154

Postscript—vision

In climate-challenged future cities, perhaps higher density housing blocks could act as 'vertical dams', irrigating biodiverse food gardens with stormwater and greywater, thus reducing the prevalence of grass monocultures and barren bitumen and solving the problems of urban heat islands and rising food prices. ✱

Acknowledgements

A big thank you to Sam Wells for his assistance with groundworks, vehicle and trailer, editing and irrigation plot drawing.

References:

Domestic Water Use Study in Perth, Western Australia 1998-2001 (2003), Michael Loh and Peter Coghlan for Water Corporation.

Code of Practice for Greywater Reuse in WA (2010), WA Health Department.

Is a plumber required?

Sub-surface systems such as this one connected to the greywater diverter device (in this case the installed diverter valve) do not necessarily require a licensed plumber, although you should check with your local EPA and council to confirm the regulations in your area. More sophisticated above-ground units that require pumps, retention tanks etc, require a licensed plumber to install them.

Light up Atauro
Or at least a glow in the village of Atecru

Peter and Lyndall Hulme travelled to Timor Leste as part of the ATA's Light Up Atauro project. The expedition was hosted by Timor Adventures and was a real adventure.

↑ Installing the panels on the school roof.

AFTER travelling in 4WD vehicles westwards through Liquaca, Balibao, we had overnight stays in Maliana, Atsabe and Gleno. As an example of how degraded the infrastructure is, the roads were horrendous and we averaged about 35 km/h, constantly in 4WD.

It was interesting to see that solar panels were a common sight as we travelled through the country. What was even more surprising was that we saw solar panels and inverters for sale in the market at Atsabe, suggesting that sustainable electricity generation is valued by the population. It will be interesting to see whether this continues, as a high-voltage network is starting to be rolled out across the country.

The main reason for our trip was to install a PV system at the primary school in Atecru, a small village on the island of Atauro, about 25 km off the coast from Dili. Led by Michael O'Connell from the Alternative Technology Association (ATA), we travelled by boat across the Wetar Strait and stayed at Barry's Eco Lodge near Vila, an example of sustainable tourism in Timor Leste. The rooms were thatched bamboo huts, each with its own 12 volt lighting and cooling system powered by PV panels. There were composting toilets and ablutions were via a large tub of spring water! Refreshing indeed.

The school already had a 12 volt lighting system powered by solar PV/battery which had been installed by the Indonesian government some years ago. However, it was not functioning as the batteries had failed, as had the controller.

We began by discussing with the school's principal what was required. It was decided to reuse some of the existing wiring and to install two 3 W, 12 V LED bulbs in each of the school's three classrooms, and a single 5 W, 12 V LED bulb in the staff room. There would be a 240 V outlet powered by a 300 W inverter which would be enough to power a TV or charge mobile telephones. The system would be powered by two 85 W panels.

We got to work with numerous willing helpers. We also had assistance from Filomeno, a young Timorese man who has finished the technical training developed by the ATA and is now an accredited solar installer, and is also bilingual (Tetun/English).

The actual installation did not take very long as we pre-wired the switchboard at Barry's Eco Lodge prior to our boat trip to Atecru, and we had a host of willing helpers to lift the panels onto the roof and run the wires and conduits. After the installation was completed Michael gave a group of villagers a briefing on maintaining and caring for the system, as well as its limitations.

That evening it was a joy to see the school lit up and the villagers using the building and surrounds as a venue to discuss the day's

↑ The switchboard for the new system (left) sitting next to the old switchboard.

↑ Helpers running cables from the classrooms to the staff room where the switchboard was being installed.

activity. This activity certainly opened our eyes to the situation in Timor Leste, one of the poorest countries in southeast Asia. We saw in graphic detail the damage done during the repercussions of the referendum for independence. It made us realise how much we take for granted our version of democracy.

The challenge ahead for the people of Atecru is to ensure the system is monitored and maintained. NGO Roman Luan, a community development organisation for the whole of the island, has been involved in this project so thought could be given to engaging them in sustainable development for the island.

What made this trip truly worthwhile was the warm welcome and acceptance we received from the villagers as we went about trying to make a difference to their lives. We thank them sincerely for letting us into their lives, albeit for a short time. ✱

↑ The panels at the Atecru school before installation.

A brief note on the Atauro solar system

The system in Atauro is typical of the larger systems that the ATA's International Projects Group installs in East Timor. As in all installations, proper system performance depends on having the right balance of equipment to meet the needs of the customer. It must be installed to a high standard and, just as importantly, maintained to an appropriate standard.

In recent times the ATA has changed its approach to the design of these stand-alone systems. This is mainly due to the rapidly falling prices of PV panels. Newer systems often have larger PV arrays, compared to a few years ago, together with slightly smaller battery banks. This means that the PV array is capable of recharging the batteries successfully even in poor weather conditions and so the requirement for the batteries to hold several days energy is reduced. The result is a system that provides similar performance to those previously installed but for a lower cost. The system in Atauro is a good example of these new design rules, having higher PV wattage relative to the battery size.

