ReNew

Technology for a sustainable future

Issue 130

SUSTAINABLE COOLING ISSUE

Save your garden this summer with our **Greywater System Buyers Guide**—find it inside!

Solar cooling in a warming climate

PLUS The Greeny Flat experiment, off-grid in the suburbs, energy-efficient cooking, solar monitoring & more

Issue 130 January-March 2015
AU $8.95 NZ $9.90
www.renew.org.au

ISSN 1327-1938

Gas vs electricity: economics & emissions
Pre-cooling with solar: pros and cons
DIY: easy, low-cost retrofitting

WIN
a hot water heat pump from Siddons Solarstream!
*Australian residents only

Contents

Issue 130, January – March 2015

- Read more articles at renew.org.au
- Follow us on Twitter: twitter.com/ReNewMagazine
- Like us on Facebook: facebook.com/ReNewMag

Sustainable cooling
in a warming climate

↑ An all-electric granny flat. Page 22.

↑ Recommended reads to inspire you over the holidays, and chances to win! Page 86.

Features

↑ Crops for food or fuel? Page 36.

↑ Holidays that make a real difference to Timor. Page 38.

← **Cover image: Uli Jakob, Solem Consulting, www.solem-consulting.com**
This parabolic trough collector sits on a movie theatre in Newcastle as part of a solar cooling system installed in 2010. It's one of the nine solar air conditioning systems installed in Australia, of around 1200 systems installed worldwide. Solem Consulting, an international consultancy with expertise in this area, was responsible for the design and commissioning of the Newcastle system. Find out more about the state of solar cooling, now and in the future, in our article on page 46.

Special feature: sustainable cooling

↑ Simple energy efficiency retrofits. Page 82.

Guides

Greywater system buyers guide

DIY

Regulars

Editorial

Energy use in a warming climate

IN THE warmer parts of Australia, air conditioners are the greatest contributor to home energy use (it's 40% in Darwin, for example). They've also become a contributor to peak demand in many places, where increasing heatwaves and the after-work switch-on of air conditioners add to peak load, even if only for a few days a year.

Better housing design is the best way to address this, rather than more-efficient air conditioners but, realistically, both have a role to play.

We're often asked about solar cooling as an option, but given the lack of domestic-sized, affordable systems, we've only covered it briefly in the past. This issue, though, we go a bit deeper with an article by Mike Dennis from ANU, a researcher with a special interest in this area. He details the systems being trialled at ANU and CSIRO, and provides a wealth of references and resources.

Of course, there are already solar cooling systems available—PV paired with an efficient reverse-cycle or evaporative air conditioner—and we do describe these options. However, as we've noted in the past, there are limitations, with the timing of peak air conditioner use misaligned with peak PV production.

Batteries can offset this, but what about pre-cooling—running the air conditioner before you get home to take advantage of daytime PV power. Could this reduce air conditioner energy use at peak times, and potentially your bills? We ask the question of Sunulator, with some interesting results.

In terms of housing design, there are many approaches where passive cooling is possible, but there are also challenges to this, with increasing heatwaves (an early reality of a warming climate) and a reduction in the diurnal range of temperatures. We reprint an article from our sister publication, *Sanctuary*, that's a call to action for our sustainable designers and planners, and for individuals, to reconsider how they approach housing design and use in a warming climate.

It's not all about cooling this issue. We also have the Greeny Flat Experiment, an owner-built granny flat: a sustainable, small all-electric home on a budget. The owner gives us a real insight into the construction costs and design decisions. It's a great read, and is paired with research that asks whether infill housing, like granny flats, could be a way to accommodate increasing population pressures, rather than developing our urban fringes.

We also present research from the ATA (*ReNew*'s publisher) into whether it's more cost-effective (and lower emissions) to switch from gas to efficient electric appliances. We cover the ethics of using food crops for biofuels, Alan Pears begins a discussion on cooking and energy use, we present a buyers guide on greywater, our 'basics' article explains energy and solar metering, and we explore AC coupling in off-grid systems; plus a holiday reading guide! We wish you a safe and sustainable holiday season and look forward to hearing from you in the new year.

Robyn Deed
ReNew Editor

In *ReNew 131*, out mid-March

Electric vehicles in Australia and overseas, battery buyers guide + more.

WOW, where has the year gone? It has been a thrilling 12 months here at the Alternative Technology Association with many exciting projects and events. We are still coming to terms with receiving $250,000 from Google Australia for our Solar for Timor project.

The project will mean a major escalation of the ATA's work in East Timor. Since 2003 we have been installing solar-powered lighting in homes, schools, community centres, hospitals and orphanages in remote villages, as it is estimated that 20% of all houses in East Timor will never be connected to an electricity grid.

We have a strong focus on training Timorese people to install and manage their own solar power and lighting. To build technical capacity in-country, in December 2013 the ATA formed a partnership with CNEFP-Tibar (an East Timorese training institution) to establish an ongoing technical support role.

With support from Google, the ATA will train and employ local technicians to install hundreds of household lighting systems in remote houses in East Timor. We will also put in place an ongoing maintenance program for existing and future solar installations.

You can help create a sustainable solar industry in East Timor by giving the gift of light this Christmas. Buy a solar panel for an East Timorese family for $50 or a whole solar system for a family for $250. Go to shop.ata.org.au to buy your gift card.

With your support, hundreds of Timorese villagers will be able to see at night with clean, solar-powered lighting instead of relying on candles or polluting kerosene lamps.

Donna Luckman
CEO, ATA

The Greeny Flat experiment
Small-scale, sustainable, affordable

Andy Lemann shares the principles, materials, results and lessons learnt in building a low-cost, high-efficiency home. Seven months into a one-year trial, the outcomes are promising.

