Renewable energy

Clean renewable electrical energy generation systems are becoming increasingly accessible to the average homeowner either installed at home and connected to the grid or purchased as GreenPower.

Renewable energy can also be used for home heating and cooling, hot water and even cooking.

Electricity accounts for about 53% of the energy used in Australian households but creates around 87% of the greenhouse gas emissions (DEWHA 2008). Most is generated by burning non-renewable fossil fuels: coal, oil, natural gas and liquid petroleum gas (LPG).

Renewable power systems use renewable energy sources to produce electricity with very low greenhouse gas emissions. These sources, such as the sun, wind and water, are replenished naturally but are not available continuously. In stand-alone systems, back-up electricity can be supplied from storage batteries and/or generators. For grid connected systems, the predominantly fossil fuel based electricity (i.e. coal or gas generated) supplied through the grid can act as back-up when renewable systems are not generating. If fossil fuel generators are used for back-up power sources, greenhouse gases are produced.

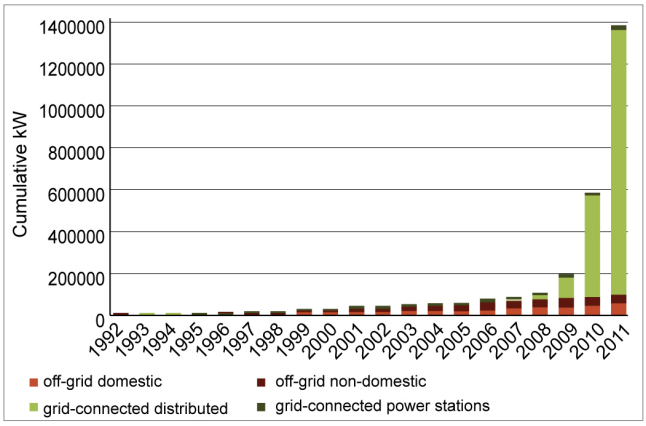
Equipment costs for renewable energy systems are generally declining

These energy systems usually operate with low running costs but can be expensive to install, although equipment costs are generally declining. Maintenance can also be a cost issue for systems reliant on batteries. The cost per kilowatt hour (kWh) for the system life includes installation and maintenance costs, but they remain unaffected by future energy price rises and can thus act as a form of insurance against such rises. The design and installation of these systems is a complex task requiring specialist knowledge. The Clean Energy Council register at www.solaraccreditation.com.au lists accredited designers and installers who can ensure systems comply with the appropriate Australian Standards.

Rebates and other financial incentives may be available to offset the initial cost of installing renewable energy power systems. For details about current financial assistance in your state visit www.yourenergysavings.gov.au/rebates.

Renewable sources

Photovoltaic (solar energy) systems (shown as 'grid-connected distributed' in the graph) have become the dominant renewable energy technology installed for domestic systems.



Source: Australian PV Association 2012

Photovoltaic, or grid connected distributed, systems are the major renewable energy installation in Australia.

There are many large scale wind farms across Australia. At a domestic level, wind power is not as easily accommodated as photovoltaics (PV), particularly in an urban context where buildings and other structures create turbulence that reduces the output of wind generators. Both wind and solar PV can be used individually or in combination where both resources are sufficiently available.

Photovoltaic modules

PV modules convert sunlight into electricity. The modules, also called PV panels or solar panels, are made up of a connected group of PV cells to form a usable size and electrical output. They have no moving parts and are therefore reliable and require little maintenance. PV modules can be expected to last 25 years or more and are suitable for use in urban areas as they take up little space, are not heavy and make no noise.

PV modules have no moving parts and are therefore reliable and require little maintenance.

Solar cells are usually monocrystalline, polycrystalline or thin film type (see *Photovoltaic systems*) depending on the application. Always seek expert advice before deciding which to use.

Solar modules come in different sizes ranging from 2 watts peak (Wp) output up to 350Wp output. The most common modules sold in Australia are in the 160–240Wp size range.