To size the system, we determined the total energy and power requirements from the load requirements provided by the local community. The requirements included the provision of lighting in three classrooms and the staff room, together with the provision of AC power in the staff room for a laptop, printer and phone chargers. The final system design incorporated two 12 VDC, 3 W LED lamps in each classroom and a single 12 VDC, 5 W LED lamp in the staff room. The staff room also housed a 300 W inverter to provide AC power. No mains wiring was required and this simplified the installation considerably. The other core components of the system were 170 W (2 x 85 W) of PV panels, 200 Ah of 12 V batteries and a PL-20 20 A regulator. For more info on the ATA's work in East Timor, see www.ata.org.au/ipg.

Shop with the ATA

Books, kits and energy-efficient devices

These are just some of the products available in the ATA Shop. To browse the full range and place an order go to shop.ata.org.au, or fill out and return the form at the bottom of the page.

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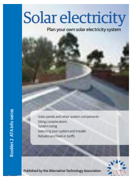
The ATA has a new webshop that makes it easier for you to subscribe, renew and make the most of the great products available. Take a look, log in as a guest or create a user profile. Remember, if you're a member you can download all the back issues of *ReNew* for free.

eKo smart meter display

Price: $149.50

The eKo in-home display allows you to view your home's energy usage and costs when paired with an enabled smart meter. Note: this version can only be used in Victoria.



Solar electricity Booklet

Price: $5

The ATA has recently updated its *Solar Electricity Booklet*. It's now available on our webshop as an eBooklet. Includes info on solar panels and other system components, siting considerations, system sizing and feed-in tariffs.

Water cube starter pack

Price: $645

Invented in Melbourne, this DIY-installable 800-litre water tank adds capacity where and when you want it. Harvest and store rainwater for your garden, toilets, laundry and car washing (i.e. non-drinking water).

Home energy meter

Price: $95

This wireless meter helps you conserve electricity by showing your usage and costs in real-time. Installation doesn't require an electrician: simply attach the LED optical sensor to your smart or other electronic meter and program in the number of pulses per kWh for your meter.

Sunrocket portable kettle

Price: $70

This kettle will heat and boil water using the sun's heat captured by an evacuated tube and reflective panels. This can take as little as 30 minutes (weather dependent). It then closes to act like a thermos, keeping water hot for hours.

Sanctuary: modern green homes issue 24

Price: $11.95

A 10 star home and Sustainable House Day special. *Sanctuary 24* also includes a South Australian sustainable designer directory. *Sanctuary 24* is full of fabulous homes, ideas and inspiration.

18 W LED outdoor bulb

Price: $49.50

At over 80 lumens per watt, this Par38 bulb is an energy efficient replacement for 150 W bulbs commonly used in driveways and outdoor entertaining areas.

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ATA members receive a 15% discount on ATA products, except where noted. Ask for your discount when you order!

Join the ATA's PVOutput team!

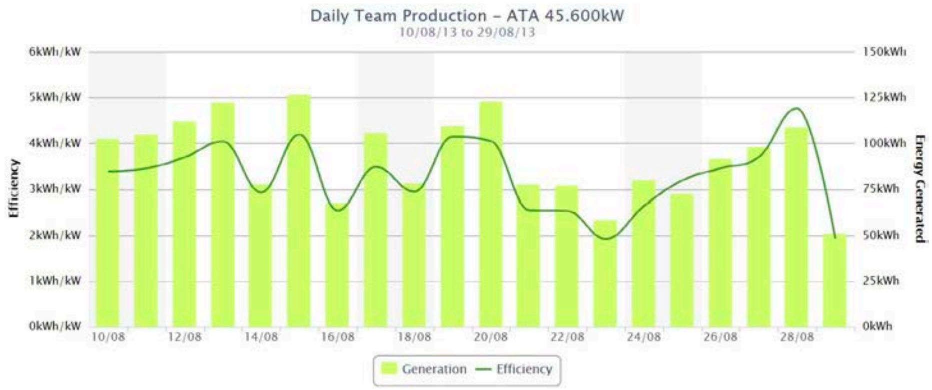
We take a quick look at how ATA members are becoming part of ATA's PVOutput team.

IN THE last issue of *ReNew* we took a look at the datalogging service for solar energy systems, PVOutput, and one ATA member's system data.

To recap, PVOutput allows you to manually or automatically upload data from your grid-interactive power system and store, display and share that data with other PVOutput users. Users have their own 'outputs' (their own individual system data) but they can also join a team, where the team's data is accumulated and displayed as a whole, with each team member's summary totals available in a separate list.

Since the last article, the ATA's PVOutput team has grown from just a few members to around a dozen, although some of those members are only actively uploading data on an intermittent basis.

Regardless, for the year-to-date so far, the team, with an average system size of 3.8 kW, has generated around 6 MWh (6000 kWh) of electricity, with an average efficiency of 2.741 kWh/kW and the highest single day output from any member being almost 40 kWh!



