# Electricity from the sun

## Solar PV systems explained

BCSE
Australian
Business Council
for Sustainable
Energy


Australian Business Council for Sustainable Energy

Australian Government

Department of the Environment and Water Resources
Australian Greenhouse Office

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Australian Greenhouse Office

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ISBN: 978-0-9802806-7-8



Australian Government funding through the Australian Greenhouse Office in the Department of the Environment and Water Resources supports this project.

# Contents

# Solar photovoltaic (PV) systems

**The aim of this guide is to provide some background information to assist purchasers in making an informed choice about solar photovoltaic (PV) systems.**

Solar PV systems:
- use sunlight to generate electricity for your domestic use, and
- store excess electricity in batteries for later use, or
- feed into the electricity grid to reduce your electricity bill.

A solar electric system is different to a solar water heater. This guide deals only with solar electricity. Solar water heaters use heat from the sun and/or surrounding air to heat water; they do not produce electricity.

## Benefits of a solar PV system to the householder

- ☑ Solar PV systems **generate electricity**
- ☑ Once the system has been purchased, electricity is generated from **a 'free' source** – the sun
- ☑ Solar electricity is generated **without emitting greenhouse gases**
- ☑ Solar panels or modules are **silent**, without any moving parts
- ☑ Solar modules are generally **unobtrusively mounted** on an existing roof
- ☑ Solar modules can be **integrated** into the building in the form of windows, walls, roof tiles or pergolas
- ☑ Solar electricity can supplement or provide **all your electrical consumption**
- ☑ Solar electricity can be **fed into the grid**
- ☑ Additional solar modules can be **added later** as demand or budget grows
- ☑ A solar module should last for at least **20–30 years**.

# Solar modules


**Solar modules are generally flat panels mounted on roofs or other structures.**

**Solar modules** convert energy from sunlight into direct current (DC) electricity.

**More energy is generated**

- in areas of strong solar radiation
- on long, sunny days.

**Less energy is generated**

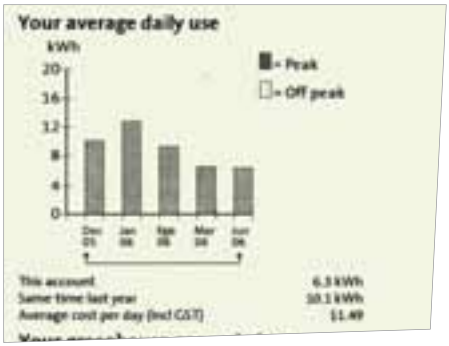
- in cloudy or rainy weather
- when the panels are shaded by trees or other obstructions
- when the panels become hot.

# Choosing the right system

**Factors to consider:**

- your **electricity demand—**how much you use. The more electricity you demand, the larger the system and the greater the cost
- **your budget—**how much are you prepared to invest. Your budget may create limits on the size of the system
- **your location—**whether the mains electricity grid is available and, if so, how much would it cost to bring power out to your property and pay for ongoing maintenance of poles and cables on your property
- **aspect—**there needs to be sufficient space on your roof for the mounting of north-facing modules
- **rebates—**Commonwealth and/or state government rebates provide an incentive to householders to invest in solar. However these are subject to change from time to time. Please check with the Australian Greenhouse Office or your local BCSE Accredited designer/installer.

Note: To be eligible for existing rebates, your system must be designed and installed by a BCSE Accredited installer




**→ The above bill shows a peak daily consumption of 12.5kWh in January 2006. June 2006 was 6.3kWh per day.**

# A designer/installer

**BCSE Accreditation** ensures that those holding Accreditation:

- ☑ have undergone the necessary **professional training**
- ☑ follow **industry best practice**
- ☑ must **adhere to Australian Standards**
- ☑ routinely **update their skills and product knowledge.**

It is also wise to:

- consider the recommendations of others who have purchased a similar system to the one you require
- engage someone with whom you're happy to work, and
- look for designing and installing experience in the industry, not just a retail outlet.

## Stand-alone or grid-connected

# Is the mains electrical supply available at an affordable price?

Yes ➜

No ➜

If **Yes** then you should consider a grid-connected power system — GC

**See page 7** ➜

If **No** then you should consider a stand-alone power system — SPS

**See page 17** ➜

# A: Grid-connected solar PV systems

## If…

- you're passionate about renewable energy
- you would like to reduce your power bill
- you're worried about the environment
- you wish to add value to your home

