

# ReNew

Issue 135

**WATER SAVING SPECIAL**

Technology for a sustainable future

## WIN

a home battery storage  
system from Enphase

\*Australian and NZ residents only; see page 73

## Every drop counts

### Water wise wicking

## PLUS

How green is your solar?

Permaculture pays off

Home battery choices & more

Issue 135 April-June 2016  
AU \$8.95 NZ \$9.90  
[www.renew.org.au](http://www.renew.org.au)



**DIY double glazing:** glassy results  
**Sophie Thomson's** dry garden tips  
**Waterless toilets:** a mini guide

**Heating Buyers Guide**  
Heat pump & hydronic



# Contents

## Issue 135, April – June 2016

Read more articles at [renew.org.au](http://renew.org.au)  
Follow us on Twitter: [twitter.com/ReNewMagazine](https://twitter.com/ReNewMagazine)  
Like us on Facebook: [facebook.com/ReNewMag](https://facebook.com/ReNewMag)

## Wise water ways

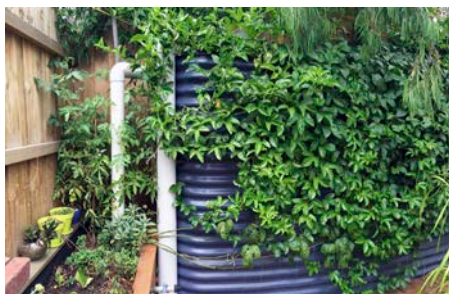
### Water-efficient gardens, no-water toilets and more



↑ Currently the world's largest offshore wind farm, the London Array is about to lose the crown to Hornsea One, off the coast of Yorkshire. Page 24.



↑ Noisy polluting generators go off; solar system lights up at a remote Indigenous rangers station in northern Queensland. Page 32.



↑ This rain garden in the inner city is providing food, cooling shade and preventing stormwater runoff into local rivers. Page 54.

#### Features

24 ↓

#### Wind in the works

Wind turbine technology is evolving. Alicia Webb takes us on a tour of the latest tech and of wind farms worldwide.

26 ↓

#### Energy storage market heats up

With industry announcements almost every week, Lance Turner takes a look at where the energy storage market is heading.

32 ↓

#### A light in the bush

A pilot project shows how collaboration can help turn off polluting generators in remote locations.

34 ↓

#### How green is my solar?

Andrew Reddaway examines the sustainability of solar and solar + battery systems, taking into account the energy that goes into their production and their effect on the grid.



↑ Sophie Thomson's thriving vegie patch in a dry climate, using wicking beds, 'measured' irrigation and low-pressure sprinklers. Page 46.

#### Special feature: water saving

40 ↓

#### At home with water efficiency

Gadgets, habits and tools to help you save water at home and in the garden.

46 ↓

#### Drop by drop

With real experience from her own patch, *Gardening Australia's* Sophie Thomson gives tips on water-efficient gardening in a dry climate.

48 ↓

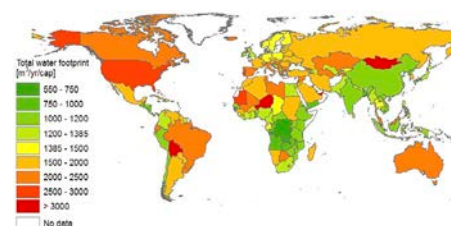
#### Measured irrigation

This Adelaide invention adjusts watering based on temperature and rainfall, and it's being used in homes and community gardens around Australia.

50 ↓

#### Wicking bed know-how

After a lot of research and experimentation, permaculture design consultancy Very Edible Gardens are wicking bed converts. Dan Palmer explains the ins and outs.



↑ Yes, Australia has an above-average water footprint. Find out what that comprises. Page 70.



← **Cover image:** A water-efficient home and garden in Castlemaine, Victoria. Photo by Calan Stanley. With an extensive vegie patch (supplying tomatoes to the *ReNew* office!), this garden in Castlemaine is watered purely from a 7200L rainwater tank, using drip irrigation and wicking beds. Two other tanks are plumbed to the home. Given the dry conditions over the last year in many parts of Australia, water efficiency needs to be back on everyone's agenda, so this issue we cover ways to achieve water-efficient homes and gardens, starting on page 40.

54 ↓

### A project for a rainy day: put your stormwater to use

Using stormwater can save water, cool cities and reduce flooding problems, at the same time as protecting local rivers. Chris Walsh shows how in his inner-Melbourne home.

58 ↓

### Common sense meets design: a permaculture approach

Sarah Coles talks to Su Dennett and David Holmgren about water efficiency and permaculture.

62 ↓

### Waterless toilets: a mini guide

Dry toilets should be able to fit into any home. Eva Matthews presents the options available.

66 ↓

### Gardening in the tropics

Rain in summer and lots of it, little rain in winter: Emma Scragg explores gardening in the tropics and subtropics with two northern Australian gardening experts.

70 ↓

### Water footprint of your food

Sarah Coles explores the relationship between water resources and our dinner.

88 ↓

### Water saving books

10 books to slake your thirst for water-saving approaches in your home, garden and community.

## Guides

# Efficient heating Buyers Guide

74 ↓

## Stay warm this winter

Reduce your heating energy use and reduce your bills. We look at the latest in reverse-cycle air conditioners (heat pumps) and hydronic heating systems.

## DIY

83 ↓

## Double glazing on a budget

With a bit of care and patience you can add double glazing to existing windows without breaking the bank. Alan Cotterill shows us how.

86 ↓

## A DIY mini hydronic system

Martin Chape describes his mini DIY system that heats just one room using solar heat.



↑ We look at both reverse-cycle air conditioners and hydronic systems for heating. Page 74.

# Regulars

06 ↓

About ATA

08 ↓

Editorial

10 ↓

Up front

14 ↓

Letters

18 ↓

Products

73 ↓

WIN! *ReNew* subscriber prize

82 ↓

Shop with the ATA

90 ↓

Pears Report

92 ↓

Q&A

94 ↓

Classifieds

95 ↓

ATA branches

96 ↓

Member profile



# Wind in the works

## Wind farm round-up

Wind turbines are getting bigger and better. Alicia Webb takes us on a tour of the latest wind turbine tech and wind farms worldwide.