PVOutput

Welcome, PVOutput is a free service for sharing and comparing PV output data.
If you own a solar system please contribute your power output readings.
Home | Latest Outputs | PV Ladder | PV Donut | Daily Outputs | Live Outputs | Teams | About | Register

ATA 45.600kW

Find: Tips

Rank	Name	Location	Size ▼	Generation	Efficiency	Average	Outputs	Seen	Health
1	design ecology - Eco Green	5061	7.410kW	25.946MWh	4.139kWh/kW	30.670kWh	846 days	Today	100% x3
2	Case Study 5.13kW	6556	5.130kW	14.885MWh	4.318kWh/kW	22.150kWh	672 days	4 weeks	85%
3	Backkootywatts	2340	5.040kW	21.481MWh	4.310kWh/kW	21.720kWh	989 days	5 weeks	96%
4	Damo&Louise	2777	5.000kW	1.088MWh	2.154kWh/kW	10.772kWh	101 days	Today	82% x2
5	TheGreatGazolio	5125	4.650kW	19.352MWh	3.960kWh/kW	18.413kWh	1051 days	Today	100% x7
6	Fleurieu Gyroplanes	5255	3.300kW	450.847kWh	2.009kWh/kW	6.630kWh	68 days	Today	N/A x1
7	EtherTech Computer Services	3175	3.060kW	281.488kWh	2.421kWh/kW	7.408kWh	38 days	Today	15%
8	Boondaburra	2153	3.000kW	594.770kWh	2.679kWh/kW	8.037kWh	74 days	6 days	95% x1
9	The Love Inn - Woolloongabba	4102	2.960kW	9.588MWh	3.965kWh/kW	11.736kWh	817 days	Today	99% x3
10	Straw-Berry Fields	2571	2.960kW	8.699MWh	3.929kWh/kW	11.629kWh	748 days	Today	94%
11	Bright in the Heights	3081	2.040kW	10.511MWh	3.153kWh/kW	6.433kWh	1634 days	5 days	100%
12	ridethetalk	3042	1.050kW	49.998kWh	7.936kWh/kW	8.333kWh	6 days	13 weeks	0%

↑ The ATA team has around a dozen members now, although not all are currently active. Here they are sorted according to system size.

↑ PVOutput also lets you upload photos of your system. This is the split PV array of team member TheGreatGazolio.

But we can make those figures better by having more ATA members add their systems to the team, so if you have a solar energy system and a little bit of time to spare, go to pvoutput.org and sign up to the ATA's team! ✱

Find the ATA's team at www.bit.ly/ata-pvout or by searching 'ATA team' on www.pvoutput.org.

Register your system on www.pvoutput.org, enter some data and then you can join the team (you'll need at least five outputs).

The Pears Report
Poles and wires welfare

The Productivity Commission fights against protection in all other industries—why not in electricity? asks Alan Pears.

THE 2012 Senate inquiry into electricity costs delivered a damning report on the performance of energy policy makers and regulators (see my column in *ReNew 123*).

Now the Productivity Commission has issued its own 820-page report. It is even more scathing.

Just about every criticism made in submissions to the Senate inquiry has been supported.

Statements include:

"These flaws require a fundamental nationally and consumer-focused package of reforms that removes the interlinked regulatory barriers to the efficiency of electricity networks. Reforms made in late 2012, including improvements to the regulatory rules, better resourcing of the regulator and greater representation of consumers, have only partly addressed these flaws."

"Delays to reform cost consumers across the National Electricity Market (NEM) hundreds of millions of dollars."

"There is, in effect, no point in simply fixing a punctured tyre if the car has no engine."

I couldn't have said it better myself...

It seems to me that the commission had to take a strong stand.

There is such widespread agreement that the energy market is a mess that to make apologies would be to undermine the future of the Productivity Commission's broader agenda of competition and privatisation. To their credit, they have made strong recommendations with delivery dates.

Yet electricity industry welfare remains

Underlying the commission's thinking, there is still a deep tension between open and fair markets and an assumption that the incumbent industry must be protected so it can recover its costs. So new market entrants such as solar electricity must receive only the value the incumbent industry places on their input, and pricing structures must allow incumbents to maintain their viability. This is simply a welfare scheme of a type that the commission fights against in all other industries.

The gas industry is not paid according to what it saves the existing electricity industry when someone switches to or from gas cooking. Online media are not paid what they save the hard copy media. And so on.

A classic example of the 'welfare' approach is the commission's conclusion that rooftop solar should, in the short term, be paid only what it saves on generation and, in the longer term, what it saves the networks. In the meantime, it proposes that retail electricity prices should be deregulated: a licence for the incumbent industry to use its market power to block emerging competitors.

The value of rooftop solar

Rooftop solar should be allowed to sell power to neighbours independent of the grid, or be paid the retail price at the time it exports, in the same way that consumers benefit at the full retail electricity price if they save electricity or switch to gas.

On the one hand, the rate paid to PV owners should be higher than the retail price, because this is 'green electricity' being fed into the grid, which is worth more. On the other hand, it is fair that the PV owner pays for use of the part of the network they actually use: that is, the very small part of the network used to deliver the PV-generated power to whoever uses it. However, this latter is very different from saying that they should be paid only the wholesale electricity price, or close to it, which assumes they use the whole network and transmission system and deserve no credit for reduced power-line losses.