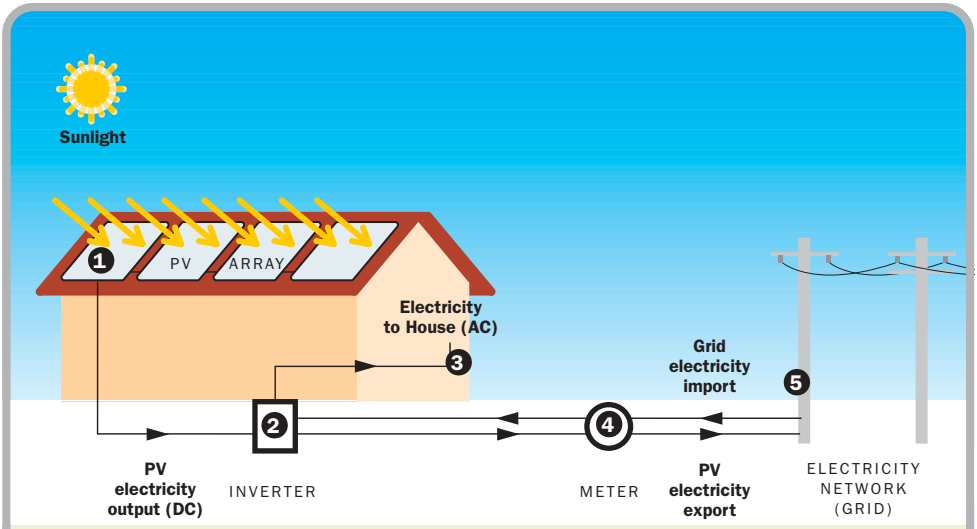
## then…

a grid-connected solar PV system may be for you

# A grid-connected solar PV system

**A grid-connected solar PV system is an array of photovoltaic modules connected via an inverter to provide power for your home, with excess production feeding into the grid.**

At night, when the solar modules are not producing electricity, the electricity comes to you from the grid. If you export enough energy during the day, it will balance or exceed the amount you draw from the grid at night.




1. **Solar PV modules** supplying DC power
2. An **inverter** changing the solar DC power into 240V alternating current (AC) suitable for your household appliances and feeding into the grid
3. Your **home** uses electricity firstly from the solar PV modules with additional demand supplied from the grid
4. A **meter** measuring your electricity production and consumption
5. Any excess is 'exported' to the electricity grid.

# Choosing the system size

**While the ideal outcome is to provide enough energy to run all your electrical appliances all year round, the reality is that your electricity usage and your budget may not always coincide.**

Often the compromise means that the solar PV system will supply only part of your total electricity demand, however, you can always add to it later.

Simply put, if you can minimise your consumption of electricity, and you are able to purchase a large system, you may be able to meet all or most of your electricity demand. Therefore your on-going electricity bills could be close to zero. However, if you use a lot of electricity, and are only able to purchase a small system, the saving on your electricity bill will be not as great.

For this reason, you may wish to consider some energy conservation and energy efficiency measures to reduce your electricity consumption, and replace a larger portion of your electricity bill with your solar PV system.

## What will I need to power a 3-bedroom home?

There's no easy answer to this question.

Everyone's electrical usage is different—it depends on:

- patterns of **energy use** in your household
- number of **occupants**
- types of **appliances**, gas or electric.

The size of the system will depend on:

- the physical un-shaded **space available** for the installation of your modules
- how much you are **prepared to spend,** and
- what portion of your electrical demand you wish to generate.

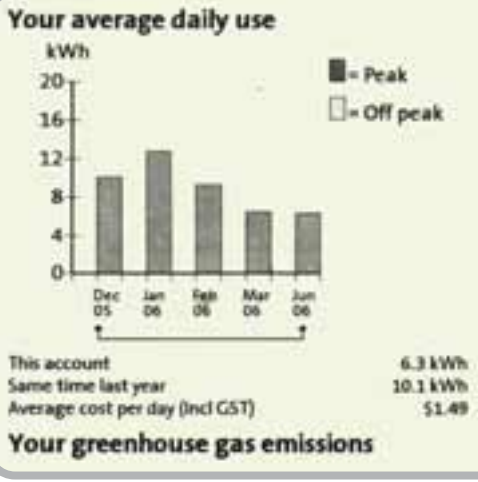
# Reducing demand

**While the power you generate can help offset electricity charges, it is important that you also consider other cost-effective alternatives.**

These alternatives include:

- using the most **energy efficient appliances**
- **replacing incandescent light globes** with compact fluoros
- **avoiding quartz halogen downlights** as most are very inefficient
- **switching off stand-by loads** such as those consumed by DVDs and computers when not in use
- installing a **solar water heater**, preferably with gas boosting—this will cut electrical costs.
- utilising **off-peak tariffs** for any large electrical loads eg: pool pumps

- utilising **motion sensors**, timers and home automation systems
- positioning **summer shading** or reflective coatings on west facing windows
- **reducing electricity demand** for space-heating and cooling (eg: by dressing for the climate, judicious setting of thermostats, use of curtains and incorporating energy efficiency features into new buildings, such as lights, insulation, summer shading etc.), and
- ensuring there's adequate **solar access in winter** to provide passive heating.




