Solar realities

On clear days around noon, up to 1000 watts of solar energy (enough to boil a kettle in about five minutes), is theoretically available on each square metre of much of the Earth's surface. Commercially available solar modules can now (2018) convert only 20% or so of that energy into electricity. By using appropriate and efficient appliances, however, such solar can free recreational vehicles and cabins substantially or totally from mains, alternator or generator power.

Whether the application is an RV, a cabin or a big property system, the fundamentals are similar. Differences are mostly a matter of scale. A good starting point is to know approximately the amount of energy different things require. Apparently similar lights and appliances may use hugely different amounts to achieve the same ends. Many older fridges use two to three times the energy of those made recently. Microwave ovens draw more current (i.e. electrical energy) than many people suspect. Depending on how it is done, water pumping may require vast amounts of energy. Or very little.

Where can solar energy be used?

It is light, not heat, that solar modules turn into electrical energy. Most solar modules lose output when hot. They work best in cold places under a bright sun. The amount of energy they produce depends on how much light (not heat) falls on them and for how long. All solar modules need at least some sunlight to operate. None work in total shade.

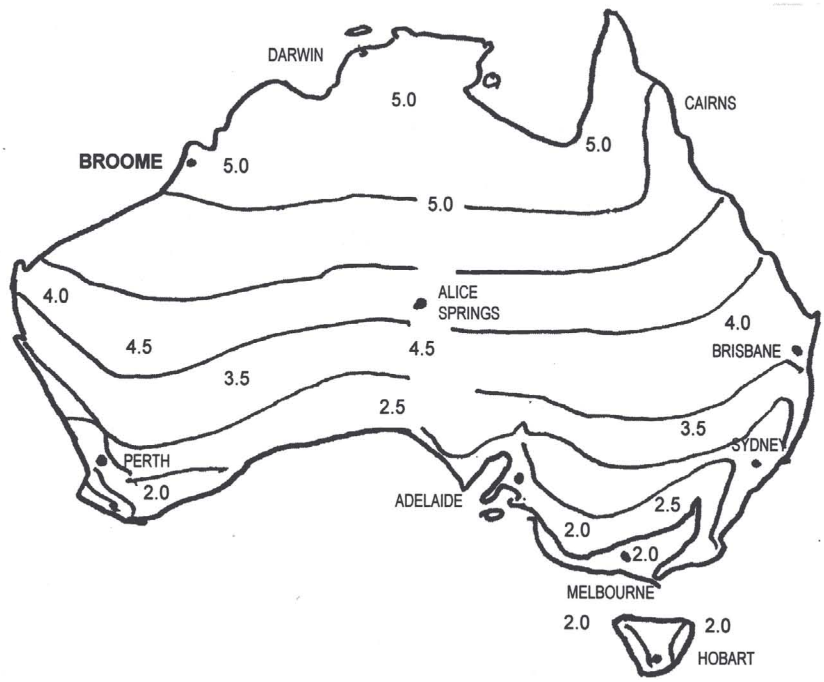
A solar module's output is measured in so-called 'Peak Sun Hours' (PSH). Each PSH is like a standardised drum full of sunlight. That drum may 'fill' in only an hour or so in Cairns or Broome during most of the year, but may take all day during Melbourne mid-winter. Each full drum can be seen as holding the equivalent of 1 PSH. The PSH concept (conceived by the solar industry) usefully averages the measurement of one's daily solar energy. It is akin to measuring the quantity of water captured over time in a rain gauge.

Our previously owned OKA in Kakadu National Park (1998). Two 80 watt Solarex modules provided ample power for all needs - including a 71-litre Autofridge. During our ten-year ownership, the batteries did not once run out of power. The spade marks where the damper was cooking. Pic: Caravan and Motorhome Books.

The map below, shows PSH for a typical Australian January (mid-summer). Irradiation varies more or less linearly from mid-summer to mid-winter. In many places and times, there will be at least 3 PSH each day. In some there will be 7 PSH or more. Full-size versions of these maps for Australian summer and winter are reproduced on page 47.

New Zealand's North Island, and the eastern part of the country's South Island have a fairly uniform 4.2-6.5 PSH between September and June, and 2-4 PSH in between.