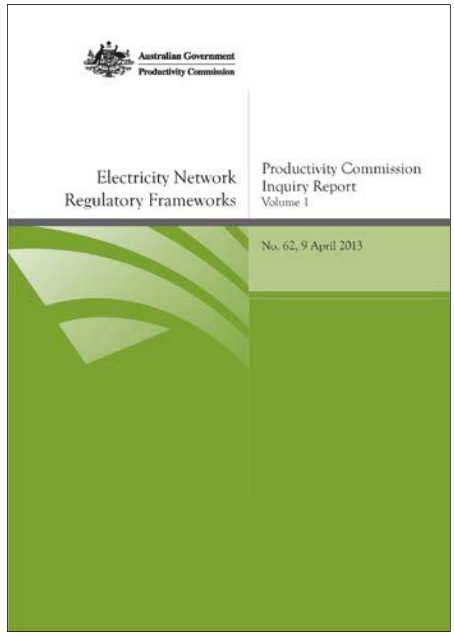
In theory, such an arrangement should force networks and retailers to introduce cost-reflective tariffs. But they have enormous market power and will not do this unless they are very carefully supervised, and independent analysis is done to cross-check their pricing approaches.

To avoid cost impacts on the grid beyond the neighbourhood level, a network could choose to install local energy storage to absorb the excess PV output at appropriate times. This storage could also enhance network profits if used to store cheap electricity for sale into the grid at times of high prices. So the cost of storage to solve the PV problem could be offset by the potential for greater profits.

Who pays to cover fixed costs?

The argument for higher fixed charges to cover network capital costs is also flawed. As the industry itself tells us, much of the network infrastructure is old. Logically, this should mean its capital value is heavily depreciated, so fixed costs are low for much of the grid. But the buyers of networks paid inflated prices, so their fixed costs are high. Why should consumers pay this cost?

> "New market entrants such as solar electricity must receive only the value the incumbent industry places on their input, and pricing structures must allow incumbents to maintain their viability. This is simply a welfare scheme..."



→ The Productivity Commission 820-page report makes strong recommendations for change but maintains its support for protection of the incumbent industry. Find the report at www.pc.gov.au/projects/inquiry/electricity/report

These were business decisions: shareholders, not consumers, should pay the price of poor decisions. And governments that have chosen to inflate the value of their network assets need to take responsibility for their decisions, not solve their problem by killing energy innovation and cost reduction.

The commission needs to step back and imagine what a truly competitive energy services sector might look like, and frame its policy recommendations accordingly.

Debating (again) a national scheme for energy savings

In recent years, several state-based schemes that create energy retailer obligations to deliver greenhouse gas abatement via end-use consumers have appeared. These include the NSW Energy Savings Incentive (based on the previous Greenhouse Gas Abatement Scheme), the Victorian Energy Efficiency Target (promoted as the Energy Saving Incentive) and South Australia's REES. The Victorian and NSW schemes use trading mechanisms.

Debate about such schemes has a long history, which is worth considering as we debate the federal government's recent report on the costs and benefits of a National Energy Savings Initiative (NESI).

In 2003, the NSW government introduced its Greenhouse Gas Abatement Scheme—the world's first emission trading scheme. Abatement certificates could be created through a variety of actions, including energy efficiency.

In 2007, Democrat Senator Lyn Allison (a long-term advocate for energy efficiency) proposed a similar national scheme. This was considered by a Senate Inquiry. I made one of 17 submissions, and also presented evidence. It was very clear that many influential people in the Canberra bureaucracy and politics were strongly opposed to such an approach. In my evidence, I warned that if the federal government didn't act, individual states would, and we would have to clean up the mess in the future.

The inquiry concluded that the (then) proposed Carbon Pollution Reduction Scheme would deal with this issue within a broader framework. It didn't. So the Victorian and South Australian governments introduced schemes in 2009.

In its conclusion, the inquiry commented that "An energy efficiency scheme set up in isolation from other climate change strategies may increase the cost of securing emission reductions..." It's strange how energy efficiency has to 'fit in' while energy market policy is allowed to conflict with policy on climate change. In practice, the present carbon trading scheme doesn't effectively address energy efficiency either.

The 2010 Prime Minister's Energy Efficiency Task Group proposed a national scheme. But powerful econocrats argued that carbon pricing would make such a scheme unnecessary, while energy retailers, who would carry the obligation, were not excited by the idea of paying to undermine their profits from energy sales. So it was to be "investigated", not implemented.

Three years later, we have a paper reporting on (very conservative) economic analysis that shows substantial net economic benefit from a national scheme based on the NSW and Victorian models. I wish I could get excited about this, but the reality is that this was obvious a decade (indeed, several decades) ago.

The questions remain. Will a national scheme actually be introduced against the opposition of vested interests whose business models are falling apart along with purist economic policy designers? Will a weak target be set, creating yet another 'boom and bust' sustainable energy market? Will the scheme be designed to deliver real savings? Will it integrate incentives for avoiding peak demand and storing energy?

Don't hold your breath. ✱

Alan Pears has worked on sustainable energy issues since the late 1970s. He is one of Australia's best recognised and most highly awarded commentators on sustainable energy and climate issues. He teaches part time at RMIT University and is co-director of Sustainable Solutions, a small consultancy.

Q&A

Do you need to know how to stop your new LED bulbs from making your radio buzz, or find out if an instant hot water unit is better than a storage unit? Ask *ReNew* your question via renew@ata.org.au.

Increasing system load

Q —

Since my household increased from one to three members I am finding my 1500 W renewable energy system, which was more than adequate for a frugal me, is not coping with the extra residents even though we use energy sparingly, only do washing etc on sunny days and have purchased low-energy computers and fridge.