Solar modules can be mounted on a frame (either free standing or on the roof) or incorporated in the building fabric. Building integrated photovoltaics are usually installed for grid connected systems rather than stand-alone systems.

Wind generators

Wind generators or turbines use the wind to turn a rotor that drives a generator. They come in many shapes and sizes. The most common is the horizontal axis turbine with blades like an aircraft propeller and a tail or vane to direct it into the wind. Medium to large wind generators are more suited to non-urban areas as the turbine needs to be mounted on a tower and emits some noise in operation.

A number of vertical axis and more aerodynamic wind generators are being developed and show promise in overcoming wind turbulence and noise problems in urban use. These machines do not offer the same energy output potential as horizontal axis generators.

A solar house with photovoltaics and solar plate hot water system.

Domestic wind generators are typically used for stand-alone power systems to charge a battery bank. In these typically semi-rural or remote locations, wind generators can be installed to optimise output

Wattle Point wind farm, South Australia.

potential (see *Wind systems; Batteries and inverters*). More recently, wind generators are being installed and connected to inverters to feed their output power onto the electricity grid.

A wind turbine produces an alternating voltage and current, which is rectified to provide direct current (DC) at the correct voltage to charge batteries. It is similar to the system in a motor vehicle. Generators connected to the grid feed the DC power through an inverter which converts it to grid compatible alternating current (AC) power.

Domestic sized wind generators range from 300W to 20kW. Before deciding which wind generator size and type to install, the location's potential must be assessed to determine where and at which height the available wind resource can be best captured. It is unwise to decide on a certain sized wind generator before having some site specific data to confirm the expected output from the generator over a typical year.

Wind generators used in combination with a solar PV system present a good mix for year round power generation: in summer, the solar resource is at its best, and in winter, the wind resource is usually at its best.

The wind generator must be installed on the highest practicable tower that is cost effective for the site. A typical tower used in domestic wind generator systems is 15–20m tall; shorter towers compromise the ability of the wind generator to convert the resource to electrical output. (see *Wind systems*)

An experienced system designer can make the best suggestions for system type and equipment combination based on the homeowner's power requirements, solar and/or wind resources available at site and the amount of money available for the system.

Micro-hydro generators

Micro-hydro generators are the least common small scale residential renewable energy source. The unit operates by converting the energy from flowing water to electrical energy. Sites with a sufficient source of energetic flowing water are extremely rare; consultation with an experienced professional is necessary to ascertain the suitability of a potential site for a hydro system.

System types

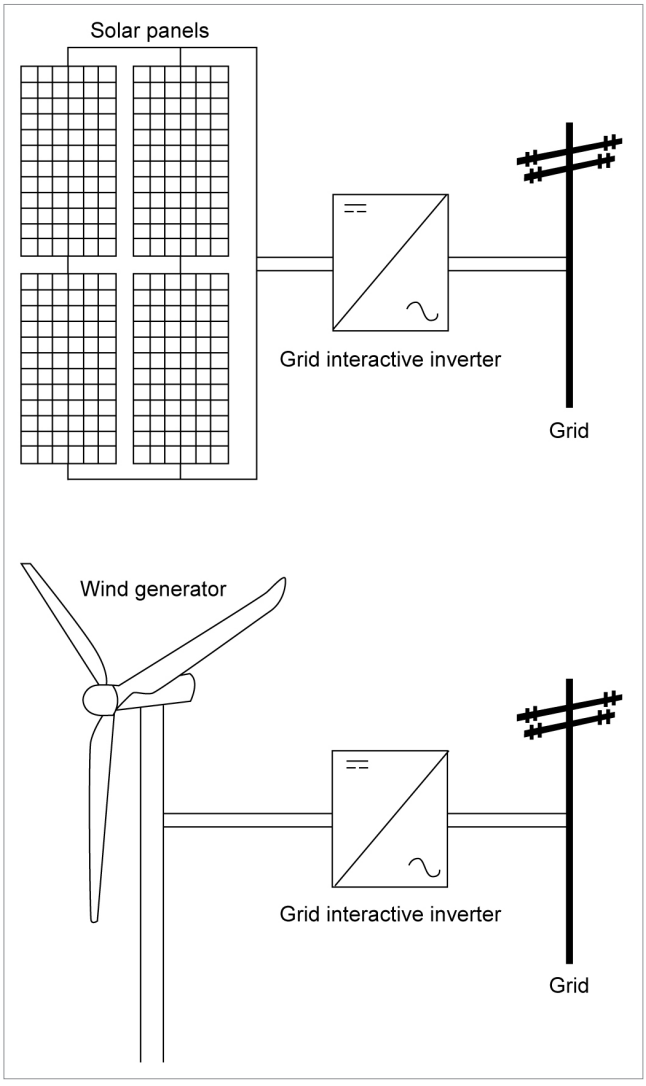
Most renewable systems are unable to provide energy at certain times because of insufficient sunlight, wind or water flow. To fill the gaps, electricity can be supplied from storage batteries and/or generators in stand-alone systems or from the electricity grid in grid connected systems.