**The most common and accurate method used to determine your energy usage is to review your electricity supply bills for the past 12 months and calculate your average annual daily consumption.**

**Use the bar graph to calculate your annual average daily use.**

**You can then compare this with the production figures, for your location, on page 13.**

**By the way this user does not use off-peak electricity.**

# The meter


**Left: Modern digital meter.**
**Right: Old-fashioned meter**

**In most cases the electricity meter records the energy sent to the grid as well as the energy consumed from the grid.**

However, in some cases it may instead record all the energy produced from the solar modules as well as all the energy consumed by the house. Your electricity distributor reads the meter and determines your balance. Your electricity retailer then bills for the energy consumed OR makes payment for the excess production.

Note: You need to check with your electricity retailer for their 'feed-in' rate, supply charges and billing periods. Arrangements differ with each retailer and differ between states. You should shop around for the best deal. Your installer will be able to advise you.

# When the grid goes down

For safety reasons, when the grid goes down your solar PV system must automatically and immediately turn off.

It is possible to have a system that will provide emergency electricity when the grid is interrupted. This necessitates the additional installation of a suitable inverter, a battery bank and possibly changes to the house wiring. The benefit is it will provide the security of a continuous electricity supply in the event of blackouts.

## Design

**A BCSE Accredited designer will provide you with the system design and specification.**

The system designer will:

- determine the **configuration** and number of solar modules
- select an appropriate **inverter**
- determine whether the PV modules will fit on the **roof or structure**
- determine constraints caused by **shading**.

## Location

The system's location requires consultation with your Accredited installer.

Suitable areas are required for the solar modules and the inverter. For example:

- The PV modules may be fixed onto the roof or a ground-mounted frame or integrated into the fabric of the building using PV roofing tiles or windows. **For best performance, a north facing area, free from shading, is recommended**.
- The inverter should not be exposed to the elements, though weather-proof models are available.

## Orientation

Solar modules produce most electricity when they are pointed directly at the sun. It is important to install them so that they receive maximum sunlight. Ideally they should be in **full sun at least from 9am to 3pm**. In Australia, solar modules should face north for optimum electricity production.

## Elevation

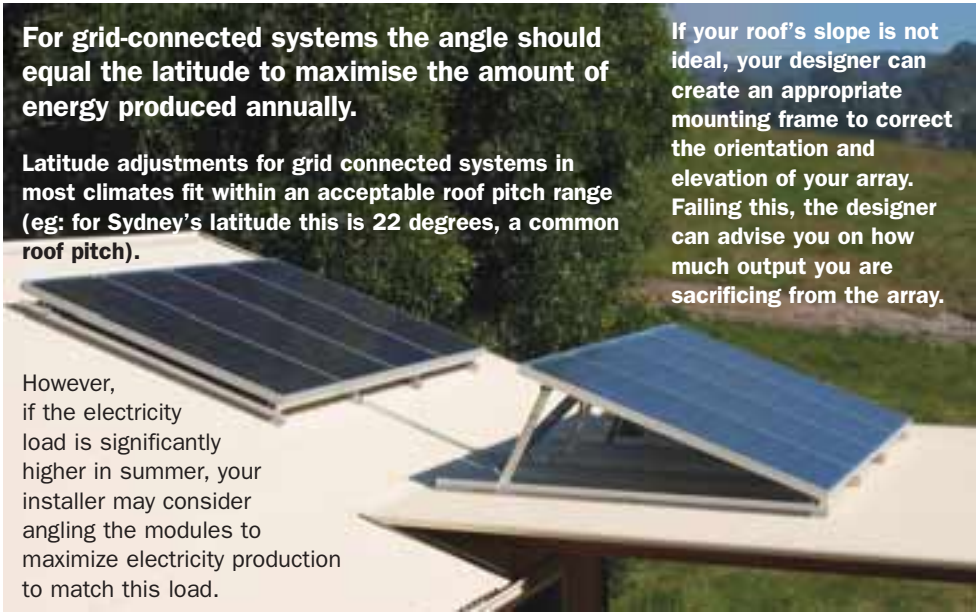
**For grid-connected systems the angle should equal the latitude to maximise the amount of energy produced annually.**

**Latitude adjustments for grid connected systems in most climates fit within an acceptable roof pitch range (eg: for Sydney's latitude this is 22 degrees, a common roof pitch).**

However, if the electricity load is significantly higher in summer, your installer may consider angling the modules to maximize electricity production to match this load.