WHILE the world pushed on with ever-increasing wind farm installations, the Australian wind industry had another quiet year in 2015. The most significant change was that the large-scale component of the national Renewable Energy Target (RET) was revised down and legislated to remain in place without further changes to 2020. While the downwards revision of the target was disappointing, the industry is looking forward to getting back on track and spending the next four years delivering the projects that are needed to reach the target.

While confidence slowly returns to the sector, the activity levels behind the scenes are encouraging. Wind farm developers are working hard to ensure their sites are ready to go, with many development permits being revised to allow for larger, more modern turbines.

State-based renewable energy schemes were a lifeline for the industry during 2015. The Australian Capital Territory's first reverse auction scheme for 200 MW of wind capacity awarded contracts to three wind farms.

The low prices awarded for these contracts (the lowest was AU\$81.50/MWh for the 20 MW Coonooer Bridge wind farm) surprised everyone and demonstrated how much progress the wind industry has made in bringing costs down. All three of these projects are currently under construction, creating jobs in rural Australian communities.

A second round of the reverse auction has also been awarded in two 100 MW lots. Hornsdale wind farm in South Australia, which won 100 MW in the first reverse auction, also secured a second stage (for a bargain price of \$77/MWh), and a wind farm in the New England region of NSW won the other half.

Australia's total installed wind energy capacity was 4187 MW at the end of 2015, made up of 2062 turbines spread across 76 wind farms. New capacity totalling 380 MW was added during the year. The graph below shows how the industry has ebbed and flowed in line with policy and funding.

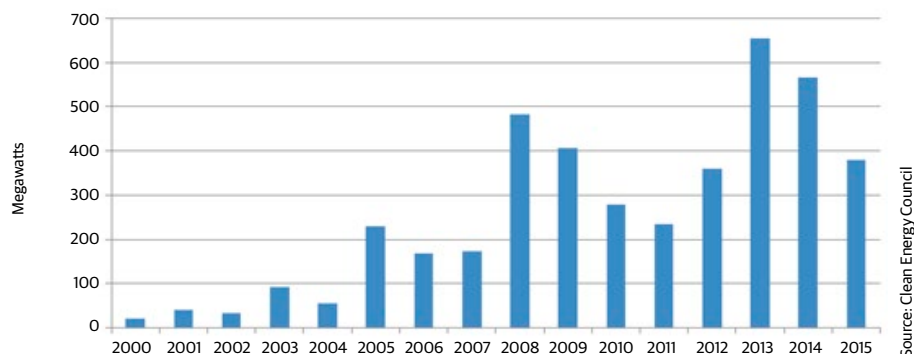
### Wind farms around the world

The world is blazing ahead with installing renewable energy and transitioning electricity systems away from fossil fuels. Compare Australia's 380 MW installed in 2015 with China, which installed 30,500 MW, about 80 times as much as us! Globally, the market grew 22% in 2015 with a total of 63,013 MW of new installations. Following China, leading countries included the 8600 MW installed by the USA and Germany's record 6000 MW of new projects, including 2300 MW of offshore wind power.

The country generating the most wind energy as a proportion of total electricity is Denmark. In 2015 Danish wind turbines generated enough electricity to provide 42% of the country's electricity consumption, a world record.

Steve Sawyer, Secretary General of the Global Wind Energy Council, said that 2015 saw China edge past the European Union in terms of total installed capacity, with 145.1 GW in China and 141.6 GW in the EU. The Chinese government's drive for clean energy is motivated by the need to reduce dependence on coal—which is a major source of the choking smog strangling China's major cities—as well as growing concern over climate change.

According to Bloomberg New Energy Finance, China's huge wind installation numbers were good news for Chinese



↑ Annual installed wind capacity in Australia over the last 15 years. The graph shows increases overall, though with considerable fluctuation. While 2015 was a slow year for wind farming, prospects for the future are looking better due to the final resolution of a (reduced) Renewable Energy Target and friendlier state governments.

# Store and deliver

## Energy storage market heats up



The energy storage sector is heating up. Lance Turner takes a quick look at where the industry is heading.

A DECADE ago, seeing solar panels on homes was a rare occurrence, yet now you will find them on more than one million Australian homes. Indeed, solar has become completely mainstream, no longer just for greenies and those living remotely.

While solar power works well to reduce dependence on the grid at peak times, the recent or pending removal of decent feed-in tariffs for many solar owners has meant that many are now looking at energy storage. A battery system means that system owners can reduce their low-valued exports to the grid and instead store the energy for later use, offsetting expensive grid imports, and potentially saving money, or at least shifting the balance towards greater self-sufficiency.

Traditionally, solar battery systems have been designed to suit the individual installation, but for grid-connected storage that is no longer a requirement. All you need is a system that can store an appropriate amount of energy and be able to supply that to your house when needed—it doesn't need to cover all demands of the home at all times.

To this end, we have seen a proliferation of domestic-oriented energy storage systems (ESS) of late. They vary in size, shape and features, but all are designed to allow the homeowner to take better control of their energy generation and use, reducing bills and, in some cases, providing a degree of backup against grid failure.

Not all systems are designed for grid backup, but this is becoming more common as manufacturers realise that customers want their systems to be as flexible as possible, even potentially allowing them to eventually go off-grid altogether.



↑ The UltraFLEX (right) and the smaller soon to be released UltraPOD (not shown to scale) use the CSIRO-developed lead-acid based UltraBattery for energy storage.

Even if you don't have a solar energy system, but are on a time-of-use tariff, you can make a battery system work for you. You can charge the battery during off-peak hours when there is a glut of electricity and low prices, selling that stored energy back into the grid at peak times. However, to get a decent price for the energy you export, you need to be able to tap into the National Electricity Market (NEM) system and get the current going rate. While domestic generators traditionally have been excluded from the NEM, this may be changing. Reposit Power is trialling a product that allows you to access the NEM, provided you are using a compatible battery system. So far, three systems are Reposit Power compatible—the Tesla Powerwall, LG Chem's RESU 6.4, and

the Magellan RES1. However, you must also have a participating electricity retailer. So far, only Diamond Energy has a Reposit Power compatible plan—which will pay customers extra when there's a grid credit event, once the trial starts (see [www.diamondenergy.com.au/reposit-GC100](http://www.diamondenergy.com.au/reposit-GC100)).