FOR me, learning to live in harmony with the planet means learning to live without fossil fuels. Before I'm accused of gross hypocrisy, let me be the first to admit that my way of life is highly unsustainable: I drive a car, I eat food grown in faraway places, I use fossil fuels. I certainly don't have all the answers, I'm simply attempting to take the first steps towards a fossil-fuel-free future. That is what the Greeny Flat is all about.

The Greeny Flat is a full-scale living experiment currently underway on a quiet street in Mittagong in the Southern Highlands of NSW. We're aiming to see if it's possible to build a small, comfortable, healthy, energy-positive, low-maintenance, fire-resistant, water-efficient, elderly-friendly infill house at an affordable price. Our two primary aims were to make it energy-positive and affordable.

For 20 years I designed and built sustainable houses in the Rocky Mountains of Montana, near the Canadian border, where the winters get down to -40 °C and the summers up to +40 °C. In that climate, attempting to come even close to net zero energy building is a huge challenge. When I returned home to the NSW Southern Highlands a couple of years ago, it occurred to me that building an energy-positive home here should be relatively easy and inexpensive.

I have since learnt that the cost of most things in Australia is much higher than in the States, so making the Greeny Flat affordable has, in fact, proved to be our biggest challenge. Meanwhile, my partner Cintia and I have lived in the house for nearly seven months, closely monitoring its energy performance, water usage, indoor air quality and comfort levels to see whether it actually meets the initial goals.

↑ The Greeny Flat aims to be both cost-effective and energy-positive.

The perfect site

The Greeny Flat is designed to meet the future needs of my aging parents who, in their infinite wisdom, had found and purchased an excellent site over 20 years ago. There's an existing fibro cottage on the east half of the lot that they rent out, which left the west half available for us to build the Greeny Flat.

It is the perfect site for a passive solar home with a gentle slope to the north-east, nice views to the north, and existing buildings and trees to the west and south providing protection from cold winter and hot summer winds. The excellent solar access is also protected by the street to the north, which means that no neighbour can build or plant anything to block our sun in the future.

Just as importantly, this is an infill site in an already-developed area. This helps to reduce sprawl, preserve open space, agricultural land and natural habitats, maximise use of existing infrastructure, and reduce driving.

On that latter point, all the things we use on a regular basis (including shops, schools, medical centres, the town library, parks, playgrounds, hardware stores and trains to Sydney, Canberra and Melbourne) are within easy walking distance of the Greeny Flat, so we could easily live here without a car. To give an indication of how important this is,

It's heating up
Energy-efficient cooking

What do you need to consider when looking at the energy and environmental aspects of cooking? Alan Pears begins the discussion.

IN ENERGY and environmental terms, cooking is just one part of a complex system in the food supply chain. The food system accounts for around 25% of greenhouse gas emissions in Australia. Of that, cooking is a small part, about 3% (see Chart 1). The other factors such as the production, transport, sourcing and types of ingredients are major issues that we don't have space to tackle here.

Even though energy use from cooking is a relatively small portion of food-related energy use, it can still be significant. An average Australian home uses around 600 kilowatt-hours (kWh) of electricity each year for all-electric cooking (costing $150 or more), while gas cooking typically uses 3 to 5 gigajoules (GJ), costing $60 to $250 depending on usage and gas price. Many homes use a gas cooktop and electric oven. Most homes also have several benchtop cooking units such as microwave ovens, toasters, electric kettles and rice cookers.

Energy use for cooking is particularly an issue for households that are off-grid. Many off-grid homes use gas for cooking rather than electricity (because of the high loads from electric cooking appliances), yet this still has a greenhouse gas impact, and can be expensive when it's LPG rather than natural gas.

Electric cooking can also be a major contributor to evening peak electricity demand. As electricity suppliers introduce time-of-use pricing or peak demand charges, it will be important to manage cooking demand. Gas prices are also increasing, while LPG is already very expensive.

So energy-efficient cooking and reduction of peak energy demand for cooking are important. This article looks at these issues.

Where is energy wasted in cooking?

As with all energy efficiency analysis, standby energy use can be an issue. The way you heat up (or defrost) food can also affect energy use, as does the way you manage cooking post the 'heating up' phase. And then, the appliances themselves (such as ovens, grillers etc) all have their own efficiencies and optimal usage patterns.

The energy use of kitchen lighting and non-cooking appliances (fridges and dishwashers) should also be considered, but they have been well covered elsewhere so won't be discussed here. But, just as an example, lighting a kitchen with six halogen lamps for two hours a day uses half as much electricity as cooking.

Standby energy

Luckily, gas cookers no longer have pilot lights that cost a lot to run. But many cooking appliances use energy when on standby for clocks, 'smart' features, electronics and in some cases keeping components hot, ready for action. Standby consumption is declining, but older equipment and even some new products, such as coffee makers (see 'Check your coffee machine'), can have surprisingly high standby consumption.

A good rule of thumb: if you're not confident an appliance has standby power under 1 watt, switch it off at the power point.

Heating up

Heating things up from room temperature or, even more significantly, from below freezing point, can constitute a large proportion of cooking energy. To heat a kilogram of food on a cooktop from room temperature to 100 °C requires around 0.85 MJ of gas or 0.15 kWh of electricity. An empty pot or casserole dish weighs from one half to two kilograms. Heating up a one kilogram frying pan can require a third as much heat as defrosting that amount of food. Heating up a pot or frying pan without a lid also dramatically increases energy costs, as air is heated, then rises to be replaced by more cold air: effectively you are cooling the pot while trying to heat it.