## Customisation

**If your roof's slope is not ideal, your designer can create an appropriate mounting frame to correct the orientation and elevation of your array. Failing this, the designer can advise you on how much output you are sacrificing from the array.**



## Average daily production

The following figures indicate the average kilowatt hours (kWh) of energy you can produce in one day from a 1 kilowatt (kW) solar electric power system in various parts of Australia.

Electricity is metered in kilowatt hours (kWh) where 1kWh = 1000Wh. Hence if you use 1 kW for 1 hour you have consumed 1kWh of energy. Some electrical retailers refer to 1 kWh as 1 unit.

| CITY | kWh per day |
|---|---|
| Adelaide | 3.74 |
| Alice Springs | 4.46 |
| Brisbane | 3.74 |
| Cairns | 3.81 |
| Canberra | 3.76 |
| Darwin | 4.00 |
| Geraldton | 4.29 |
| Hobart | 3.11 |
| Melbourne | 3.15 |
| Oodnadatta | 4.44 |
| Sydney | 3.50 |
| Perth | 3.94 |
| Tennant Creek | 4.49 |
| Wagga Wagga | 3.76 |

# Quotation

**Following the design and specification, you may request a quotation for the supply and installation of the system.**

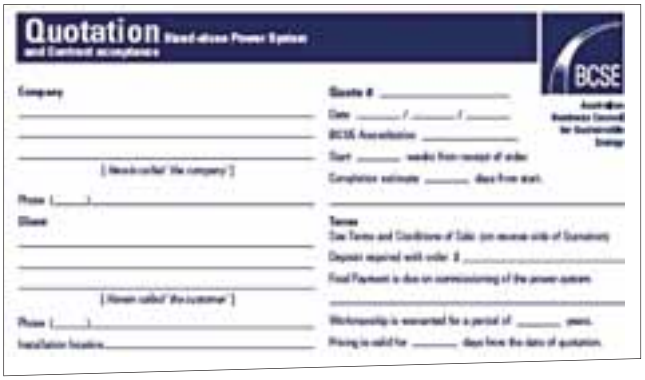
The **quotation** should provide specifications, quantity, size, capacity and output for the major components, including:

- solar PV modules
- mounting frames or structure
- inverter
- any additional metering or data-logging
- travel and transport requirements
- other equipment needed
- any trench digging
- a system user manual.

The **quotation** should also specify a total price, together with proposed start and completion dates. The quotation should form a basis for your contract with the designer/installer.

In addition, a **contract** for the supply and installation of the power system should be included with the quotation.

Whilst the initial cost is very important, it is wise to consider all the costs and benefits over the life of the system, together with the service you expect from the system designer and installer.


Quotation

BCSE

**Sample of a quotation pad available from the BCSE**

The **contract** should include:

- an estimate of the average daily electricity output (in kWh)
- the estimated annual production
- the estimated production in the best and worst months
- the responsibilities of each party
- warranties and guarantees, including installer workmanship
- a schedule of deposit and progress payments.

It is important to remember that a good relationship with a reputable, experienced, quality installer may be more valuable than a few dollars saved on a quote. This will be a significant investment so you should ensure the decision you make is the best.

## Australian Standards and industry guidelines


Solar grid-connected power systems must comply with a range of Australian Standards covering the grid connection of energy systems via inverters, the installation of PV modules and *The BCSE Design and Installation Guidelines*.

## Documentation

A system manual that provides operation, maintenance and safety information should be provided by your installer. This must also include a design of the system. Also ensure you obtain written confirmation of statements made by your installer, performance claims, guarantees and warranties.

Documentation will be essential when you need to make warranty or insurance claims.

## Preventative maintenance


**After installation, the owner is responsible for ensuring the equipment is maintained in good working order.**

**Please note that appropriate instruction by the installer, backed up by maintenance information in the system manual, should be provided. Safe work practices for any maintenance tasks must be followed.**

**For further information on the future maintenance of your system please refer to the BCSE's guide "Solar PV Systems Maintenance Guide For System Owners" ISBN: 978-0-9802806-9-2.**

## Electricity distributors

**All poles, lines and meters are provided by an electricity distribution business. You cannot choose your distributor as they are allocated geographically throughout Australia.**

## Electricity retailers

**Electricity itself is sold to you, or bought from you, by an electricity retailer. In most states you can choose your retailer although not all will agree to sell or buy from a solar powered generator.**

It is important to shop around for the best deal including buying rates and conditions.

**Before signing with a retailer, check all the following:**

- ☑ Cost of electricity you purchase in cents per kWh
- ☑ Price they will pay per kWh for electricity you feed into the grid
- ☑ Whether your metering registers the total production from your solar panels or just the excess, (beyond what is consumed in your home)
- ☑ Penalty clauses including termination costs
- ☑ Billing/payment periods.