### Battery types

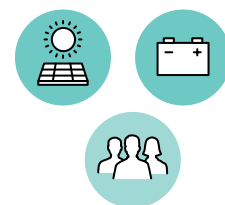
Before we go too much further, we should cover the different battery chemistries available.

The traditional chemistry for energy storage has been the lead-acid battery—and for good reason. Lead-acid batteries are robust, reliable, well understood and, if treated correctly, can last a decade or more, especially in standby and low discharge



# A light in the bush

## A powerful collaboration up north



A pilot project at an Indigenous ranger station in northern Queensland has shown how collaboration can help bring low-cost sustainable power to remote bush locations—and turn off the polluting generators. By David Tolliday.



Image courtesy Andre Grant

↑ 24-hour reliable power for the rangers station—a job well done! (Left to right) Local electrician Jared Warren, land and sea manager Chris Hannocks, ranger and traditional owner 'Brolga' (Philip Yam), ranger Garry Hudson and ATA volunteers John Dickie and David Tolliday in front of the new solar PV array installed at the Oriniers Ranger Base.

FOR many years now, volunteers with the Alternative Technology Association (ATA, *ReNew's* publisher) have been working with other organisations to provide solar lighting and improve quality of life in East Timor. Last year, ATA's volunteers were called on to similarly help power up Oriniers Ranger Base in Cape York, northern Queensland.

### A seed is sown

In 2014, the Kowanyama Shire Council's Land Office invited the Centre for Appropriate Technology (CAT) to visit their Oriniers Ranger Base (160km west of Laura, on the Cape York Peninsula) to look into the power and water situation there. In particular, the base was in need of a new, reliable stand-alone solar

energy system to replace the old 12V system that had, sadly, been stolen from the site a couple of years earlier.

The land office hoped CAT's experience and design knowledge would help them find the best way to set up a system, maximising the use of very limited funds (from their own income sources) to achieve a high-quality, durable remote-area solar power system. Looking at the challenge, CAT considered a collaborative model that would incorporate pro-bono installation by experienced solar industry professionals combined with 'sweat equity' from the community. This model would use key elements of their highly successful Bushlight Program (see box), along with the pro-bono partnerships.

### A project is born

In early 2015, after discussions with the ATA (whom CAT considered a natural partner for the project), CAT's pilot proposal was accepted. The ATA had agreed to support the pilot by sourcing two volunteers with the appropriate technical expertise and experience to take care of the installations. The ATA put out a national call for suitable volunteers and, after a selection process, I was chosen to be the lead installer, with John Dickie assisting. I'm from Melbourne and John's from Canberra, and we are both electricians and Clean Energy Council (CEC) accredited solar installers.

After months of planning, we arrived in Cairns to meet CAT's Project Manager, Andre Grant. We then spent two days checking and loading equipment, and purchasing last-minute supplies before heading off for the seven-hour 4WD trip to Oriniers Ranger Base.

After meeting the Indigenous rangers—'Brolga' (Philip Yam), Garry Hudson and John Clark—along with land and sea manager Chris Hannocks and local Kowanyama Shire electrician Jared Warren, we surveyed the existing power setup. It consisted of an array of petrol generators, extension leads, portable lights and power boards, mostly laying across the ground. In anticipation of the arrival of the truck and container the next day, we headed to bed early.

As with all good plans, things didn't go *quite* right—the truck had to turn back because of a leaking radiator; two days later, it arrived. The days were very hot and the humidity high, so work was limited to early morning and late afternoon. (You know it's hot when not even the Indigenous rangers will work in the midday heat!) At one point we realised

# Energy flows

## How green is my solar?



How long does it take to pay back the energy used in the production of solar + battery systems and how much of an effect do they have on the greenness of the grid? The ATA's Andrew Reddaway investigates.



↑ Many people are considering adding batteries to their solar systems as prices come down and more all-in-one systems become available. It's a good time to examine greenness of solar and solar + battery systems. Image: Fronius International.

BY GENERATING clean electricity, solar systems reduce the amount of coal and gas that's burned in power stations. This reduces pollutants and greenhouse gases released into the atmosphere, which cause disease<sup>1</sup> and man-made climate change<sup>2</sup>. Fossil fuels also require extractive processes such as fracking and open-cut coal mining, which have led to negative effects on the environment such as land degradation, water contamination and mine fires.

It seems clear that installing a solar system will have a positive effect on the environment. But with several different types of system now available, including systems with batteries, how do they compare in terms of the environment?

### Grid-connected without batteries

The vast majority of existing solar systems are connected to the grid and have no batteries. Your solar panels' electricity is first used by on-site appliances, and any excess is exported to the grid to be consumed by your neighbours. Any shortfalls are supplied from the grid. This setup is relatively cheap and efficient, using a simple inverter that relies on the grid for its stability. However, it's not very self-sufficient, because if a grid blackout occurs the inverter will switch off. (Although not always; some rare grid-connect inverters can use direct solar generation to supply household appliances in a blackout, even without batteries; for example, the Nedap PowerRouter.)

Since the grid has minimal energy storage, whenever your solar system is operating, a centralised power station will reduce its output to compensate. Each kilowatt-hour

of solar generation reduces power station generation accordingly. In fact the benefit is even greater, as the power station must supply not only the end-user demand but also the losses incurred in the power lines, which can be over 20% for remote locations. Some people argue that because coal-fired power stations are inflexible, they'll keep consuming coal at the same rate regardless of solar generation. Actually they are responsive enough; for example, Loy Yang A in Victoria can halve its output in less than an hour. Spread out over a geographically large area, solar systems' overall impact is relatively gradual even when a cloud front arrives; this is forecast and managed by the grid operator in five-minute intervals.

With enough panels you can generate more electricity than you consume over a whole year, with your night-time imports more than compensated for by your daytime exports.