Grid connected systems

Grid connected systems interact with the electricity supply grid in urban and rural areas — anywhere there is a reliable electricity grid. The main components of both solar and wind systems are the renewable energy source (i.e. solar and/or wind) and a grid interactive inverter.

The inverter converts the DC voltage generated by the renewable system to the normal 230V AC household supply. It also monitors the operation of the system to control how much electricity is drawn from or fed to the grid.

If the household uses more energy than the renewable sources can supply, the shortfall is supplied by the grid, so power is always available.



Both solar and wind generation systems can be connected to the grid.

If the system is supplying more energy than is needed, the excess energy is fed back onto the grid. Historically 'net metering' systems had the meter running backward when electricity was feeding onto the grid. The household paid the difference between the amount of energy imported and the amount exported. In recent years, states have introduced some form of feed-in tariff which requires installation of a new more intelligent electricity meter. These meters either allow for the total amount of electricity generated by the renewable energy system to be exported directly into the grid (gross metering), or measure the amount of electricity exported into the grid after household appliance consumption (import/export metering). Different suppliers have different buy-back rates and metering arrangements. Check with your electricity retailer for precise details about the feed-in tariff and metering options available, and the criteria your renewable energy system must meet.

A grid connected system feeds excess energy back onto the grid.

System sizing is not critical as the grid is used for back-up when system output is insufficient for household needs. Often the sizing of these systems is limited by the project budget or, for solar, the available roof space. Financial incentives may also be limited to certain sizes or systems.

As a rule of thumb, an installed system comprising a 1 kilowatt peak (1kWp) array produces about 1,000–1,400kWh (depending on location) of electrical energy per year and requires 9m^2 of space (Clean Energy Council 2011). A system using thin film modules requires more space. The system designer will specify and size it accurately for the particular location and the amount of energy required by the customer. Typical households install systems of 1–5kW, generating 1,000–7,000kWh annually. Household annual electricity consumption falls in the range 1,000–10,000kWh, so most PV systems rely on the electricity grid for part of their supply. Most systems export power at some time of the day but import power overnight and at times of high usage or low solar radiation.

Standard grid connected systems do not require storage batteries and, without them, cannot provide a guaranteed continuous power supply. If the grid fails, the grid connected inverter cuts out for safety (so power company workers are not at risk of being electrocuted) and the solar array doesn't provide any energy via the inverter. If continuity of supply is critical for any part of the household's load, a system can be designed using a special type of inverter and batteries for an uninterruptible power supply. This naturally adds to the cost of the system.

Stand-alone power systems

Remote area power supplies or off-grid systems are used in semi-rural or remote areas where the cost of connection to the electricity network is expensive or not available. Some people install them to be independent from the mains supply or to have reliable power in areas where blackouts are common. These systems are more complex and expensive than grid connected systems because they need to be able to meet the total energy requirements of the household.