## Feed-in tariffs

**A mandatory feed-in tariff is a rate (in cents per kWh) at which the electricity retailers are obliged to purchase electricity from your system.**

Some states are in the process of introducing mandatory feed-in tariffs. Check with your installer on developments in your state.

# B: Stand-alone solar PV systems

## If…

- you need 24-hour power but you're a long way from the electricity grid, or
- you're passionate about renewable energy, or
- you dislike using diesel, petrol or LPG generators

## then…

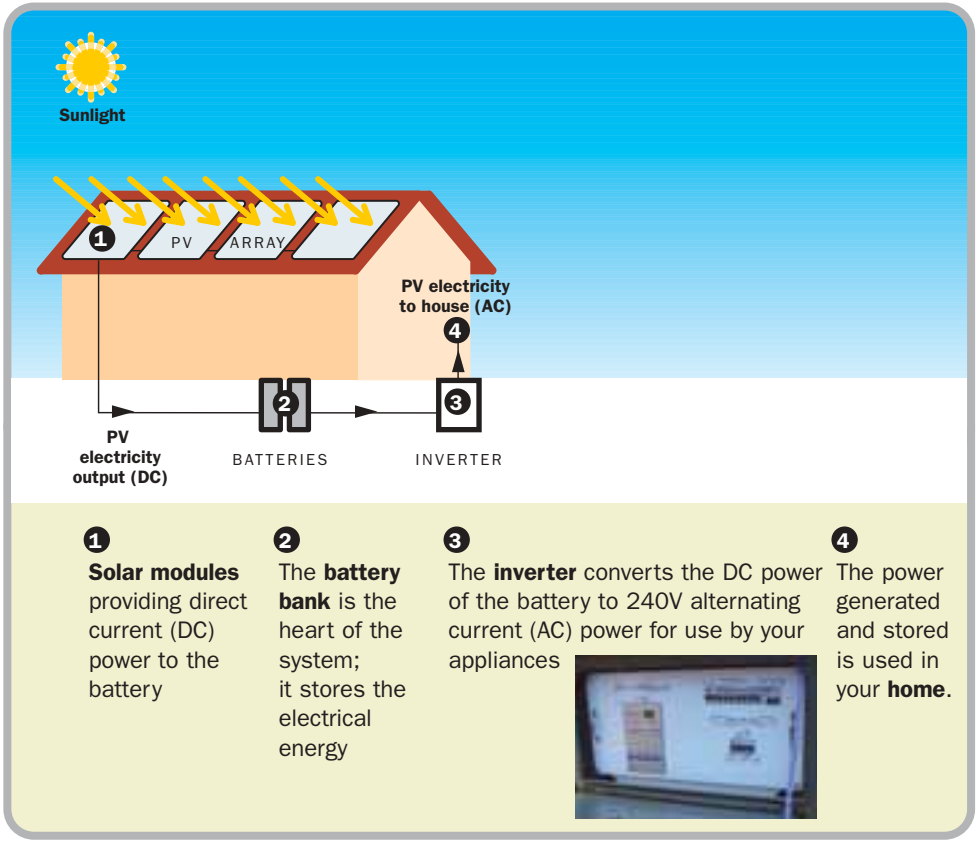
a stand-alone solar PV system may be for you.

# A stand-alone solar PV system

**A stand-alone solar PV system (SPS) is not connected to the electricity grid.**

Together, the battery bank and the inverter supply electricity to your appliances. But, if you try to use more electrical energy than the battery bank holds, you will run the batteries too low and reduce their life expectancy.

The number of solar modules and the size of the **battery bank** can be increased to generate and store more energy, or you may decide to include a diesel, petrol or LPG **generator**. In areas of high wind, a small **wind turbine** could also be an option. Such systems, which use a variety of generating technologies, are called **hybrid** systems.




**1** **Solar modules** providing direct current (DC) power to the battery

**2** The **battery bank** is the heart of the system; it stores the electrical energy

**3** The **inverter** converts the DC power of the battery to 240V alternating current (AC) power for use by your appliances