### Grid-connected with batteries (hybrid)

There are a variety of reasons to include batteries in a grid-connected solar system. Some of these systems are quite self-sufficient as they can supply your appliances during a grid blackout. With enough batteries and solar panels, imports from the grid can become rare events. However, adding batteries doesn't increase your net impact on fossil fuel generation. Sure, you're importing less from the grid at night, but on the other hand you're exporting less during the day. Batteries also incur losses when charging and discharging, so your house will consume slightly more electricity than it would have without batteries.

# Wise water ways

## At home with water efficiency



Eva Matthews looks at the gadgets, habits and tools that can help you make the most of our precious H<sub>2</sub>O.

THE water account for 2013–14 from the Australian Bureau of Statistics reveals some useful facts about our water use at home. Household water consumption for the year totalled 1872 GL—equivalent to just under four Sydney Harbours. And the Sydney Harbour analogy is particularly relevant, as NSW was the highest-using of the states and territories by almost double that of the next-highest, partly because of its larger population. Per capita usage was highest in WA (361 kL) and NT (416 kL) per person per day; Victoria was the lowest at 175 kL and NSW, ACT, SA, Tasmania and Queensland were all in the range 200 to 220 kL (see graph overleaf).

In the same time period, this water use cost households around \$5 billion, and prices are rising (up around 25% on the previous year in NSW and Vic). And then there's the fact that, despite Australia's average rainfall being well below the global average and likely to remain so, we are the greatest per capita consumers of water, not even including the water embodied in the production of the food and products we consume. These stats make it pretty obvious that we are not, as a nation, living sustainably or smartly enough when it comes to this precious natural resource.

So what can we do to improve this situation? Primarily, use less water and make the most of the water we have! There are also national and state/territory-based rebates and incentive schemes (such as showerhead swaps, rainwater tank and greywater system rebates, appliance upgrades, toilet replacement and leak fixing services) to help people become better water savers. Check out [www.yourenergysavings.gov.au/rebates](http://www.yourenergysavings.gov.au/rebates) for basic info and useful links.

### How can you save water in the home?

#### APPLIANCES

The Australian Water Efficiency Labelling and Standards (WELS) scheme requires products such as showerheads, toilets, washing machines, dishwashers, taps and flow controllers to be rated and labelled for their water efficiency. The Star rating system (up to 6 Stars, more stars means more water efficient) and data on actual water consumption will help you make the most water-efficient choice for your budget.

#### LEAKS

Dripping taps and leaking toilets and pipes are the 'stealthy saboteurs' that can undermine your other water-saving measures.

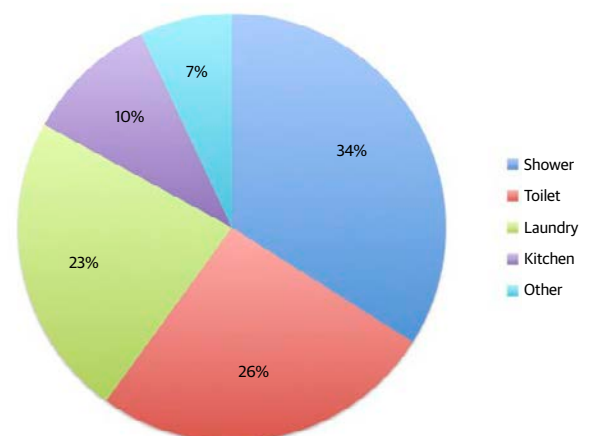
A slight leak in your toilet can waste more than 4000 L/year; a more significant leak, up to 96,000 L. A significant leak will be fairly obvious, but you can check for a smaller leak

by placing a few drops of food colouring in the cistern; if the dye comes through into the bowl within 15 minutes of flushing, you have a leak.

A tap dripping once per second wastes around 7000 L/year (that's 7 m<sup>3</sup>!). Leaking pipes are harder to detect, but the losses here could be enormous. You may be alerted to a problem if you notice your water bills increase significantly (or, if you're on tank water, your supply dwindling more rapidly than normal). Alternatively, you could install an Australian invention called the Aqua Trip Leak Detection System (from \$139 plus plumber installation costs, [www.aquatrip.com.au](http://www.aquatrip.com.au)), which is able to differentiate between normal water use and a plumbing problem, and can switch off the water supply before it becomes a big problem.

The key to water saving here, of course, is to fix the problem—be it in the tap, the toilet or the pipes—as soon as it's detected.

→ Average percentage of water used indoors in Australian homes for each water-using activity. By following the water-saving tips described, these figures could reduce by 50% or more. Data source: [www.yourhome.gov.au](http://www.yourhome.gov.au)





# Wicking beds

## Irrigation from the ground up



Seven years ago, when permaculture design consultancy Very Edible Gardens began, they had no idea what a wicking bed was. After repeated queries from clients, they started to research and experiment. Dan Palmer, co-founder of VEG, shares the fruits of their labour.

PRIOR to our foray into wicking beds, all of our raised vegie beds were either unirrigated or set up with drip irrigation. But then someone whispered these words to us: "Wicking beds... We want wicking beds." So we started setting up wicking beds in old bathtubs, and using plastic liner in standard raised beds. We set out to learn by doing, our initial intention to prove to ourselves that wicking beds didn't work. We gave it a pretty good shot, learned a lot in the process and refined how we went about them—a good example of iterative design, where you keep doing what's working and improve what isn't, then repeat.

### What is a wicking bed?

Invented by Australian Colin Austin, the wicking bed idea involves the prevention of water loss from your garden bed through the use of a waterproof liner or layer. This creates a reservoir of water beneath the soil and means that, instead of watering from above via drip irrigation, a hose or a watering can,

the water wicks up into the soil from below.

This keeps the soil nice and moist. You prevent the weight of the soil from squashing all the water out by having the water sit in a layer of small stones, sand or similar, which can accommodate the water while bearing the weight of the soil. You prevent the soil from dropping down into gaps between the stones or sand particles with a layer of something that lets water wick up, but stops soil moving down. The last essential piece of the wicking bed puzzle is that you need a designated overflow point so that the soil layer doesn't get flooded and kill the soil life and plants by rotting their roots.