Our system was only designed to take up to 2000 W of solar panels, so after I put on two new panels the system is still short on energy when we have two cloudy days in a row.

My battery charger will be getting regular use from now on, but only puts 10 A (300 W) into the batteries. I am looking for a battery charger that can deliver 30 amps and reduce the time I need to run my 3000 W generator.

Longer term, I may have to buy a second system, but can you suggest a suitable charger that is not too expensive please?

—Jane Marriott

A —

There are plenty of chargers around that will do that sort of current, and more, but the maximum current rate depends on the battery bank size. See www.baintech.com.au/chargers and www.inverter.com.au/category5_1.htm for examples, and there are a lot of other suppliers, but high-powered chargers like this are never really low cost. There are some cheap ones on eBay, but bear in mind that some are not well regulated and can overcharge the battery bank, and many are direct from China, so if they fail, there's no real recourse.

Generally, if you are finding that your battery bank is struggling after the second day then you are cycling it way too deeply and it is too small for what you are drawing from it. The use of a charger will help but it is still adding cycles to the bank and the bank will degrade faster than it otherwise would.

Something to note regarding generators, they are usually rated in VA (volt-amps), not watts. They are not the same thing unless the load on the generator (battery charger or whatever) has a power factor of 1. Very few electronic loads do, especially battery chargers, so a genset rated at 3000 VA won't be able to power a 3000 watt charger. Obviously, a 30 V, 30 A output is only 900 W and probably needs around 1200 W input at most, but it's surprising how much some gensets struggle with battery chargers.

—Lance Turner

Smart meter costs

Q —

Do you know if any comparison has been done between the price of having a smart meter installed and the actual cost to the company installing the meter? I am thinking of the situation where the banks were called to account for the fees they were charging for credit card transactions, which were disproportionate to the actual cost to the bank.

We already had a smart meter, so all it took was for the inspector to press a few buttons to connect us when we got solar PV, and we were charged a 'Meter Alteration Fee' of $281.16.

—Bernard Cannon

A —

It's a little hard to get this information as the actual costs aren't transparent for customers, but the Australian Energy Regulator (AER) approves the amounts charged by the networks for new meters and meter reconfiguration. It sounds as though you might have been charged a meter replacement fee when you should have been charged a remote reconfiguration fee. I would check that with your distributor to make sure that you haven't been overcharged.

—Craig Memery

Electric instantaneous water heaters

Q —

I have a three-level apartment with an electric storage hot water system. I am looking for alternatives, but solar and gas are not options. The on-demand electric systems, such as the Gleamous GL5, might be possible. Do you have any information on this type?

—Michael Oxer

A —

There's not a lot to them, they just heat the water you need like a gas instantaneous unit does. The only requirements are a suitable electricity supply. For instance, the GL5 needs a three-phase supply. Many new residences have all three phases connected, so if that's the case, then you will just need an electrician to run the new cable from the switchboard.

Bear in mind that storage systems are often powered from cheap off-peak electricity, whereas with an instantaneous unit you are paying the peak rate. So, if your current storage is off-peak, your water heating costs will probably increase with an instantaneous system, even though energy use will decrease.

—Lance Turner

LED bulbs and radio buzz

Q —

I recently bought four LED lights to replace CFLs in the kitchen. I'm very happy with the light output and colour, but unfortunately there is one side effect—when they are turned on they make my clock radio in the bedroom buzz. What is this caused by and is there anything I can do to stop it? I would just put these globes in a spot where I don't need to use them in the morning, except that they are the only screw fittings in the house. Another LED in the pantry has no effect.

—Jane

A —

This is a common problem: many LED bulbs produce electrical noise as they have switchmode drivers inside them to convert

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*, Level 1, 39 Little Collins St, Melbourne VIC 3000, or renew@ata.org.au the power supply voltage down to whatever voltage and current is needed for the LEDs. The electrical noise can be radiated as radio waves from the house wiring, causing interference, or it can travel back through the wiring as electrical noise, causing the same problem. I suspect your problem is the former.

There are a number of solutions, of which several are quite simple. The first is to get some clip-on ferrite beads, these are the sort of thing you see at the end of some computer leads, basically a lump in the cable, but in clip-on form rather than moulded in. Examples can be seen at www.bit.ly/ferrite1 and www.bit.ly/ferrite2. You simply clip them over the cable as close to the light fitting as possible.

If that doesn't fix it entirely, using a larger ferrite and winding two or three turns of the cable through it will increase the effectiveness of the ferrite.

You can also put small value capacitors directly across the socket, but this involves electrical wiring, so you'll need to find an electrician experienced at mains wiring, and you must also use the correct capacitors (X2 types of appropriate voltage rating). A simpler and more electrician friendly option would be to have mains filters connected at the fittings. A typical example of a suitable unit (which could be fitted inside a junction box) is Jaycar Electronics part number MS4001.

But definitely start with the clip-on ferrites, they are simple to install and no electrician needed, assuming the wiring is accessible from inside the ceiling. Just be careful if installing them that you ensure the wiring is in good condition—old wiring can have degraded insulation and be very dangerous. If in doubt, contact an electrician.

—Lance Turner

House movement and windows

Q —

The latest edition of *ReNew* includes a buyers guide to energy efficient windows. However, although I have thought of investing in such windows, the movement and cracking in our brick veneer house makes me wonder if it would be worthwhile.