Meteorological offices have solar irradiation maps for almost anywhere, but these require you to juggle scientific units. Here, the numbers shown are PSH. Multiplying the solar modules' true wattage output each day by the PSH shown is the number of watt/hours (see page 97) you can, on average, expect each day.



Peak Sun Hours (mid-January). Multiplying the data shown by a solar module's true wattage gives the total average output for that day in watt hours/day. This map, plus that for mid-July, is reproduced at larger scale on page 47.

'True' wattage output is emphasised because the solar industry's unusual way of rating module output causes the solar unwary to expect 25%-30% more than they thought they had paid for. This particularly catches out those who understand electrics and/or physics - but does not explain the curious ways of the solar industry. Page 17 explains how and why

To ensure you will have a robust solar system that still works in less than optimum conditions, this book advises to design an RV system assuming an absolute maximum of only 70% of the rated solar module output. If space permits, 50% is safer. Solar capacity is now so cheap that cost is usually less of an issue.

Peak Sun Hour maps allow for average seasonal cloud cover, but there are day to day variations. Input typically halves during heavy cloud, bush fire smoke may reduce it by two-thirds but it is rare to have no solar input. Output is usually high on sunny days that have light haze. It may increase yet further if sunlight is reflected from water or light sand and back to the haze layer, from where it is reflected down again.

Shortfalls resulting from long periods of cloud cover and night-time usage are covered by drawing on energy stored in battery banks. These typically provide three to five days reserve. Larger systems, and those with electric-only fridges, are likely to have generator or fuel-cell back-up.

Solar limitations

Subject to the above, solar can be used successfully in most temperate areas. Differences in its scale and implementation primarily depend on the various needs, finance and (very much for most RVs) space and weight carrying ability.

The weight carrying capacity of a vehicle's axles, wheels and tyres is legislated. As that capacity is directly related to cost, most RV builders provide what many owners believe to be less than adequate provision for payload. Included in that payload are gas, water, food, personal possessions: in essence everything placed in that vehicle after it leaves the factory. Even 'optional extras' specified in the original contract may be installed by the dealer and thus likely to further reduce available allowance.

For most caravans the personal allowance rarely exceeds 250 kg and 350 kg respectively for single and twin-axle units. Many campervan and motor home makers provide the maximum possible living space in vehicles still light enough to be driven by holders of a car licence. This has resulted in a caravan-like situation: loading space may be available but weight restrictions limits its usage. This is less of an issue with larger motor homes. Their load-carrying capacity is less limited and their length allows more space for solar modules.

If building your own RV, beware of believing weight does not matter. If you avoid MDF (a form of chipboard) you should be able to accommodate the weight of solar modules, generator and batteries.

Weight carry issues until recently restricted battery capacity, but the much lighter lithium-ion batteries now ease this issue. Pages 22-28 refer.

Fifth-wheeler caravans

Some fifth-wheelers' axles and running gear have limited payload capacity but it is usually feasible to house some part of the battery bank behind the cab of the towing vehicle or in under-floor lockers. Having some solar capacity on the towing vehicle's roof enables that vehicle to be in the sun and the trailer in the shade or partial shade.

Converter electrical systems

Almost all US made and now many locally made RVs have 12 volt systems of which the battery back-up is intended only for occasional single overnight use away from 230 volt power. These systems are close to useless for camping. Pages 86-87 address this, and also compliance issues in general.

Cabins

Cabins have fewer restrictions. There is usually ample space for solar modules and batteries. Theft was initially an issue but less as solar module cost dropped dramatically after 2010.

For cabins used irregularly, sealed lead-acid deep-cycle batteries can safely be left permanently on charge as long as the necessarily high-quality solar regulator is programmed for the specific battery type.

Providing they are fully charged beforehand, AGM batteries may be left for 12 months or so before dropping below about a (non-damaging) 60% remaining charge at ambient temperatures below 25^0 C. Gel-cell batteries are less accommodating but can be left for two to three months between recharges.

AGM and gel-cell batteries need only a tiny float-charge, yet few chargers can be programmed to do this. The AGMs in particular are damaged if overcharged. Lithium-ion batteries are widely claimed to be able to be left for many months if 50% charged.