Boiling off water uses nearly seven times as much energy as heating it from room

→ The Flare Pan range from Lakeland in the UK feature fins to increase the surface area of the pot which improves heat absorbtion on a gas cooktop by up to 40%.

ATA research
Are we still cooking with gas?

Gas report author Kate Leslie gives the lowdown on the research and its findings.

The Alternative Technology Association (ATA), has just launched a report that considers the economic implications of projected retail gas price rises on households, and asks whether there are efficient electric alternatives that are more cost-effective.

Funded by the Consumer Advocacy Panel, the research aims to identify those locations and household types that may benefit from a switch from gas to efficient electric appliance use—or from staying off the gas network in the first place (in the case of new homes or existing all-electric homes). The research also separately analysed the environmental impact of these potential switching decisions.

Much of the emphasis in the gas debate to date (which has been largely dominated by industry) has been on increasing gas production, as opposed to considering potential changes in demand. ATA's research asks whether increasing gas production is the most cost-effective, efficient and sustainable approach.

Gas price rises are already an important issue for residential consumers; according to the Victorian Council of Social Services, "Household gas prices have risen 33% in real terms since 2008–09, largely unnoticed because all the attention has been on the more rapid growth in electricity prices over the same period (53%)." (www.bit.ly/VCOSSGPR)

Analysts vary on how much gas prices will rise over the next 5 to 10 years, but all agree that more rises are coming.

So what are the alternatives?

Gas is typically used in homes for space heating, water heating and/or cooking. Over the last few years, efficient electric alternatives for all these end uses have become available. The most cost-effective, efficient electric alternatives chosen for the research were:

- heat pump reverse-cycle air conditioners—for space heating
- heat pump hot water systems—for water heating
- induction cooktops and efficient electric ovens—for cooking.

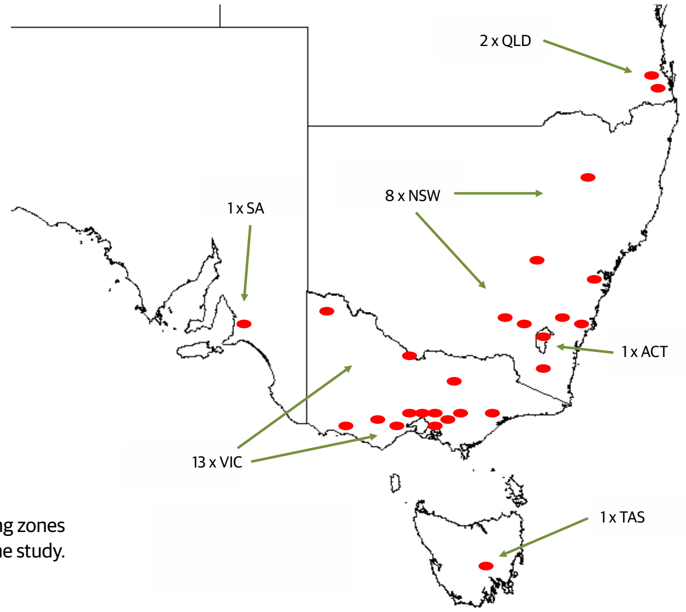
Scenarios

The research considered the economic case for replacing gas appliances with electric options in a range of different 'gas zones', for a range of different house types and under a range of different 'replacement cases'.

Replacement cases include whether or not the house is currently gas connected, the number and type of gas appliances to be switched, and whether existing gas appliances are close to the end of their life (i.e. due to be replaced within five years).

Figure 1 shows the 26 gas pricing zones modelled. The variety of zones meant that the research could take into account the different gas prices and pricing structures that exist across locations, as well as the different space/water heating end-use needs by climate zone; Table 1 shows the heating load assumed per climate location.

The research also modelled six different household types, ranging from small to large existing homes (all assumed to have R2.5 ceiling insulation), a typical public housing home (taking into account relevant energy concessions), and a new 6 Star home (see Table 2). This enabled analysis of households with different space and water heating requirements as well as cooking energy use.



→ Figure 1. The 26 gas pricing zones that were modelled for the study.

Food vs fuel
Ethics and sustainability

Does biofuel production contribute to global food shortage and hunger, or not? Dr Seona Candy steps us through the pros, cons and complexities of using food crops for biofuels.

Photo: Carrstuff. Source: www.all-free-download.com.

↑ Biofuels are generally made from crops high in sugar (e.g. cane), starch (e.g. corn, wheat) or oils (e.g. canola); these are also human food staples.

IN A recent edition of *ReNew* (*ReNew 127*), an article describing the use of grain as fuel for wood pellet stoves was published. It inspired some opposing comments regarding the use of food for fuel. Although I can't comment directly on this particular case of burning grain for space heating, I can perhaps provide some insight into the complexity, ethics and sustainability of the wider debate.

The 'food vs fuel' debate, as it is commonly known, is mainly concerned with first-generation liquid biofuels. These biofuels are derived from various agricultural crops that can also be used for food and feed, and have been developed primarily for transport uses. This is the case because there are already considered to be sufficient renewable energy options available to provide stationary energy.

The central argument in the 'food vs fuel' ethical debate is about whether the development (or not) of biofuels will cause people to go hungry. Critics of biofuels argue that diverting food crops to biofuel production will increase food prices and cause hunger, particularly among the global poor. Advocates of biofuels argue that their development will help mitigate climate change, and its potential future impacts on agriculture and food production, thus avoiding hunger for everyone (the global poor included) in the longer term.

The first of these two arguments seems fairly straightforward. Indeed, biofuel development in the early 2000s did precede significant rises in the prices of staple crops, causing the 2007/08 global food crisis and food riots in many countries. But it is not safe to assume that biofuels alone caused food prices to rise or that the impacts of rising food prices were negative for all groups who make up the global poor.