Our house on reactive clay soil is brick veneer on mainly waffle-pod foundations. Over time, doors and windows have stuck due to movements and can only be opened after planing. Some movement was due to the El Nino drought that finished a few years ago but other movement doesn't seem to be related to weather or climate changes.

For energy-efficient windows to be effective they need good seals, so will they be able to cope with the type of house movement we get on clay soils?

—Barbara Ryan

A —

It seems as if there may be excessive movement in the slab, indicating it's not stiff enough for the site conditions. Waffle pod slabs can certainly be made stiff—indeed they were invented specifically in response to Adelaide soils. But be that as it may, we still need to find a solution to the window question, assuming the slab will remain structurally viable (note, flexibility does not equate to failure).

The windows and doors need to remain square within their own frames, meaning the fixings to the house frame will need some flexibility, and the sealing will need some sponginess and more clearance than usual. How much is a function of building movement—this needs to be quantified, so that the system provides just the right amount, not too much or too little. Indeed, it may be worth checking that the smaller windows even need such flexibility.

One side of each frame opening must be fixed, while the other three are free to move a bit. Unless there is some peculiar reason not to, the sill should be fixed, although there may be no fixings directly through it. The sill can be fixed via rigid lower side fixings, as long as they are within 50 mm of the bottom (sill) of the frame.

Then all other fixings need to locate the window or door frame in alignment with the wall, allowing for movement in that plane only, not in and out. This requires slip ties, as used in masonry construction expansion joints, and available from builder's hardware suppliers. How these are fixed between window frame and wall stud will require careful forethought, and if one brand doesn't work another may.

Next we need to seal the remaining changeable gap. One method would be to install a closed-cell flexible foam rubber as the gap sealer. This will allow massive movement without crushing or memory effect. But it may mean the window or door is 25–40mm smaller than the opening. The gap can be closed off visually and to weather by the usual means of architraves internally (fixed only to the window/door frame, so they can slide over the wall face), and storm moulds externally (fixed only to the brick reveal, so they can slide over the window/door frame face).

A bit of invention required, but if the building is going to have another 25+ years of working life, it's probably worth it.

—Dick Clarke
Director, Envirotecture
Accredited Building Designer (6029 NSW), Fellow of the Building Designers Association of NSW

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ATA BRANCH REPORT

***ReNew* is published by the not-for-profit ATA. The ATA has active branches all over Australia and here's what they've been up to recently!**

Adelaide: In the last few months the Adelaide branch heard from experts on the topics of cool roofs, household Energy Star ratings and had updates on hybrid cars and PV systems. They also partnered with the City of Marion to hold an ATA Speed Date a Sustainable Designer event in August.

Brisbane: In May, the Brisbane branch assisted with an ATA Speed Date a Sustainable Designer event and investigated the concept of positive development. Their June meeting was a presentation on sustainable building materials and in July they learnt about solar cooking and off-grid power.

Cairns: The Cairns branch had a huge weekend of activities in July with an ATA stall at Mareeba Markets, the Cairns Sustainable Living Expo and a talk on the advantages of hempcrete as a building material.

Geelong EV: The Geelong EV branch continued regular meetings to look at the latest in EV technology from around the globe and to discuss member projects. They also meet monthly in private workshops to assist fellow EV builders.

Melbourne: The Melbourne branch has held meetings recently on the varied topics of window and glass technologies, community renewable energy, coal seam gas and the ATA International Projects Group's activities in East Timor.

Melbourne EV: The Melbourne EV branch has heard from industry experts on electricity network management and smart meters, investigated the exciting world of electric vehicle racing developments and held a film night with the popular documentary *Revenge of the Electric Car*.

Sydney Central: The Sydney Central branch has recently hosted a number of excellent speakers on topics relating to sustainable building, including 'Why natural buildings are better' and separate sessions on how to make insulation and glazing work for you.

Sydney West: The Sydney West branch recently visited the University of Western Sydney's solar car 'Solace' workshop. This branch is based at the Hawkesbury Earthcare Centre which hosts a range of workshops and education sessions. A weekend-long workshop in August focused on unfired earth building techniques.

Tasmania North: The Tasmania North branch has been out and about again, visiting their local sustainable supermarket as well as hosting a federal election policy forum. In August a number of branch members were involved in a range of events as part of Sustainable August with Tamar NRM's Sustainable Living Working Group.

See www.ata.org.au/branches for upcoming events, including from the ATA's other branches in Canberra, Coffs Harbour, Perth, Sunraysia and Warkworth, New Zealand.

Advertiser Directory

See the earth move
Make a seismometer from a tape deck

Combine an old tape deck and the speakers from a junked TV and you have yourself a seismometer. Julian Edgar shows how.

SEISMOMETERS measure earth vibrations. You've probably seen them on TV after an earthquake—the seismographic record shows the magnitude of the quake and three or more seismographs can be used to establish where the epicentre is located. The seismometer presented here won't be finding a use in too many geological laboratories, but it's fun and easy to construct, and sensitive enough that on a wooden floor it can detect a cat walking past—plus it costs nearly nothing to make.

↑ It looks like a thousand dollar instrument but cost nothing to make. The two-channel seismometer is based on a slightly modified old cassette deck and uses normal speakers as the earth vibration sensors. It's sensitive enough that on a wooden floor it can detect a cat walking past.