### Water efficiency

The water held in the reservoir can only leave the bed by wicking up through the soil profile, to be sucked up and incorporated or transpired out by the plants. With ordinary raised beds, most of the water you apply drains straight out of the bottom and is lost to your precious vegetables forever. This is not possible in a

wicking bed. Every drop is forced to stick around, at least until the reservoir is full.

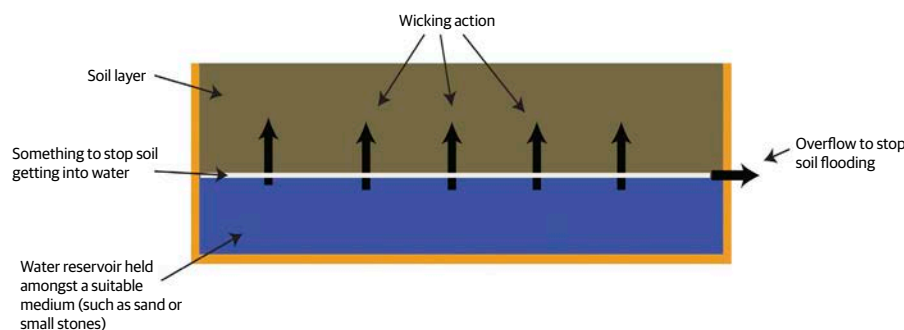
With many irrigation systems, water is lost into the atmosphere as evaporation, before it even has a chance to drain through. Much of the remainder can be lost by leaching out of the bottom. The water storage and application solution embodied in a wicking bed eliminates water loss through evaporation and leaching. If set up just right, the zone of moist soil starts about 5–10 cm down into the soil, meaning the plant roots can easily reach it, but the sun's rays cannot.

Wicking beds maintain a more constant desirable soil moisture profile than other irrigation approaches. So long as the reservoir is kept topped up, the soil around your plant roots is always just right. Excess or deficiency of soil moisture is almost never a factor. Gardeners don't need to group particular groups of plants (i.e. 'similarly thirsty') together in the same wicking bed; the beauty of this concept is that plants just take the moisture that they need.

These days we install more wicking beds than not. We have to admit that, despite our initial scepticism, they have proven themselves.

### The be-all and end-all?

We don't necessarily think wicking beds are a panacea. There are still times when we think non-wicking beds, whether in the ground or raised, are more appropriate. For example, they may not work in large-scale applications (e.g. market gardens), in situations where wicking beds wouldn't be properly installed or the setup budget is very low, or when the managers are very happy to manually water



↑ The essential ingredients of a wicking bed.

# A project for a rainy day

## Put your stormwater to use



Even dense inner-city housing can easily hold back most of its stormwater runoff—saving water, cooling cities, reducing flooding problems and protecting rivers. Chris Walsh's inner-Melbourne house shows how.

OUR little Richmond house needed renovating. In the process, I wanted to take the opportunity to practise what I preach in my work on urban stream ecology and show that a densely developed residential block can avoid contributing to the wrecking of my local river.

This would require two things: capturing runoff from all the hard surfaces of the property and using as much of it as possible. Ideally we would also allow some of the captured water to infiltrate into the surrounding soil, as rivers need groundwater flows, but as we are surrounded by constructions this wasn't possible in our case.

However, if all properties could successfully keep most of their runoff out of the council drainage system, as we are doing, then it would become more feasible for councils to build infiltration systems that can cope with the large volumes of stormwater generated by

roads. If this were done along all city streets, then our cities' streams and rivers could be truly healthy again—a revival of natural assets that for too long we have assumed must be lost from our urban landscapes.

### Just a square metre of runoff

So about 18 months ago as part of our renovation (and at little extra cost), we constructed two small, productive 'rain gardens' that capture runoff that would otherwise go into the stormwater drains.

These garden beds keep our household in herbs and vegetables (and provide cooling shade) without the need for mains water or active watering. We also installed a small rainwater tank that takes up less than 1% of the property area and captures water for use in our toilets, laundry and another garden bed.

Only a square metre or so of brickwork at the front gate drains to the street. With our

stormwater system, no runoff should leave the property from any surfaces other than this square metre of brickwork, except in large storms.

### The tank installation

Our house sits on a 160m<sup>2</sup> block, with a roof area (post-renovation) of 118m<sup>2</sup>. To capture water from the roof, we installed a 2750L slimline tank along the back wall of our courtyard. All the downpipes (draining about 114m<sup>2</sup> of roof) except one (draining 4m<sup>2</sup>) drain to the tank via a 'charged' system (also known as a 'wet' system, the downpipes are always full up to the level of the tank inflow).

Each of the downpipes has a rainhead with a flywire screen to prevent debris flowing down the pipe and to keep out mosquitoes. This was particularly challenging for two downpipes on walls along the boundary, where we only had 150mm between the wall and the boundary. I managed to source two frogmouth filters—narrow enclosed filters that are no longer manufactured. [Ed note: A product called Superdiverta, which sits flat against the wall, may be an alternative solution, [www.supadiverta.com.au](http://www.supadiverta.com.au).] The small amount of water that splashes out of these filters is directed through a second pipe into the small garden outside our kitchen.

The 100 mm sewer-grade downpipes (necessary for charged systems) connect under the house to the tank. This pipe system has a slight slope to a purge point at the front corner of the house; in case the system ever needs to be emptied, it can be drained slowly into the front rain garden.



↑ Tank overflows to the rear rain garden and the rain garden plants grow over the tank and, eventually, the northern wall of the house!

# Going waterless

## The composting toilet



While flushing toilets have been the popular option for centuries, dry systems are a worthy alternative. Eva Matthews investigates.

FOR millennia people have been working on the problem of what to do with their poo. Essentially, there have been two basic approaches—the ‘wet’ and the ‘dry’.

From as far back as the Bronze Age (3300–1300 BC), there is evidence that the Harappan civilisation of the Indus Valley, on the Indian subcontinent, used flowing water to wash away their business via brick-covered drains. Throughout the Roman Empire, from the first to fifth centuries AD, water-flushing systems were also prevalent. In the absence of flowing water, human waste has largely been deposited into a hole or pit and covered over. Over the centuries, these approaches have seen various developments.