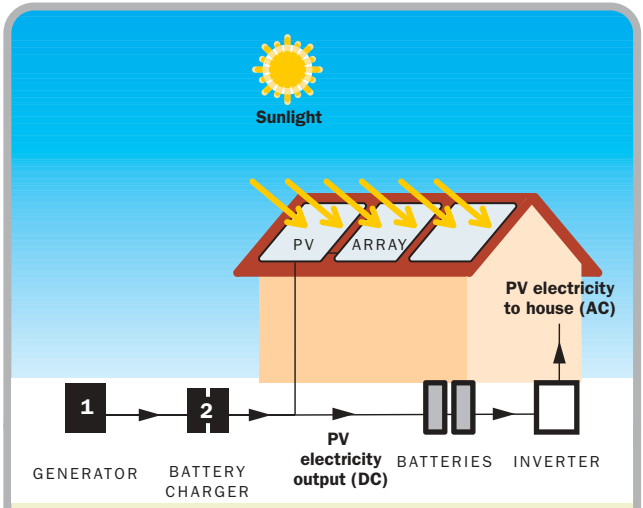


**4** The power generated and stored is used in your **home**.

**A generator and battery charger are normally part of an SPS so that, when extended bad weather occurs, you have a back-up supply which helps safe-guard your batteries.**

To reduce load requirements, make sure that all your lights and appliances are the most energy efficient available.

A large diesel generator




❶ A petrol, diesel or LPG fuelled **generator** (genset)

❷ A battery charger to charge the battery on demand.

## Generators

The **advantages** of an SPS with a generator is that electricity is available during prolonged periods of overcast / rainy weather, or when big power loads are required. It may also allow for a smaller battery bank and inverter to be used.

The main **disadvantages** are the higher capital cost for the genset and battery charger, and the ongoing fuel and maintenance costs.

# System size

## What will I need to power a 3-bedroom home?

There's no easy answer to this question.

Everyone's electrical usage is different—it depends on:

- patterns of **energy use** in your household
- number of **occupants**
- types of **appliances**, eg: gas or electric fridge, hot water system, etc.

The size of the system will depend on:

- the quantity of electricity you wish to consume
- how much you are prepared to **spend**.

# Design

A BCSE Accredited designer will provide you with the system design and specification.

The system designer will:

- ☑ perform a **load analysis** on the use of your household appliances
- ☑ determine the **configuration** and number of solar modules
- ☑ select an appropriate **inverter**
- ☑ select a suitable **battery bank**
- ☑ select a suitable **genset**
- ☑ **advise** on any other appropriate technologies, eg: solar water heater, wind turbine, etc.

# Load analysis

**The first step in the design process is to establish your electrical loads over an average day using a load analysis.**

The system designer uses the load analysis to:

- ☑ calculate the daily energy demand
- ☑ recommend where energy savings can be made
- ☑ determine the peak power demand
- ☑ select the system voltage
- ☑ determine the configuration and number of solar PV modules
- ☑ select an appropriate inverter—power output and surge
- ☑ calculate the battery size
- ☑ determine size and type of genset
- ☑ estimate genset use—maximum and minimum run times.

TABLE B3
A.C. LOADS

| (1) Appliance | (2) No. | (3) Power W | (4a) Winter or dry season: Usage time h | (4a) Winter or dry season: Energy Wh | (4b) Summer or wet season: Usage time h | (4b) Summer or wet season: Energy Wh | (5) p.f. | (7) Contribution to max. demand VA | (8) Surge factor | (9) Cont. (cont.) |
|---|---|---|---|---|---|---|---|---|---|---|
| LIGHTS | 2 | 15 | 2 | 60 | 1 | 30 | ·8 | 37 | | |
| LIGHTS | 2 | 11 | 8 | 176 | 7 | 154 | ·8 | 27 | | |
| LIGHTS | 1 | 20 | 2 | 40 | 1 | 20 | ·8 | 25 | | |
| TV | 1 | 80 | 3 | 240 | 3 | 240 | ·8 | 100 | | |
| MICROWAVE | 1 | 1200 | ·05 | 60 | ·05 | 60 | ·9 | 1200 | | |
| WASHING MACHINE SATELLITE | 1 | 100 | 1 | 100 | 1 | 100 | ·9 | 111 | | |

**An example of a load assessment form**

The system design may need to be repeated before an economic and satisfactory 'agreed load' is established.

# Reducing demand

**It is important that you consider cost-effective methods of reducing your electricity demand.**

These methods include:

- using the most **energy efficient appliances**, especially for refrigeration
- **replacing incandescent light globes** with compact fluoros
- **avoiding quartz-halogen downlights**; most are very inefficient
- **using LPG** for some loads such as cooking and hot water
- **switching off stand-by loads** such as DVD players
- **utilising sensors**, time-switches and a home automation system

- **installing solar water heating**—preferably with gas boosting
- **reducing electricity demand** for space-heating and cooling (eg: by dressing for the climate, judicious setting of thermostats, use of curtains and incorporating energy efficiency features into new buildings, eg: lights, insulation, summer shading etc.
- ensuring there's **adequate solar access** in winter to provide passive heating.

# Locating the system

The system's location requires consultation with your Accredited installer. Suitable areas are required for the solar modules, inverter, battery bank and genset.