According to a report[1] from the International Food Policy Research Institute, the 2007/08 food crisis was primarily driven by a combination of rising oil prices, a greater demand for biofuels and trade shocks in the food market.

Rising oil prices led to increased costs of cereal production, as conventional agriculture is an energy-intensive enterprise. Higher energy prices increased the demand for biofuels, which became more competitively priced when compared with oil. At the same time, cereal demand increased from oil-producing countries and weather shocks reduced the supply of some grains, increasing prices further. This led to a ban on exports by producers and panic buying by importers, which only increased prices yet again.

These increased prices led to food riots in developing countries. As Thompson[2] argues, though, increased food prices negatively impact mainly the urban poor, who must purchase their food. For the rural poor, however, who produce and sell their food, rising food prices could be an advantage. It would increase their income and ability to buy food that they don't grow themselves. Since the rural poor make up around 80% of the global poor, fewer people may in fact go hungry due to rising food prices.

In reality, corruption, weak land tenure, land grabbing and increasing numbers of landless rural poor in developing countries may mean that the benefits of increased food prices often don't end up with those who are growing the food. These problems relate to issues with food sovereignty and major inequities in the distribution of power in our

Kael Rail
Ultralight solar bike rail project

Being involved with the ATA (*ReNew*'s publisher) is something that brings great variety and enjoyment. A great example of this was a chance phone call with Danielle and her seven-year-old daughter Kael. Doug Rolfe explains.

SEVEN-YEAR-OLD Kael had an idea for her local school science competition, but working out if the idea was realistic was proving a problem. After all, where do you go to ask about solar-powered trains for transporting kids with bikes to school?

Queensland Rail did their best to help with information about their electric rolling stock, but the scale of the average locomotive and standard carriages was well beyond what Kael was thinking of.

Happily, someone put Danielle, Kael's mum, onto the ATA. We quickly saw that Kael's idea had merit and pooled our office expertise to help find existing projects worldwide. Our local experience with Melbourne trams and custom electric vehicles also proved helpful.

After some help in understanding the rough energy requirements, Kael was able to finish her research and complete her project.

Prize-winning

A few weeks later, we got the exciting news—after receiving a highly commended award at Mudgeeraba Creek State School, Kael had won first place in the Year 2 and 3 division of the Griffith University Gold Coast Schools Science Competition in the Environmental Action Project section. Of course, Kael was most excited by the prize of an iTunes voucher:"You can download games!"

This success also meant that Kael's project was automatically entered in the science competition run by the Science Teachers Association of Queensland. After some nervous days, Danielle received word that Kael had to attend as she had won a prize.

In the end, Kael's project won her first prize in her division in the Queensland event. Mudgeeraba Creek State School won the prize for best overall school—they received 21 prizes from their 31 entries, including the Queensland Science Student of the Year!

> "If 30 kids can go on my solar-powered bike rail and it can run 8 trips each day, that's 240 kids' trips per day; 1200 less cars trips over a week."

What gave Kael the idea?

Kael says: "We love our school, which is why we travel the extra distance. I have always wanted to ride my bike to school. But Mum and Dad say it's too dangerous and there are places without bike paths. We do have electric trains, but not near us. I like riding my bike and I'm getting really fast. At school, we were looking at how we use energy in our lives. So then I thought of a solar-powered bike rail. Solar is free energy from the sun and no pollution."

Danielle, Kael's mum, says that the local roads are a big traffic area during school times. Some mornings it can take 40 minutes to do what's usually a seven-minute drive. The high concentration of schools in the area means

Who needs fossil fuels? Tricks and traps of solar car design

In part 3 of our series on the SolarX car design, Swinburne University's Clint Steele talks to product design engineer Davis Tolley about the challenges and the refinements made so far.

OVER the past months, much work has gone into refining the body of the SolarX sports car. In fact, it could be argued that it has been much more than refining. Some dead ends have been encountered and the car now looks very different to what we showed you in previous issues.

So, in this third instalment, we talk with one of the engineers involved in the car's design. Davis Tolley is a product design engineer, a discipline that combines mechanical engineering with industrial design. Such engineers, with an ability to make products that perform and look good, are ideal for this challenging task.

Davis has been on the team for over a year now and has proven his ability when it comes to designing highly refined engineering systems that still need to capture hearts and minds. I asked Davis about the challenges faced and what he can share with other EV enthusiasts interested in solar.

↑ Davis investigating how driver position and field of view can be achieved while maintaining good aerodynamics.

Q: What are the challenges when designing a solar sports car body?

A: By far the biggest challenge is achieving a satisfactory balance between aerodynamic performance, looks and solar panel alignment. Good aerodynamic performance requires tapering of the body towards the rear as well as enclosed wheel shrouds, and it's difficult to achieve, even without the extra requirements of 'sporty looks' and solar panels. Sporty cars feature exaggerated wheels and chunky rear ends, the opposite of aerodynamic. Solar panels add to the difficulty even more as they must be uniformly aligned, so the top of the car must be made as flat as possible. This detracts from the look and is often not aerodynamic.

Q: What design targets did you have and how do they compare to other cars?