A forerunner to the modern flush toilet, comprising a water-filled tank and bowl, was invented in England in the late 16th century. The Industrial Revolution saw the invention of the S-trap in 1775 (a crucial bit of plumbing, still used today) and the first modern toilet went into production shortly thereafter. Growing levels of urbanisation and wealth, and the development of more sophisticated sewerage systems, saw the flushing toilet become more widespread from the mid-1800s, not only in Britain, but also across Europe and into America.

There followed many iterations of the flushing toilet, but the next revolution came in 1980, when Bruce Thompson, who worked for Caroma in Australia, designed the dual-flush cistern as a water-saving measure (reducing a standard flush from 12L to just 9/4.5L; this has since further reduced to 4.5/3L). This technology has now spread widely across the world, preventing many gigalitres of good drinking water going to waste.

The modern version of the dry toilet system—essentially a seat with a collection vessel underneath and requiring the addition of a covering material, such as peat or sawdust—was invented, again in England, in 1860. However, it didn't gain the same popular support as the flushing toilet (which so beautifully addressed our desire to have as little as possible to do with our waste once it leaves our body). Despite the commercial development of the Clivus Multrum composting toilet back in the 1930s, the waterless loo has largely remained on the fringe. Modern iterations have proven very useful in rural/remote areas that are short on sewerage infrastructure and/or water, and in places where disturbance of the environment needs to be minimised (such as national parks). And the suburban backyard dunny (basically a big collection bucket located underneath a bench with a hole in it to sit on, which was taken away during the night and replaced with an empty) remained in use in some parts of Australia even into the 1970s. But, where infrastructure has been available, the popular choice has always been the flushing system.

However, with the water crisis currently facing the planet, there is good reason to reconsider the waterless toilet.

There are also water-saving toilets, such as those covered in *ReNew 125* (urine-separating, vacuum and air-assisted), and water-treating and re-use systems (such as worm-based or aerated); however, the focus here is on completely waterless—you can't get more water-saving than that!

There are different definitions of what constitutes a dry toilet, but the most common

type is the composting toilet. So let's find out more about it...

### What is a composting toilet?

Basically, a composting toilet is one in which human waste is captured in a chamber and processed, over time, into a rich fertiliser—endearingly known as ‘humanure’—that can be used to feed your garden.

The process requires a combination of air, heat (optimally 40–60 °C, to kill the pathogens) and the action of aerobic organisms such as fungi, worms, bacteria and insects, to break down the waste over a period of at least six months, and up to three years. Exactly how long the decomposition

↓ Looking at it in its slick and shiny setting, there is not anything obvious to differentiate this—a composting toilet—from a modern flushing unit with a hidden in-wall cistern. Just one of several good reasons to consider going waterless in the loo.



Photo courtesy Anthony Smith, 'The Water Wally'



# It never rains, but it pours

## Gardening in the tropics



Rain in summer and lots of it, little rain in winter—gardening in the tropics and subtropics requires a different approach to water management. Emma Scragg explores the topic with two northern Australian gardening experts.

DIFFERENTIATED by summer rain rather than winter, the northern half of Australia requires a very different approach to gardening and selection of plants from the south. In the tropics and subtropics, there are longer periods of sunshine, and generally people talk of rainfall in metres rather than millimetres. Roof gutters, drains and rainwater tanks often can't keep up with the rainfall rate and valuable stormwater for the drier winter months is lost. The focus of successful landscape design and gardening in the north is not water-conservation but rather capturing the water effectively when it falls and selecting plants appropriate to the wet summers and dry winters.

Yungaburra garden designer and landscaper David Leech and Brisbane-based landscape architect and horticulturalist Arno King shared some of their knowledge to make the most of the abundance that these climate regions can offer.

### Soil as storage

Arno suggests the most effective place to store stormwater is in the soil. Rainwater can be slowed and absorbed through the use of swales, terracing, vegetation and optimum soil structure.

Australia's soils are generally heavily degraded from fire, agriculture and compaction, leaving us with "some of the

lowest levels of micro organisms in the soils," says Arno. "And minerals that rely on the organic matter to hold them in the soil have been flushed out." In high rainfall areas of the tropics and subtropics, it is critical to have good soil structure and biology. Fungal webs (mycelium) in particular, along with invertebrates and other microorganisms (bacteria and protozoa), are encouraged by high levels of calcium and organic matter. These aerate the soil: they make the soil more like a sponge and "plants can tap water immediately around them," Arno says.

Subtropical and tropical calcium levels are generally low on the east coast but are better in some areas near Darwin and in Western Australia, where limestone is the parent rock. To improve calcium levels, Arno suggests adding lime, dolomite or gypsum (refer box).

Another mineral additive that Arno recommends is humates, from humic acid deposits and fossilised plant matter, often associated with coal. These are economical and have huge impacts on soil and its water-holding ability. Diatomaceous earth and zeolite have a similar effect but also encourage and provide shelter for microbes which in turn transport moisture to plants. This is useful Australia-wide.

### Pests and diseases

Pests and diseases can be best managed Australia-wide through soil minerals and appropriate plant selection. "90% of pests are to do with poor plant nutrition," says Arno. A lot of pests and diseases are again a reflection of lack of calcium. "Calcium is essential for cell structure. Also, if you're getting pests eating your plants, it's often a lack of silica. Add them



Image: Arno King

↑ Growth can be verdant in the tropics and subtropics! Above shows a thriving vegie patch in Arno's garden in August (late winter) with a mixture of salad greens: "so much better and so much more variety when you grow your own," says Arno.

# The hidden cost of food

## The water footprint of what you eat



The relationship between water resources and our dinner is a complex one. Sarah Coles takes a look at the facts.