The main components of a stand-alone system are:

- a renewable energy source
- control equipment for battery charging and back-up power operation
- storage batteries
- a back-up generator
- an inverter.

An inverter may not be required if the home runs 12V and 24V DC appliances (as used in caravans and boats). Although DC appliances are usually more energy efficient than their AC counterparts, their range is very limited and they are more expensive. DC systems also need wiring to be of a suitable capacity, which is also more expensive than standard 230V AC wiring. Some stand-alone power systems may combine the use of AC and DC appliances.

A generator set is commonly required for back-up or emergencies. Generators are installed as part of PV and wind systems to complement the intermittent nature of renewable power sources. Micro-hydro systems usually do not need this back-up provision as the power source, i.e. water, is often continuously available.

Generators are used for:

- charging the batteries
- supplying specific high power loads
- emergency back-up in periods of unfavourable weather or when loads are larger than the original design.

A generator set can operate in parallel with the 240VAC power provided by the inverter/battery setup of a stand-alone power system. The generator set must synchronise with the prevailing 240VAC supply or it cannot deliver its power. It must synchronise with the operating AC network to which it is connecting in the characteristics of: line voltage, frequency, phase sequence, phase angle and waveform.

It is generally recommended that the system include a generator for battery charge equalisation. (see *Batteries and inverters*)

Design your stand-alone power system to meet identified household power needs. Excess energy generated is stored in batteries for use when the renewable source is not available. Ensure battery bank capacity is sufficient to provide power for several days.

Reducing energy consumption

A stand-alone power system has to generate and store the energy the household requires. Therefore investing in energy efficiency, which reduces this energy demand, avoids unnecessary expenditure on system capacity.

This is particularly important for systems that must be self-sufficient, do not have access to the electricity supply grid and use expensive fuels in generators for back-up power supply.

For grid connected systems, implementing energy efficiency measures reduces the amount of energy purchased from the grid or increases the amount that can be sold back to the grid. Either way you save money or make more money from energy exports.

Before installing a renewable energy system, review your electricity usage patterns and the amount of energy consumed. This energy consumption figure can be minimised through energy efficiency or the use of alternative fuels to reduce the size and cost of the system.

General rules for reducing energy consumption

Use energy sources other than fossil fuel generated electricity where possible, e.g. solar water heating. If solar water heating is not suitable, consider an efficient heat pump system. (see *Hot water service*)

Limit the use of high power-demand electrical appliances such as cookers, microwave ovens, water heaters, room heaters, clothes dryers, air conditioners, vacuum cleaners and hair dryers.

For stand-alone systems, it is not practicable nor cost effective to operate high power-demand items with heating elements such as cookers, water heaters and room heaters from a battery based system. Replace these items or use alternative fuel sources such as LPG. If a high power demand item is used only for short periods (e.g. electric kettle), the power it requires can be included in the system design.

Stand-alone system owners should invest in energy efficient appliances, especially fridges and freezers, which represent a sizable proportion of daily electrical energy use (see *Appliances*). Washing machines can operate using either cold or hot water; for a hot water wash, it is preferable to use a washing machine without an internal heating element. Dishwashers, if used, should bring in externally heated water, preferably from a solar water heating system. Where possible, the use of passive design building principles can reduce the need for heating and cooling (see *Passive cooling*; *Passive solar heating*). The informed use of these principles significantly reduces demand for electrical energy, and thus the required capacity and expense of the stand-alone power system. Natural lighting and energy efficient fluorescent or LED lighting achieve the same effect (see *Lighting*).