A: The major aerodynamic design target was to achieve a CdA (coefficient of drag area) of 0.2. A vehicle's CdA is equal to its drag coefficient (Cd) multiplied by its frontal area, A. The drag coefficient is a dimensionless quantity that is used to quantify the drag or resistance of an object in a fluid environment, such as air or water. It is calculated using the formula $\frac{F}{\frac{1}{2}\rho v^2 A}$ where F is the drag force, ρ is the density of air, v is the speed of the car and A is the frontal area of the car. The coefficient of drag area provides a method of comparing the aerodynamic drag produced by different vehicles, independent of speed. The CdA of modern passenger cars ranges from 0.47 (Honda Insight) to 2.5 (Hummer H2), with the average car having a CdA of about 0.6 (the Tesla Model S is 0.613). The car also had to be designed to achieve near zero lift and down force, as well as maintaining aerodynamic performance in strong crosswinds.

The body also needed to be able to sport at least 350 solar cells to achieve acceptable endurance and performance.

Q: What's the key to achieving each of these?

A: I think the key to designing a car body like this is to nail the aerodynamics before anything else. As a designer you immediately want to get out a pen and pad and start sketching, but that just doesn't work for a car like this. I've learnt that it's much easier to make an aerodynamic car look good than to make a good-looking car aerodynamic. To meet the CdA target, the car basically became a big fat airfoil in disguise.

Reducing air conditioner impacts
The state of solar cooling

It's the holy grail of cooling—using the sun to power your cooling system. Mike Dennis from ANU takes us on a tour of where the solar cooling market is now and where it's headed.

MOST Australian homes are now equipped with some kind of air conditioner, but their rise in popularity over the last decade has put substantial pressure on the electricity transmission and distribution network—and the required investment in 'poles and wires' has been blamed for recent spikes in retail electricity bills.

Some electricity retailers charge a premium for grid electricity drawn during afternoon periods when air conditioning may be in use, but offer a paltry sum in return for photovoltaic power supplied to the grid during the same period. One NSW retailer charges over 50c/kWh between 2 pm and 8 pm on weekdays while offering only 6c/kWh in return for net photovoltaic energy exported to the grid.

Water heating and air conditioning are usually the two main energy sinks in a residence. To some extent, water heating may be time-shifted to avoid exposure to peak tariffs, but air conditioning load offers less flexibility. What can be done about this?

The first consideration, of course, should be to try to reduce or eliminate the need for active air conditioning. A well-designed building with appropriate shading, insulation and thermal mass is a good start. Secondly, householders should explore opportunities for passive air conditioning using prevailing breezes and carefully designed cross and stack ventilation. *ReNew* readers will no doubt be well aware of this from previous articles (for example, see Alan Pears 'Guilt-free cooling' article in *ReNew 122* and 'Design for a changing climate', p. 58 this issue).

As a last resort, a householder may decide to install an electric air conditioning system. These devices are intoxicatingly effective in providing comfort with convenience and immediacy. The shopfloor price may not be as confronting as the first electricity bill, however!

So, how can householders sidestep peak electricity charges and be comfortable in their homes at the same time?

Image courtesy Solem Consulting, www.solem-consulting.com

↑ This trough collector sits on the Charlestown Square Shopping Centre in Newcastle, NSW, as part of a solar cooling system installed in 2010; for more info, see p. 50.

Active air conditioning options that minimise environmental impact

PV-POWER

The obvious option is to install a photovoltaic (PV) system to drive a regular air conditioner (see Figure 1). Several companies offer packages to do this directly, or it can simply mean installing a larger PV system to run the whole house (see 'Solar cooling options available now', p. 50).

However, electrical supply will be required late in the afternoon and into the evening to offer proper service during summer cooling and winter heating periods.

It is worth noting that peak summer cooling loads often occur late in the afternoon, while peak solar is at noon. In winter, peak heating loads are in the evening.

Hence, backup will be required in the form of either a grid connection or a local electricity

COOLmob
Smart cooling in the tropics

With cooling the biggest contributor to household energy use in the tropics, an innovative new project is finding smart, simple ways to change that. Jessica Steinborner from COOLmob explains.

THIS time of year in Darwin sees two things rising to uncomfortable levels: temperatures and power bills.

The onset of the hot, wet season leads people to seek relief indoors with the aid of air conditioners, with a consequent spike in their energy consumption and bills, particularly an issue for those on low incomes.

But a program currently being rolled out in the Top End is aiming to change that. The message, and practice, of the program is that keeping cool in the tropics doesn't have to mean the household budget taking a hit.

Smart Cooling in the Tropics, funded by the federal government's Low Income Energy Efficiency Program (LIEEP), is helping people keep cool while keeping costs to a minimum.

Its focus is on educating and assisting people to use a range of strategies to make their living spaces cooler. This includes getting maximum efficiency from their cooling devices and making their homes easier places to keep cool.

The program, which began in March this year, is being delivered by COOLmob, a Darwin-based program run by the Environment Centre Northern Territory that promotes energy efficiency and other aspects of sustainable living.

A three-pronged approach

Each Smart Cooling participant receives an energy-use assessment from a visiting trained COOLmob officer. The outcome of this assessment determines the type of treatment. The project focuses on three things: energy literacy, effective use of appliances and appliance upgrades, and retrofits that improve the thermal performance of the building.

Energy literacy promotes simple, practical actions such as understanding electricity consumption and bills, setting timers and thermostats on air conditioners to reduce electricity use, and making use of prevailing breezes.

The appliance upgrade service can provide pedestal and floor fans, to encourage less energy-intensive cooling systems. It can also retrofit devices such as a thermostat controller to older air conditioners, clean air conditioners to make them more efficient and

← The Smart Cooling program starts with an energy-use assessment. Assessor Glenn Evans looks at energy bills with client Ananthan Ginadasa.

Design for a changing climate
Heatwaves

Heatwaves are already becoming more frequent, and are likely to increase exponentially as the climate warms. Dick Clarke and Chris Reardon look at how we need to rethink the way we are designing our homes.