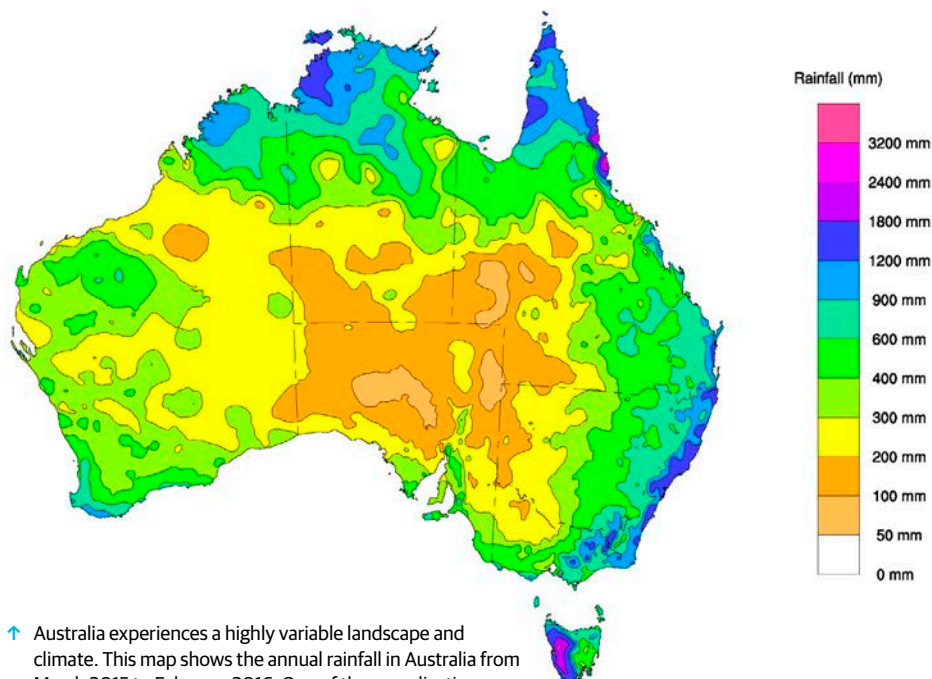
THE amount of water embedded in the food that we eat depends upon a number of factors including how the food is grown, processed, packaged, stored, transported and cooked. The water footprint concept shines a light on the total amount of water required to produce the food that we eat. The concept can help us to navigate the relationship between our consumption and increasing water scarcity, but it does have some limitations.

The water footprint concept originated with Arjen Hoekstra, Professor in Water Management at the University of Twente, the Netherlands. Hoekstra defines the water footprint of a product as the total volume of freshwater that is used to produce it. A water footprint comprises direct and indirect water use.

The direct water footprint refers to the freshwater consumption and pollution that is associated with the water used by the consumer. Indirect water includes three components: blue water, green water and grey water. The blue water footprint refers to the volume of surface water and groundwater, for example lakes and aquifers, evaporated as a result of production. The green water footprint refers to the volume of rainwater consumed. Grey water refers to a hypothetical volume of freshwater which would be needed to assimilate a load of pollutants.

In *The End of Plenty: the Race to Feed a Crowded Planet*, Bourne writes, "[Of] all the freshwater available for human use around the world, agriculture sucks down nearly 70%." According to WWF, "Australia has the 12th largest water footprint in the world. India has the first, followed by the United States and China." For the world's driest continent, currently in the grip of an El Nino drought, high water usage is of concern.

A 2001 Australian Bureau of Statistics report



↑ Australia experiences a highly variable landscape and climate. This map shows the annual rainfall in Australia from March 2015 to February 2016. One of the complications of the water footprint concept is that it assumes that water that would be made available by reducing a high water footprint activity such as dairy farming would be available for use in a less water-intensive activity such as potato farming. In Australia this is often not the case, according to CSIRO researcher Brad Ridoutt, as a lot of livestock are farmed on land that is unsuitable for other purposes.

into embodied water intensities by Lenzen and Foran estimated the amount of water needed in litres to produce \$1 worth of goods and services. They found that \$1 worth of fruit and vegetables required 103 litres of water, \$1 of beef required 381 litres and \$1 of dairy products used 680 litres of water. David Holmgren, co-founder of permaculture (see article on p. 58) has studied the 2001 report and estimated that Melliodora, their permaculture property, used 20 litres of water for every \$1 of fruit and vegetables produced and only two litres of water for every \$1 of goat's milk produced.

The food that we eat accounts for about 50% of our total daily water footprint. Food requires a lot of water to grow, process, package, store, transport and prepare. A lot of this is 'virtual' or embodied water. It is

hard to figure out how much water we are consuming when we sit down to eat a cheese and tomato sandwich; particularly because of the amount of virtual water consumed. According to a UNESCO report 'The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products', when considered per ton of product, commodities with relatively large water footprints are: coffee, tea, cocoa, tobacco, spices, nuts, rubber and fibres.

The Water Footprint Network (WFN), based in the Netherlands, has come up with embedded water figures for a number of foods and drinks. According to the WFN it requires, on average: 3400 litres to produce one kilogram of rice ready to eat, 5000 litres for one kilogram of cheese, 120 litres for one glass of wine, 140 litres for one cup of coffee

# Stay warm this winter

## A heating buyers guide



Heating can be a large proportion of energy use in the home. Lance Turner looks at what efficient options are available, including hydronic and reverse-cycle air conditioners.

OUR previous heating buyers guide looked at heat pumps (commonly called reverse-cycle air conditioners) due to their high efficiency, low cost and simple installation. Later in this guide we take another look at reverse-cycle air conditioners and their advantages, and list the most efficient units currently available.

However, there is another form of heating that not only lets you choose a heat pump as the heat source, but other energy sources as well if they are more appropriate. That system is hydronics.

### Hydronic heating

#### THE BASICS

Hydronic systems consist of a heat source (commonly called the boiler) to heat water, and one or more pipe circuits which have the heated water flowing through them. Each circuit incorporates one or more radiators, which emit warmth into the room.

Most hydronic systems have multiple circuits, so you can heat all or only part of a home, allowing you to leave unused, closed-off rooms unheated to reduce energy use.

Water is circulated through the system using low-pressure pumps, and circuits are turned on/off by electrically operated valves, usually controlled by an electronic controller. The controller enables a system to be programmed to heat certain parts of a home at particular times—for example, heating the living areas during the evening and the bedrooms just before bedtime.