For example:

- the PV modules may be fixed onto the roof, a ground-mounted frame or integrated into the fabric of the building using PV roofing tiles or windows. For best performance, a north facing area, free from shading is recommended
- ideally the inverter should not be exposed to the elements, though weather-proof models are available
- the battery bank must be in a separate, lockable and well-ventilated battery enclosure
- the inverter and battery charger should also be in a secure, weatherproof and well ventilated enclosure
- the generator should be situated out of ear-shot and with adequate ventilation
- if system components are located a long way from the house, the cost of trenching needs to be considered.

# Orientation, elevation and customisation

**Solar modules produce most power when they are pointed directly at the sun.**

It is important to install them so that they receive maximum sunlight. Ideally they should be in full sun from at least 9am to 3pm. In Australia, solar modules should face north for optimum electricity production.

## Elevation

For stand-alone power systems, where winter operation is crucial, the angle should be the latitude plus 15 degrees.

## Customisation

If your roof's slope is not ideal, your designer can create a suitable mounting frame to correct the orientation and elevation of your array. Failing this, the designer can advise you on how much output you are sacrificing from the array.

# Average daily production

The following figures indicate the average kilowatt hours (kWh) of energy you can produce in one day from a 1 kilowatt (kW) solar electric power system in various parts of Australia.

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| Tennant Creek | 4.49 |
| Wagga Wagga | 3.76 |

# Quotation

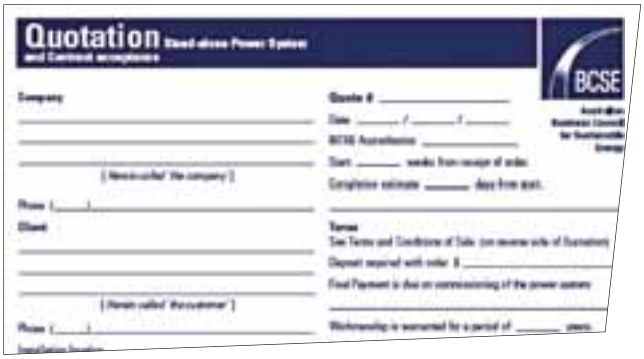
**Following the design and specification, you may request a quotation for the supply and installation of the system.**

In addition to the **quotation**, a contract for the supply and installation of the power system should be included with each quotation. (There's a sample on the BCSE web-site at http://www.bcse.org.au/default.asp?id=96 )

The **quotation** should provide specifications, quantity, size, capacity and output for the major components, including:

- PV modules
- mounting frames or structure
- battery
- inverter
- design, travel and transport costs.
- installation and other equipment costs
- carpentry such as building a battery enclosure
- generator (if required)
- any trench digging
- battery charger
- system user manual.

The **quotation** should also specify a total price, together with proposed start and completion dates. The quotation should form a basis for your **contract** with the designer/installer.


Quotation
BCSE

➔ **Sample of a quotation pad available from the BCSE**

The **contract** should include:

- an estimate of the average daily energy output (in kWh)
- the estimated annual production
- the estimated production in the best and worst months
- the responsibilities of each party
- warranties and guarantees, including installer workmanship
- a schedule of deposit and progress payments
- expected operator run times in hours per month.

The renewable energy resource data used should be identified.

Whilst the initial cost is very important, it is wise to consider all the costs and benefits over the life of the system, including replacement, maintenance and fuel costs.

It is important to remember that a good relationship with a reputable, experienced, Accredited installer may be more valuable than a few dollars saved on a quote. This will be a significant investment so you should ensure the decision you make is the best.

# **Australian Standards** and industry guidelines

**Stand-alone solar PV systems must comply with a range of Australian Standards covering stand-alone power systems, batteries, the installation of photovoltaic arrays, together with** *The BCSE Design and Installation Guidelines.*





**A range of safety signs required under the Standards**

## Breakdowns — emergency call out

The system installer should be able to offer a quick response for any major system problems, for instance, equipment failure.

## Documentation

**A system manual that provides operation, maintenance and safety information should be provided by your installer.**

Also ensure you obtain written confirmation of statements made by your installer, performance claims, guarantees and manufacturers' warranties.

## Preventative maintenance

**After installation, the owner is responsible for ensuring the equipment is maintained in good working order.**

This will include checking the water in the batteries, cleaning modules and visually checking the wiring.

Please note that appropriate instruction by the installer, backed up by maintenance information in the system manual, should be provided.

Safe work practices for any maintenance tasks must be followed.


## Maintenance contracts

The system installer can offer a maintenance contract. This will usually include regular maintenance visits, at agreed intervals, to ensure that your power system is performing optimally.