How it works

This seismometer takes advantage of the fact that a cassette deck uses two amplifiers that are designed to work with very small signals. Normally these signals are read off the tape by the heads, but what we can do instead is feed in new signals derived from coils of wire being moved past magnets. Since speakers have very strong magnets and coils (attached to the back of the cone) with lots of windings, with very small internal clearances between them, they make ideal sensors for the seismometer as any movement of the cone produces a good signal.

If the speaker basket (frame) is firmly attached to the ground and a vibration occurs, the basket and the speaker cone will tend to move at different rates. For example, if there is a sudden movement upwards, the inertia of the cone will mean it gets left behind for a moment. As a result, the magnet will move past the coil, causing a small voltage to be generated in the coil. This voltage is amplified and displayed on the VU (volume unit) meters. The greater the needle deflection, the greater the amount of vertical vibration that has occurred.

Building it

To make the seismometer you'll need a discarded (but still working) cassette deck that has VU meters. The meters can be either analog or digital. In addition, you'll also need a couple of speakers—for example, the speakers salvaged from a stereo TV. If you can't score that lot free of charge, you're not really trying.

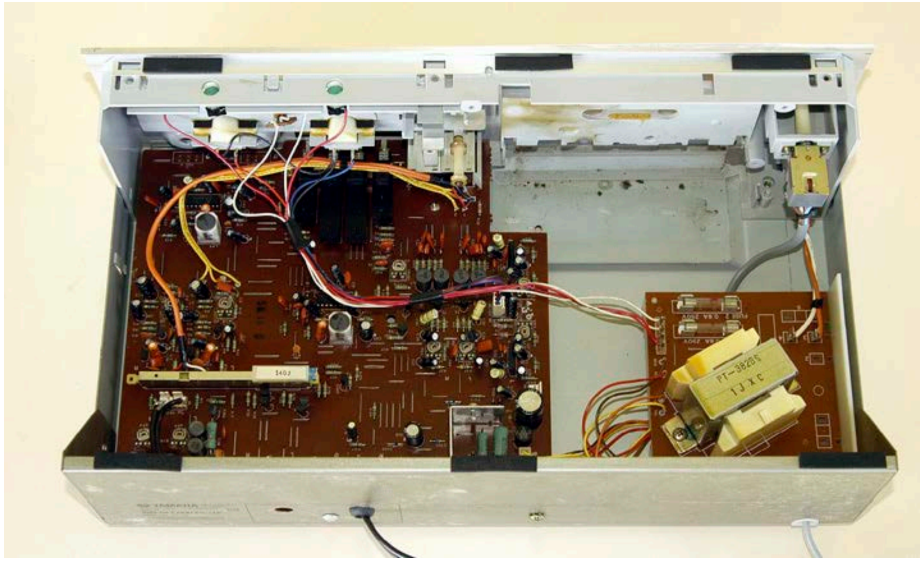
If you want to make a fancy new faceplate, you'll also need your PC, a printer and a scanner.

At its simplest, the seismometer will take only a few minutes to make. Ensure the power cord is disconnected from mains supply and then take the cover off the cassette deck. Trace the wires (they'll be shielded with braid) that connect the electronics PCB to the heads. There will be six conductors in these leads—a common, play and record signal feed for each head. Cut these wires and feed them out of the case so that you can put the lid back on.

Replace the lid, power up the deck, press the 'play' button and then connect the wires for one channel across a speaker (it should only have two terminals), trying the various combinations of wires until you find a pair which causes a VU meter to strongly react to any speaker movement. Then do the same for the other channel. You may need to extend these cables—in my case I used the RCA cables that came with the deck.

A more complex approach (and what I did here) is to also strip the cassette deck of the surplus parts. For example, I removed the complete tape mechanism. Why? Well, the DC motor, drive belts and springs can find a use in another project, as can the tape counter. It seems a shame to leave them inside the seismometer. If you take this approach, you'll need to activate the same switches that pressing the 'play' button normally does. For example, if when 'play' is pressed a single switch is closed, the wires leading to that switch will need to be connected together. On the other hand, you may find that when the cassette mechanism is removed, the PCB is

→ I chose to remove the internal bits and pieces that were no longer needed: the cassette mechanism, tape transport buttons, opening door and so on. This allows those components to be used in other projects and gives a significantly lighter end result.



← The speakers detect vibration, with a small voltage generated as the magnet moves past the cone-supported coil. The larger the speaker, the more sensitive the instrument.

effectively always in 'play' mode.

Different speakers will provide different sensitivities. I tried a variety and found that the larger the speaker, the more sensitive the seismometer became. The speakers shown here (100 mm units salvaged from a stereo TV) gave the seismometer sufficient sensitivity that in a wood-framed, two-storey-on-stilts Queensland house, anyone walking anywhere within the house gave a noticeable reading. Incredibly, that even included walking on the concrete pad under the house!

A professional finish

To make the cassette deck look less like a deck and more like a seismometer, you can make a new faceplate. If the original faceplate is removable (most are), take it off and scan it in to your PC. Then use image manipulation software to construct the new design, putting on whatever labels you want. That done, print it out at full size on heavy stock gloss paper. After that it's just a case of sticking the paper over the original. I used clear 'contact' adhesive film to protect the paper.