CLIMATE change is with us and no achievable amount of mitigation is going to reverse its effects sufficiently to prevent our need to adapt. Australian houses today are largely designed or modified based on historic climate data, even though we (or someone else) will be living in them for at least 50 years. Quite simply, this approach is inadequate in a rapidly changing climate. While we will no doubt survive the two to three degrees of warming already locked in, we urgently need to re-think our approach to housing to cope with the extremes.

Hotter for longer

Heatwaves of increasing frequency, intensity and duration are occurring in the southern half of the nation and have already killed many hundreds of people. CSIRO and the Bureau of Meteorology predict that these will increase exponentially. We will not be able to cool or air-condition our way through these crises.

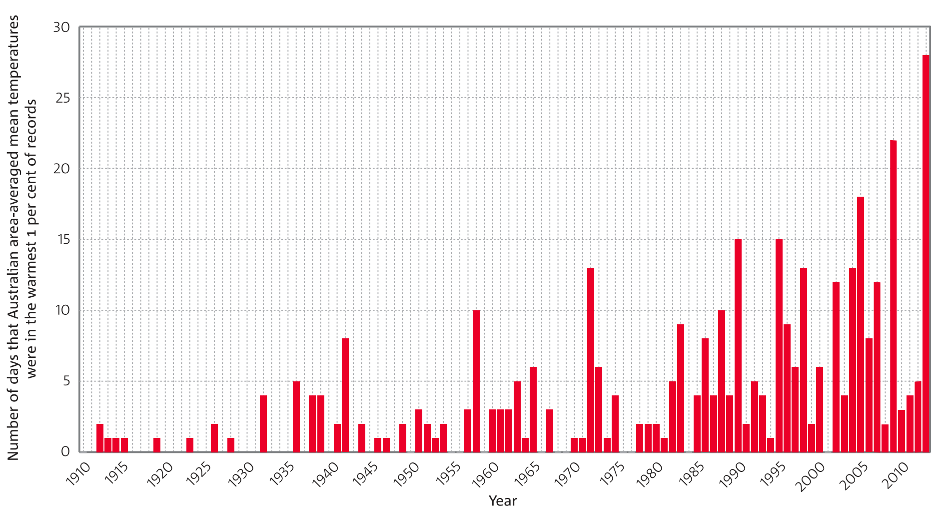
Heatwaves are regional events. When we all cool our homes at the same time, we cause electricity demand to peak and, on top of increasing electricity costs, grid failure becomes increasingly likely during peak demand periods. Homes without an alternative coping strategy will become uninhabitable at best. While those of limited means will likely be most severely affected due to cooling unaffordability and poor home design, comfort moves beyond the reach of everyone when the grid is down.

Australian cities likely to experience increasingly severe heatwaves include Melbourne, Adelaide, Perth, Launceston and Hobart as well as most south-eastern regional areas. These climates traditionally require significant amounts of heating in winter. Our standard design response to-date has been to apply passive design principles, relying on significant amounts of thermal mass.

This approach allows dense materials to store daytime warmth from the sun and release it into living spaces at night to offset the coolest temperatures in winter, and night purging during summer to take advantage of cooler outdoor temperatures.

As the climate warms and winters become shorter, homes in these areas will require less winter heating and more summer cooling. In many of these climates, night purging via cross ventilation and convection (internal hot air rising and exiting that in turn draws in cooler night air at floor level) would become gradually less effective. During heatwaves, temperatures can remain well above comfort levels all night—thus, eliminating any passive cooling opportunities. Under these conditions, the temperature of the thermal mass would increase substantially and take many days to cool down when a heatwave eventually passes.

While many regions in our southern states will have heating-dominated climates for decades to come (where more energy is used for heating than cooling), the following suggested measures will also help keep homes warm and so are prudent investments.



↑ The number of days on which Australian mean temperatures were in the warmest 1% since records began. Courtesy of the Bureau of Meteorology, *State of the Climate 2014*.

AC versus DC coupling
Advanced energy transfer in solar systems

There's been a shift in off-grid solar systems towards using an AC coupling topology; but just how does that work? Lindsay Hart from Selectronic explains and describes Selectronic's homegrown solution.

UNTIL the early 1990s, renewable energy systems were basically all battery based. Then we saw the creation of the new breed of grid-connected systems, which were much simpler and generally did not contain batteries.

Thanks largely to government subsidies around the world, grid-connnected solar systems have proven extremely popular—the introduction of these systems was the first time the renewable energy industry saw real mass production possibilities for equipment manufacturers.

We have seen PV panels plummet in price over the past 10 years and panel sizes have continued to grow in size, with some small gains in efficiency also.

Grid-interactive inverters have also fallen in price, with efficiency and features steadily improving. Initially all inverters featured one maximum power point tracker (MPPT) to extract the maximum possible amount of power out of an array of solar panels. As system sizes got bigger, shading became an issue and most inverter manufacturers now offer models with two separate MPPTs to help alleviate this issue.

But have any of these advances provided any benefits for battery-based systems?