Many appliances use 'stand-by energy' when not actually being used. Televisions, videos, clocks, computers, faxes, battery chargers and power packs still draw power when they are 'switched off'. These small appliances may be enough to keep the inverter 'on' continuously, and inverters are often very inefficient when run at low power. Turn appliances off at the power point when not in use and buy models with the Energy Star logo. Also look for appliances that do not need continuous power to maintain their memory of such things as radio stations or washing programs. (see *Appliances*)

Energy storage

Batteries have been used for stand-alone renewable energy systems for many decades. New developments mean they can be included in grid-connected renewable energy systems as well, with the use of advanced inverters. Lead-acid batteries, traditionally used for storage, require careful management; abuse, such as repeatedly discharging them beyond around half charge, can dramatically shorten their lives. While lead-acid batteries are improving, emerging alternatives, including lithium ion batteries (as used in many electric vehicles) are becoming cheaper and better.

Given the rapid rate of change in this area, consult experts when considering battery purchases.

GreenPower

GreenPower enables householders to buy accredited renewable energy from the electricity grid.

This national accreditation program sets stringent environmental and reporting standards for renewable electricity products offered by energy suppliers across Australia. It aims to increase Australia's capacity to produce environmentally friendly renewable electricity by driving demand for alternative electricity generation.

> *GreenPower accreditation makes it easier for customers to choose between different renewable energy products.*

Accreditation by the GreenPower program manager, an independent authority operated across all state governments, means a specific renewable energy generator is endorsed by the collective state governments that manage the GreenPower program. For a renewable energy generator to gain endorsement from the GreenPower program, the power must be generated from:

- eligible renewable energy sources that meet strict environmental standards
- a new renewable energy facility built after January 1997 or generating at levels above those before January 1997 (other renewable energy generation may not be accredited because it was built before 1997 and was already contributing to the electricity grid in the base year of the scheme).

Accreditation ensures that energy companies are producing renewable energy of the same standard, making it easier for customers to choose between different renewable energy products. From a customer's perspective, the GreenPower label demonstrates at a glance that they are supporting renewable energy that is best for the environment and the renewable energy purchased is decreasing greenhouse pollution.

Data published at the end of 2010 show that more than 835,000 residential and commercial customers Australia wide contributed to reducing greenhouse gas emissions by buying GreenPower (www.greenpower.gov.au). The GreenPower website also has more information on GreenPower and you can check with electricity retailers to see the options for buying accredited GreenPower.

GreenPower™
Accredited Renewable Energy

GreenPower accredited schemes have stringent environmental and reporting standards.

Energy management

Diurnal cycling and periodic interruptions of natural resources can make renewable energy output fluctuate. Solar power drops when the sun goes behind clouds, wind turbines slow down when the wind drops and micro-hydro systems produce less electricity when water flows are affected by drought. If renewable energy is to represent a significant part of Australia's energy supply, management and storage of these resources needs to play a part.

Electric vehicles have been proposed as a way of smoothing peaks in energy consumption and supply by absorbing the grid's excess energy and then releasing it from these vehicles' batteries when required. This innovative idea makes use of the short use of electric vehicles each day, often to drive to and from work. For the remainder of the time they can act as a buffer for the energy system.

Demand management technologies are developing rapidly, and the cost of monitoring and managing the operation of appliances so that they match energy availability is falling.

References and additional reading

Contact your state, territory or local government for further information on renewable energy, including available rebates: www.gov.au

Alternative Technology Association. www.ata.org.au

Australian PV Association. 2012. APVA response to the draft Energy White Paper, December 2011. http://apvi.org.au

Australian Solar Energy Council. www.solarchoice.net.au

Clean Energy Council. www.cleanenergycouncil.org.au

Clean Energy Council. 2011. Consumer guide to buying household solar panels (photovoltaic panels). www.solaraccreditation.com.au

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2008. Energy use in the Australian residential sector 1986–2020. Canberra. www.energyrating.gov.au

Gilchrist, G. 1995. The big switch: clean energy for the 21st century. Allen and Unwin, St Leonards, NSW.

GreenPower. www.greenpower.gov.au

Your Energy Savings. www.yourenergysavings.gov.au

ReNew. http://renew.org.au

Authors

Principal authors: Geoff Stapleton and Geoff Milne

Contributing author: Chris Riedy

Updated by Geoff Stapleton, Susan Neill and Matthew O'Regan, 2013