If you want, you can also replace the scales behind the VU meters. However, in the case of the seismometer shown here, I elected to keep the original scales.

If the sensitivity of the seismometer is too great, reduce the size of the speaker. Adding weights to the cone also alters the response. When exploring the use of different speakers, you should be aware that a typical house is full of background vibrations. The compressor in the fridge can cause sufficient vibration to swamp other signals; a PC cooling fan can also cause clearly visible room vibration. So, to be able to watch the earth vibration caused by (say) visitors walking up to your front door, you'll need to remotely mount the speaker sensor away from house-borne noises—although note that too long a cable will cause a reduction in sensitivity.

Finally, if you want to feed the output signal into a logging system or drive an external display, line-level output voltages are available on the normal RCA outputs of the deck. ✱

A note on safety

Never open the case or work on any mains powered equipment while it is plugged in and/or turned on. Always unplug the device from the power point before making modifications, and always make sure all mains powered components are covered before applying power. If you believe that the device's circuitry is not fully isolated from the mains, do not modify it—find a device that uses a fully isolated power supply.

ATA member profile
Bernie Hobbs

You might know Bernie Hobbs from the ABC show *The New Inventors*, but she's also an ATA member and has the electric car story to prove it, finds Beth Askham.

↑ Then and now. Then, Bernie's new electric car in the *Sydney Morning Herald* Drive section. Now she rides a bike.

BERNIE became a member of the Alternative Technology Association (ATA) a couple of years ago. She loves what it is—a huge self-help group for people who want to do things better. And a great intro to new tech for non-experts like her. She appreciates that there is always "someone who knows how" in the ATA.

When I spoke to her, she was monitoring her home's power usage via an energy monitor and web interface. It's a new obsession that's part of the Power Women project run by climate action charity One Million Women. The project helps Australian women set themselves energy reduction goals. And it's working; Bernie says she can see energy usage spikes from offending appliances in real time. She then problem-solves to reduce their energy use, or as she said, yells, "turn it off!".

Behaviour change is not the only way Bernie is reducing her energy use. Since buying a block of three Sydney flats with her partner and a friend, they have put in insulation and installed an off-peak heat pump and a 1.5kW solar system. She adds that there is still a bit to do (like hooking up the water tanks that are still standing in the front yard!).

Electric car dramas

"The main lesson to learn is that early adopting is risky and you need to have the right personality type," says Bernie about her electric car saga, quickly adding, "I don't have the right personality type".

In 2010, mindful of Shayi Agassi's line that every time you buy a petrol-based car you are signing up to fossil-fuel companies for the life of the car, Bernie decided to get an electric car to replace her clapped-out Corolla. She soon became a champion for electric cars in Australia, a valuable role at the time for the fledgling Australian electric car market.

The car she bought for $48,000 was from a small, Australian maker and Bernie says she really loved it. It didn't take long after the honeymoon period, however, for things to start going wrong.

At first it was just small problems—blown fuses, a cable tie wearing through insulation, the power steering dying—but eventually, as the car's battery management system did not prevent the batteries from being over-discharged, the inevitable happened. Bernie drove the car after it had sat uncharged for 10 days and damaged the battery cells through over-discharge.

Doug Rolfe from the ATA Geelong EV branch says that battery over-discharge isn't necessarily the end for the battery but it does need quick intervention to get the cells back to life. He says you can use low-current chargers, one per cell, to slowly trickle electricity back into the undercharged battery.

Without a handy technical team nearby, it was months before the car's interstate manufacturer and a local autoelectrician were able to replace the dead cells for a cool $3200 (the batteries aren't covered by car insurance or the warranty). And it was another six months before the car's other problems were fixed by a separate Melbourne company that came to the rescue. Or so they thought. The battery management system had the last laugh and a sneaky constant discharge meant the batteries were once again driven into the ground and over-discharged. This car seemed determined to die.

Bernie points out that all this was because it was still early days for electric cars in Australia, and her car was very much a prototype. It really needed an owner with a bit of technical know-how who could work with its peculiarities—and it wouldn't have hurt to have a trained repairer within 1000km.

She adds ruefully that the business hit trouble 18 months into the car's life, for a time not answering her phone calls or emails, and this added to the stress of the experience. It folded a couple of years into the car's life. "If you are taking a risk with a business and you are the business operator you need to stay in touch and be up front with your customers—we're right there taking the risk with you", says Bernie.

She finally sold the car, almost three years after she bought it—and a year after she'd last seen it!—for $8000 in its damaged state, to someone who is working with the Geelong EV group. They have replaced the damaged batteries and are coaxing the vehicle back to life.

Doug adds that electric car technology is moving so fast that the new cars such as the Nissan Leaf and Tesla Model S have sophisticated battery management systems that would not allow a driver to over-discharge a battery in this way.

Amazingly, Bernie says she will get another electric car in the future, but needs to pay back the loan she has on the first one before she saves up for it. Or better still, get one with a battery leasing arrangement like the new Smart Fortwo EV. In the meantime, she rides her bike and uses a GoGet car when she really needs one. Go Bernie! ✱

Take a look at the ABC science website, Bernie's Basics: www.abc.net.au/science/basics

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