This 11.3 metre fifth-wheeler built by Glenn Portch is exceptional in weighing only 3200 kg. It has a payload of an extraordinary 1300 kg! Pic: Glenn Portch.

Battery capacity

With battery capacity, 'more' only rarely means 'better'. Lead-acid batteries are damaged if routinely deeply discharged. Further, if the battery bank is overly-large relative to the charging source, that source may not be available to recharge it fully, let alone quickly.

Adding more batteries *alone* is like opening more bank accounts for the same deposited money. All that can do is to increase the overhead losses. Economise on batteries but never on solar modules. As a very rough guide you need 200 watts of solar for every 100 amp hours of a 12 volt battery. Ideally have more as that improves charging in overcast conditions.

If you use energy-hungry arc welders and/or big angle grinders only occasionally, scale the system for 'normal' loads. Supply the rarely-used excess by a generator. This also applies if planning to spend only an odd winter month in places with short hours of sunlight (despite lower fridge energy usage in winter).

Cooking and heating

As roof space for solar modules is limited, solar generated electricity (alone) is not practicable in RVs shorter than about 7 metres for anything that, as its main purpose, generates heat. Electric ovens, fryers, and water heaters are best avoided. Hair dryers are borderline. Electric irons are best used where there is mains power. For such RVs, use gas for cooking and for heating water.

For cabins that have ample space for solar modules and battery storage, it is feasible to use solar energy for cook tops (but less so for ovens).Use LP gas/solar water heaters for water heating generally.

Energy-efficient appliances

Coffee grinders, blenders and other small appliances vary in efficiency but, if used normally, their energy use is rarely of concern. Microwave ovens, however, use more energy than many suspect. Their wattage rating refers to the work they do (i.e. 'cooking power') not the energy used when doing so.

Most '800 watt' ovens consume close to 1350 watts, or 1500 watts via an inverter. Ten minutes use may draw a day's output from a 100 watt module. That oven may thus cost only $195 or so, but running it from solar can add many times that for the extra solar capacity and battery capacity needed to drive it. And it can still only be used when there's enough power. Excepting for big rigs with ample solar capacity, or a generator, consider running a microwave only when you have 230 volt mains access.

Water pumping

Apart from hand- or foot-operated pumps (both are still available), the only practicable pumps for RVs are those that run from 12 or 24 volts. Mains-voltage pumps are available but they use several times as much energy for pumping the same amount of water.

Where there is a washing machine or dishwasher, and also in large cabins with flush toilets, a 'pressure accumulator' (page 40) overcomes the otherwise high energy draw of pumping water. It also results in a system that does not fluctuate in pressure, is silent most of the time and saves electrical energy. There are also variable speed pumps that provide constant pressure.

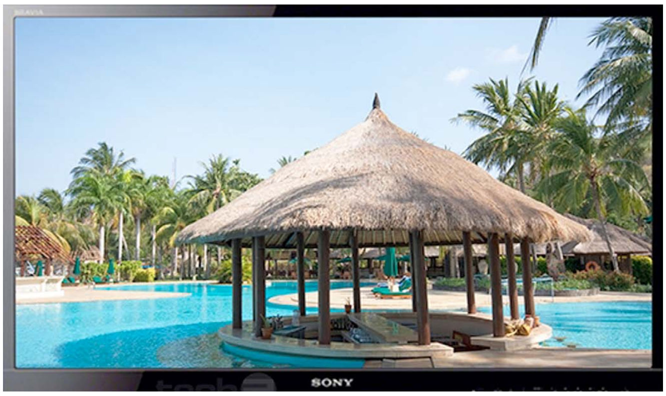
Washing machines/dishwashers

Most front-loading washing machines use less energy and water than top-loaders. The more efficient units run readily from a medium-sized RV solar system and inverter. They wash well using only cold water as long as cold water washing powder is used. These machines are fine also for cabins. Many current models draw only 200 watts or so when run from cold water.

Dishwashers need a hot water supply. It is not feasible to supply this via solar electricity, but a number of owners have built their own thermal solar water heaters from coiled copper tubing or black poly pipe. If doing so, to avoid scalding (especially of children) it is essential to include a 'tempering valve' (from plumbing suppliers) to ensure the water does not exceed 50^0 C. In some states it is legally required.