Hydronic systems are recognised to have a number of advantages over other forms of heating. The heat being either underfoot or close to it (through the use of skirting radiators or panel radiators mounted at



Image: maramicado via iStock

↑ Hydronic heating systems produce radiant warmth that many people (and critters) prefer.

floor level) means that you get the feeling of warmth with lower ambient room temperatures than with space heating. Also, there is generally very little air movement with hydronic heating, reducing the potential cooling effect of airflows produced by convective heating such as reverse-cycle air conditioners or ducted gas systems.

Depending on the boiler used, some hydronic systems, such as heat pump systems, can also provide cooling in summer. Another advantage is that some hydronic boilers also provide domestic hot water, eliminating the need for a separate water heater.

Hydronic systems also have some disadvantages. First is the cost. A complete system can easily cost \$10,000 or more,

depending on the boiler, the number of circuits and type of radiator. The cost is likely to increase if fitting a hydronic system as a retrofit to an existing home if pipe runs are difficult to install due to lack of space. However, prices have dropped over time due to increased competition as hydronics have become more popular. Indeed, we have seen complete hydronic heating packages for under \$7000, but larger heat-pump systems can exceed \$20,000, and geothermal heat-pump systems can be considerably more than this.

The next disadvantage is complexity. Hydronic systems can end up using a maze of pipes and valves, so you need a space for all this equipment. This is usually housed



# Double glazing on a budget

## Saving money one window at a time



Double glazing can be very expensive, but with a bit of care and patience you can add double glazing to existing windows without breaking the bank.

Alan Cotterill shows us how.

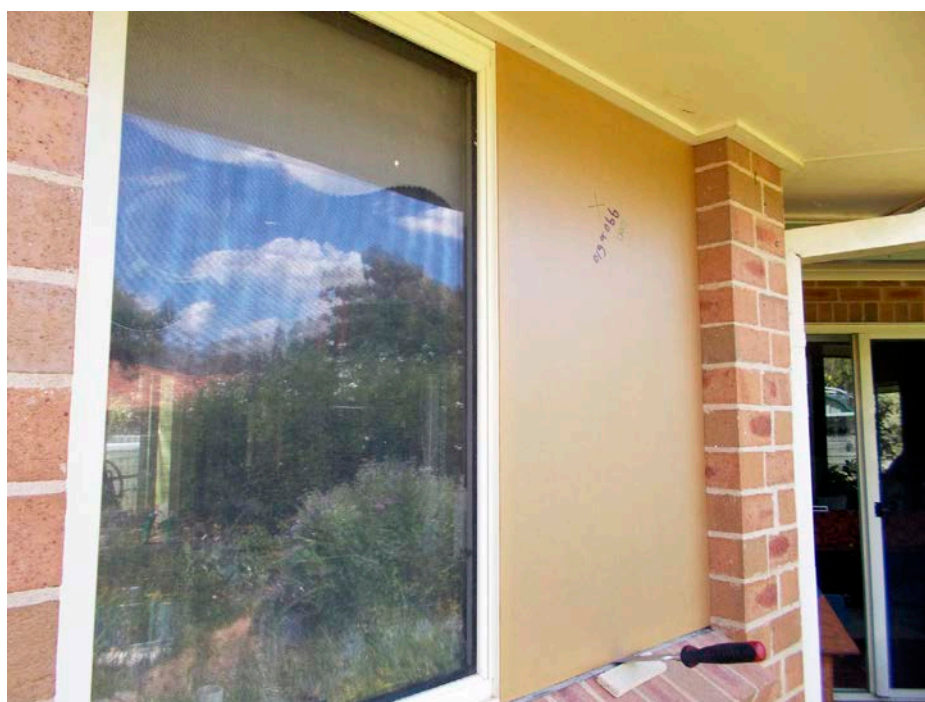
BUILT in 2002, my four-bedroom brick veneer house has stock standard powder-coated aluminium windows and doors. With my previous efforts to retrofit for energy savings and thermal comfort (see 'Efficiency on a budget' in *ReNew 130*), I had already fitted effective shading for my windows in the warmer weather. As I understand it, this is a prerequisite if double glazing is not going to be counterproductive in summer. But for winter, double-glazed windows insulate and thus hold in the heat much better than a single-glazed pane. Thus, I embarked on a project to retrofit my windows with a second (acrylic) pane.

### Materials

For the additional panes, I used 3mm cast acrylic sheet accurately cut to size commercially by The Plastics Factory. They cut 34 panels within a tolerance of 1mm to my requested dimensions. Accurate measuring by myself was of paramount importance for this! Buying direct from a wholesaler meant a good saving; in fact, the cost was around half that of uncut sheets from local retail outlets.

I adhered the acrylic sheet to the aluminium surrounds of each panel of glass using highly flexible silicone sealant. The reasons for this choice were two-fold.

Firstly, the linear expansion rate from a change in temperature is significantly different between the acrylic sheet and the aluminium frame, with the acrylic expanding at three times the rate of the aluminium. With a 1200mm edge and a temperature change from 0 to 40°C, the acrylic would expand nearly 4mm more than the aluminium frame. Flexibility of the sealant would cater for this to some extent.



↑ Here you can see one of the acrylic sheets attached to a fixed window, before the protective paper is removed.

Secondly, if a glass panel needs replacing down the track or a return to single glazing is desired, the silicone sealant could be scraped off (although still a tedious, fiddly job!)

### Selection of sealant/adhesive

I tested several sealant products in my workshop. I already had decided to use highly flexible silicone sealant to cope with differing expansion rates between aluminium and acrylic. All the silicone sealants at local outlets advised that bonding may be poor with many plastics. Initial testing with both flexible and highly flexible silicone sealants suggested that bonding to sheet acrylic was poor regardless

of brand or label descriptions—silicone sealant is always silicone sealant. I found that most silicone sealants adhered firmly to the powder-coated aluminium. However, the bond to the acrylic sheet was poor using any of the available brands.

I trialled the highly flexible sealant on a number of windows with mixed and usually short-lived success. Some acrylic is still bonded after twelve months, but other panels separated along some edges and needed to be redone. Sizing without allowing any tolerance for the acrylic expanding more than the aluminium was often to blame.

Even though I shaded the double glazing