# Alternative renewable energy resources

**Like solar modules, that require full sun, all renewable energy devices must have access to a reliable energy source.**

There is no point in installing a wind turbine in a low wind area or a pico-hydro system in an area prone to drought.

# Wind turbines and pico-hydro

**As with solar PV, wind and hydro can be used to charge your batteries.**

For reliable power, the resource should be located close to your power system.

**➔ Some properties have sufficient wind to propel a small wind turbine,**
**Other properties may have access to rivers and creeks to propel a pico-hydro generator.**

# Further information

Sections A and B were written to provide you with an overview of PV systems to enable you to make an informed purchasing decision.

For more detailed information on the following contents, please refer to the BCSE website at www.bcse.org.au.

## Australian Greenhouse Office (AGO)

http://www.greenhouse.gov.au/energy/index.html
http://www.greenhouse.gov.au/appliances/index.html

Your Home Technical Manual
http://www.greenhouse.gov.au/yourhome/technical/fs00.htm

Research Institute for Sustainable Energy (RISE)
http://www.rise.org.au/

## Contents on web

http://www.bcse.org.au/default.asp?id=310

- What is renewable energy?
  — RE resources
- What is a stand-alone power system?
  — Genset only
  — Genset—battery charger—battery—inverter
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- Solar modules
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- Gensets
- Battery chargers
- Wind turbines
- Pico-hydro generators
- Input regulators and controllers
- Power and energy
  — Energy services
- Extra Low Voltage (ELV) and Low Voltage (LV)
- Power system quotes
- Australian Standards
  — System documentation

## State Agencies

**Queensland**
http://www.epa.qld.gov.au/environmental_management/sustainability/energy/renewable_energy_rebate_programs/

**West Australia**
http://www1.sedo.energy.wa.gov.au/pages/rrpgp.asp

**South Australia**
http://www.sustainable.energy.sa.gov.au/pages/programs/electricity_supplies/renewable_energy/renewable_energy.htm

**Tasmania**
http://www.dier.tas.gov.au/energy/rebates

**Victoria**
http://www.sustainability.vic.gov.au/www/html/1388-photovoltaic-rebate-program.asp?intSiteID=4

**New South Wales**
http://www.dwe.nsw.gov.au/energy/Renewable%20Energy/Solar%20Power/Solar%20Power%20Rebates.asp#TopOfPage

**Australian Capital Territory**
Phone: 02 6247 2099

# Glossary

**Accredited** deemed qualified to design / install by the BCSE, 5
**agreed load** production output that matches your budget, 26
**array** a collection of modules, 14
**Australian Standards** mandatory electrical safety requirements, 6
**battery bank** group of battery cells, 25
**BCSE** Business Council for Sustainable Energy, 5
**compact fluoros** electrically economical light globe, 12
**configuration** layout pattern, 14
**data-logging** system generated data, 16
**electricity retailer** company selling and buying electricity, 13
**elements** unprotected weather such as rain and sun, 14
**excess production** power left over after your home's consumption, 13
**feed-in rate** price paid for excess power, 13
**generator** petrol, diesel or LPG powered 240 V electrical source, 21
**genset** electrical generator powered by fossil fuels, 25
**greenhouse gases** gases emitted that contribute towards global warming, 3
**grid** the poles and wires forming a city's electrical network, 3
**home automation systems** computerised system controlling windows, etc., 12
**hybrid** using more than one generating technology, 21
**incandescent** light element used in conventional light bulbs, 12
**inverter** device for converting from DC to AC, 9
**kilowatt** 1000 watts, 15
**kilowatt hours** power in kilowatts multiplied by time in hours, 15
**load analysis** analysis of power requirements, 25
**loads** power requirements, 25
**mandatory** compulsory, 19
**meter** meter recording electricity movement, 13
**off-peak tariffs** incentive to delay power use for quiet time, 12
**out of ear-shot** placing a noise source where it can't be heard, 28
**peak power demand** maximum electrical power required, 26
**penalty clauses** payments owed when a contractor fails to perform or deliver services, 19
**quartz halogen downlights** an uneconomical low voltage light, 12
**rebates** financial incentives offered by governments, 5
**runtimes** length of generator running time, 26
**solar access** letting the sunshine in, 12
**solar water heater** hot water system heated by the sun's energy, 3
**solar panel** converts solar energy into electrical energy, 3
**specification** module and inverter models, 14
**SPS** stand-alone power system, 23
**stand-alone solar PV system** power system independent of the mains grid, 23
**stand-by loads** power to keep an appliance warmed up for a quick start, 12
**surge** additional power required to start motors, 26
**system design** number of modules, size of inverter and cables, 14
**system voltage** voltage of battery and inverter, usually 12V, 24V or 48V, 26
**termination costs** costs incurred in severing the contract, 19

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