Television

Unless left on day-long, there are no major energy problems with post-2014 TVs with 36 inch (92 cm) LED screens. Most now draw about 60 watts. Older ones may draw over 150 watts. Almost all 12 volt TVs are made primarily for use in underdeveloped countries and use old energy-gobbling technology.



This Sony Bravia 32 inch TV draws 55 watts. Pic: Sony.

Computers

The most realistic choice for RVs and cabins is a laptop. As with TVs, conventional screens are responsible for about half of the draw - and by much the same amount. LED screens draw less. See also page 41.

Allow for the energy draw of charging iPads and also that drawn by communication modems. Specialised game-playing computers use far more energy, and are used for longer times.

Lighting

Incandescent (230 volt) globes are no longer legally sold. Halogen globes use about half the energy for the same amount of light but were an interim technology now mostly replaced by light emitting diodes (LEDs). Halogen globes will be banned from sale in Australia in 2020.

Fluorescent globes and tubes and compact fluorescents use only a quarter of the energy of incandescent globes. The very latest white and warm white LEDs use even less. Pages 36-38 refer.

Air conditioning

Given at least 750 watts of solar modules for this alone, solar-powered air conditioning is feasible for daytime use, but unless run from mains electricity, or from a generator, having air conditioning all night is not practicable in any but the very largest RVs.

Solar modules, air conditioners and batteries are, however, becoming increasingly efficient. Later editions of this book may have a different view of feasibility.

Evaporative coolers use much the same energy as big cooling fans but lose effectiveness above 25% humidity. Their vendors often claim they work in up to 40% humidity. But vendors *sell* them - they do not necessarily *use* them.

What voltage?

Twelve and twenty-four volt systems are cheap and simple. Their wiring is relatively easy (and legal) to install. There is negligible risk from electric shock.

One drawback (for 12 volts) is that surprisingly heavy cable has to be used to reduce energy losses (pages 59-65). There is a wide range of 12 volt appliances, but (apart from fridges), very few for 24 volts.

Some coaches and a few motor homes have 24 volt alternators and batteries. To run 12 volt lights and appliances, companies such as Redarc and GSL offer 24-12 volt charge equalising units.

These draw the required 12 volts from one of the two series-connected 12 volt batteries used in most 24 volt systems, whilst constantly equalising the voltage across both batteries. A more efficient approach for lighter loads is to use a 24-12 volt dc-dc converter.

Roof-mounted air conditioner. Pic: original source unknown.

Mains-voltage via an inverter

An inverter provides mains-like electricity. Many seemingly identical units cost far less but may only be able to supply their rated maximum output for a second or two. They only *seem* identical.

This is less of an issue with those over 1000 watts or so because they are made for a more electrically sophisticated market. More on inverters: pages 30-32.

Costs

The draw of a large electric fridge still dictates system size and cost. To safeguard against spoilage, it is advisable to have a back-up generator.

A microwave oven may cost only $195 but the solar capacity and battery capacity to drive it may add $1000. By all means have one, but (for use with small solar systems) run it only from a generator, or when you have access to mains power.

Solar is becoming cheaper, but battery capacity is not. Having adequate solar capacity alters the role of the battery. Sufficient battery capacity is still needed overnight and for dull days but, given sufficient solar, battery capacity can be reduced because solar modules charge to some extent even on overcast days.

Solar module price plummeted after 2010. Battery prices soared, but still differ considerably from vendor to vendor. It pays to compare prices but, because most batteries are so heavy, transport costs can wipe out otherwise bargain prices.

Seemingly promising small scale fuel-cell technology seems stalled. The initially promising Truma's VeGA LP gas-fuelled product, proved too costly. It was withdrawn from sale in 2014. The EFOY methanol fuelled product (page 29) is still on sale. Rival LP gas-fuelled fuel cells are just (mid 2018) appearing on the market.

Avoid cheap products

In the RV area particularly, unless you really know what you are doing, it is better to spend more and buy high-quality products from well-established companies rather than seeking bargain-priced products of unknown provenance and often negligible technical support. There is the odd bargain on eBay but much is close to junk.