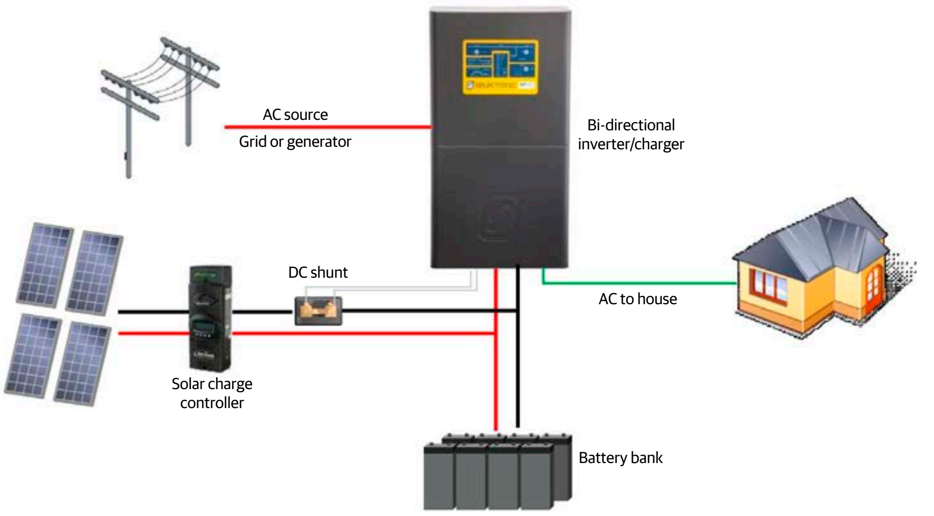


Figure 1. DC-coupled systems charge their batteries directly from the solar array via a charge controller.

DC coupling

Traditionally in battery-based systems, the solar panels directly charge the battery bank via the charge controller which ensures the batteries are not overcharged. Such a system is known as DC-coupled, as DC from the solar panels is fed directly into the battery bank (DC = direct current, current that stays fixed in polarity).

Recently, there has been a trend away from the older type of charge controllers that used PWM (pulse width modulation) charging regimes towards those that use MPPT inputs. These enable arrays of higher voltage than the battery being charged: the controller steps down the array voltage to suit the battery voltage, while boosting the current. The input voltage of an MPPT controller is typically in the range of 100–150 V, with some of the latest releases offering 600 V inputs. This means smaller-sized cables and lower power losses.

Figure 1 shows how a DC-coupled PV system might be configured. The charge controller works independently of the inverter/charger to charge the batteries directly. Some systems use only battery voltage to determine when the battery needs charging; a more advanced system will use communication with the inverter/charger to calculate a more accurate battery state of charge for better battery health. Energy in the battery is converted to AC by the inverter/charger to power the loads.

The efficiency of most DC MPPT charge controllers is very good, up to 99%. They provide reliable and stable battery charging control using multi-stage battery charging algorithms.

Compared to AC coupling (described later), DC coupling has both advantages and disadvantages. The purchase price of the hardware tends to be more cost-effective for systems below 4 kW and the electrical efficiency for battery charging is very high. However, most solar controllers will require the wiring of multiple solar panel strings in parallel, which increases on-site labour costs. In addition, many charge controllers can only operate with 12, 24 or 48V batteries.

Save your garden this summer
Greywater system buyers guide

Although many regions no longer have water restrictions, water is still a very precious resource in a country as dry as Australia. Greywater systems let you use water at least twice, which makes good environmental sense. Here, we look at what systems are available.

THE advantage of greywater is that we produce it on a daily basis. In many cases it can be diverted to the garden with minimal effort and cost in a number of different ways. You can opt for a low-cost DIY system using something as simple as a greywater diversion hose attached to your washing machine outlet. Or you might be considering installing a full commercial greywater system. Whichever way you go, there are a number of things you need to consider.

This guide highlights the main issues associated with greywater reuse. There are many choices available and there is no single solution for all circumstances. Therefore, the more research you do, the more suitable your system will be for your particular situation.

There can be many restrictions as to where systems can be installed. In some cases, especially for retrofits, installing a greywater system will require major works—this can make the system cost-prohibitive.

Image: Josh Byrne & Associates, www.joshshouse.com.au

↑ Greywater is fed to the garden in Josh's House (joshshouse.com.au) via a series of drip-feed lines. Here they can be seen before being covered with 100mm of mulch. Some states, such as WA, only allow sub-surface distribution of untreated greywater.

Greywater sources

Greywater is any wastewater generated from your laundry (sinks and appliances), bathroom (baths, showers, basins) and kitchen (sinks and dishwashers), before it has come into contact with the sewer. It does not include toilet wastewater, which is classed as blackwater.

However, while kitchen and dishwasher water is technically greywater, unless you are treating it, it is recommended that you don't use this water source. Kitchen water only makes up around five percent of total water consumed in the average home, yet it is considered the most contaminated. This is partly due to high sodium levels from some dishwashing detergents, particularly from dishwashers, solid matter such as food waste from rinsing dishes, as well as fats, grease and oils from cooking and cleaning, which can all damage soil structure if allowed to build up.

What's in the greywater?

The chemical and physical quality of greywater varies enormously, as greywater is essentially made up of the elements that you put into it.

Generally speaking, pathogen and bacteria content is low in most greywater sources (unless you are washing contaminated items, such as nappies) and, provided you take steps to minimise potential contact, such as using subsurface delivery of the greywater, it is of minimal concern.

Choosing the right cleaning products is perhaps one of the most important elements in reducing the risks associated with greywater reuse. The elements phosphorus and nitrogen are nutrients necessary for plant growth. If these elements are kept to a suitable level by choosing cleaning products with low phosphorus and nitrogen content, they can replace the need for fertilisers for gardens and lawns—the nutrients can actually be utilised by plants and soils.

The main concerns with greywater are salt build-up from cleaning products and increased pH levels in the soil. Both can have a detrimental effect on your soil and plants. However, they can both be mitigated by monitoring, conditioning your soils for optimum health and taking care to choose cleaning products with little or no salt.

Off-grid in the suburbs
EV power to the home

One *ReNew* reader has used his electric vehicle to take most of his energy consumption off-grid. He explains how he did it.

I WAS keen to increase the size of my PV system as my house was using more energy than the system produced in winter. This meant I was importing energy from the grid at 29c/kWh (100% GreenPower, I hasten to add!).

I was also keen to experiment with going off-grid. I considered going completely off-grid, but that would mean losing the perceived reliability of supply from the grid, requiring a leap of faith for a suburban consumer like me.

Off-grid economics

My solution, instead, was to install a separate off-grid PV system. I now have two PV arrays with separate inverters, one connected to the grid and one off-grid, with the house running (mainly) on the off-grid system.

The idea of going off-grid with battery systems was featured in *ReNew 128*. One article suggested that price parity with a grid connection is yet to arrive, particularly in metropolitan areas, as PV may now be cheap but batteries are still expensive.

However, I already had a good-sized (8kWh) lithium ion battery in my plug-in Prius conversion. I was able to use this battery for my off-grid system, with it providing around 6kWh storage at 75% depth of discharge. So, even though I live in metro Melbourne, the economics worked out well for me.

Technology needed

My system required some technology: I purchased a 4kVA Ecotronics unit from Commodore Australia that does it all. It is a MPPT (maximum power point tracking) PV controller, battery charger, AC inverter and grid UPS all in one (see *Products*, this issue).

It is designed to run off a 48 volt battery, the same as my Prius PHEV conversion system battery. The conversion system, from Enginer in the USA, uses a 48 volt battery and a DC–DC converter to step the voltage up for the Prius's drive system.

The Ecotronics unit can also automatically revert to grid power if there is not enough sun or the battery is low. It can even be set up for load levelling—i.e. charging the battery bank on night-rate mains power then supplying power during the day. However, with a relatively high night-rate tariff (19c/kWh), the economics for this are marginal for me—a 10c/kWh saving over the day rate of 29c/kWh.

The Ecotronics unit simply connects to the Prius conversion's 48 volt battery via a large Anderson connector (a high current rated two-pole connector popular in DC systems). When not running the house loads, the Prius battery can either be charged from the Ecotronics unit's built-in battery charger or the charger that came with the Prius conversion kit.

Powering the house

My total house load (house plus granny flat) is about 6kWh per day. The larger loads are intermittent and flexible; the heat pump hot water system is around 1kW (used only for winter boosting of my evacuated tube solar hot water system) and the PHEV charger is around 1.3kW. I use a simple timer to ensure they don't

↑ This is the plug-in Prius conversion kit in the Prius's boot. On the left is the 48 volt mains battery charger and on the right is the 48 to 240 volt DC-DC converter, which takes power from the add-on battery (the large silver box underneath everything else) and steps it up to match the Prius's system voltage. Alan's home power system runs from the 48V battery. The small box in the middle is the battery's management system.

Efficiency on a budget
Easy, low-cost retrofitting

Alan Cotterill takes us on his journey retrofitting a standard brick-veneer home for energy savings.

ELEVEN years ago we bought a near-new four-bedroom brick-veneer house in Wagga Wagga, an inland town in NSW, in an area that experiences hot summers and cold winters.

It's a fairly standard house for the area, set on a concrete slab, with a verandah running the length of the eastern side. The house is long and narrow, on a north–south axis, with only the double garage facing north. Excluding the double garage and verandah, the house size is 183 m² and the window area is 19% of the floor area.

R3.3 batts were already installed in the ceiling, along with reflective foil in the walls and under the colorbond roof. We found that an evaporative cooler provided effective summer cooling on most days and later-fitted gas central heating provided winter heating, albeit at a cost.

There were several areas, however, where we found we could significantly increase comfort and decrease bills, through simple retrofits. Some of these are detailed below, including information on any issues we encountered and how we overcame them. Hopefully this will be of assistance to others planning similar retrofits.

Downlight gaps

The house's original lights were 12 V, 20 W halogen downlights. A 30 cm clearance without insulation batts is required around each downlight to guard against overheating and fire. There were 18 halogen downlights, meaning 18 gaps in the insulation. Thus, there was about 6 m² of ceiling without insulation.

So, four years ago I did a simple changeover from 20 W halogen globes to 3 W LEDs ($15 each at the time), using the existing fittings and transformers. I later covered each downlight with a downlight mitt ($18 each) and, ensuring that all transformers were held above any insulation to prevent overheating, I filled in the insulation gaps up to the mitts.

Each mitt comes with a wire support to secure it to the plasterboard and a wire tower to secure each transformer above the mitt and batts. Installation of the mitts was easily done from below, standing on a ladder. Because they are soft, you can simply collapse them, insert them through the hole for the light fitting, and open them up inside the roof cavity and position them over the hole. Then you just push the light fitting back in place, as they are held in the ceiling with spring clips.

The main energy saving wasn't from the significantly lower wattage for lighting, but from the improved ceiling insulation, which reduced energy costs, especially from winter heating.

There were some problems, however. The original transformers were designed to run with a higher wattage than the 3 W LED globes I used, resulting in some flickering and some transformers failing. With what is available today, I would, instead, plug in an entire new 12 V LED downlight unit, which includes a matched transformer ($28 from a specialist electrical trade/retail outlet).

Also, the 3 W LED bulbs were bright enough for general socialising, but a little dim for reading. We've since added newer 8 W LED bulbs selectively, such as over a chair used for reading or over a work area in the kitchen. Not only is there now plenty of light, but the beam angle of 95 degrees (rather than a narrow 33 degrees) gives wider and more even illumination.

The choice of downlight mitt also needs to be considered carefully. Mitts need to

↑ Vent covers prevent heat loss through air conditioning vents.

↑ A DraftStoppa prevents heat loss from updrafts through exhaust fans.

↑ Downlights were covered with mitts to eliminate holes in the roof insulation.