ADELAIDE CITY COUNCIL GREEN BUILDING FACT SHEETS

Photovoltaic (PV) *systems*

INTRODUCTION

Electricity generation from fossil fuels creates greenhouse gas emissions and air pollution. Photovoltaic (PV) systems provide a cleaner, environmentally friendly alternative. They convert solar radiation into electricity and are a great way to reduce the environmental impact of your home or workplace. As well as harnessing electricity from a renewable source, PV systems allow electricity to be generated close to where it is used. This avoids the significant energy losses associated with the transmission of electricity over long distances.

PV systems are non-polluting, low maintenance and provide a very reliable source of power. They're relatively easy to install and have a long life span of approximately 20 years.

When installing a PV system, the most cost effective approach is to reduce energy demand first. Energy demand can be reduced through good building design and the use of energy efficient building services and equipment. *(See Adelaide City Council fact sheets Energy Efficient Glazing and Energy Efficient Lighting)*. This approach allows the PV system to be downsized, saving money.

HOW A PV SYSTEM WORKS

The main component of a PV system is the photovoltaic array, a number of connected photovoltaic panels that generate electricity. The system also includes an inverter (if stand alone) and batteries (if grid connect) or a metering system.

Photovoltaic panels are made of semiconductor material. When light particles (photons) strike the surface of the panels, the electrical properties of the semiconductor material initiate an electrical current. The inverter converts this current from Direct Current (DC) into Alternative Current (AC) for use within the building. Batteries are used in stand alone systems to store excess electricity generated for later use.

Grid Connect PV Systems

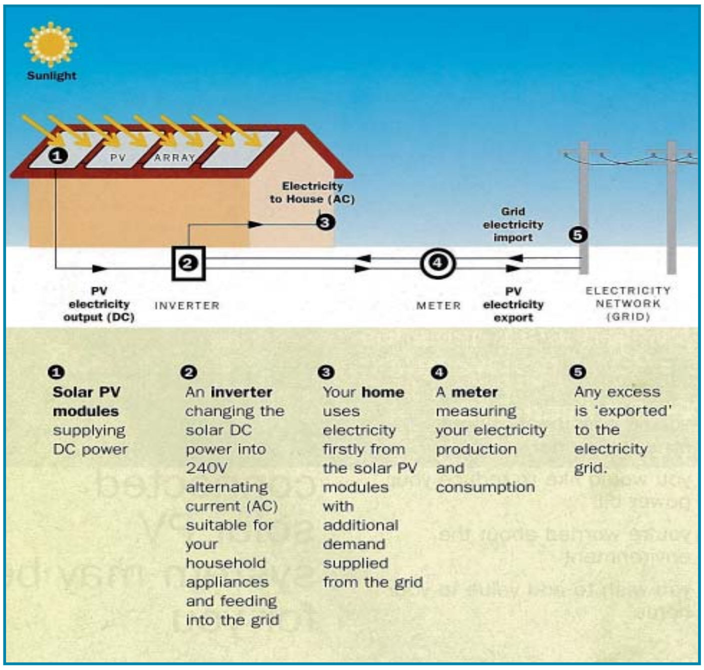
Grid connect systems are the most suitable for areas with existing electricity networks, such as Adelaide. They provide the flexibility to optimise use of dual (mains and PV) electricity supply. Grid connect systems include an inverter and a 'bi-directional' or 'import/export' metering system. Electricity can be drawn from the grid at times when the PV system can't produce enough to meet total demand. Alternatively, when excess electricity is being produced by the PV system it can be sold back to the grid.

Adelaide City Council has acquired a solar electric powered community bus. Batteries are recharged from an iconic solar PV system at the new Adelaide Central Bus Terminal. This is Adelaide's largest grid connected at 50 kW peak.

ADELAIDE CITY COUNCIL

Fig 2: Grid Connected PV system assembly for a house

(BCSE booklet)



Courtesy of Your Home

Stand Alone PV Systems

Stand alone systems are suitable for remote locations, where connection to the electricity grid is either not possible or expensive. They are most cost effective when electricity requirements are relatively low. Stand alone systems include a battery bank, inverter, battery charger and a fuel generator set.

Hybrid Systems

These are PV systems combined typically with diesel or fuel-fired generators, or occasionally with wind turbines.

PV SYSTEM COMPONENTS

PV panels

Semiconductor material is manufactured in the form of silicon cells, which are then assembled in groups to form PV panels. A number of these panels are then connected together in a 'photovoltaic array'. The number of panels required depends on the desired electricity output. A typical PV panel is about 600 mm wide, 1200 mm tall and 25 mm thick, with an aluminum frame around the edge.

There are a number of different types of PV panels. The most common types are crystalline and thin film technologies.

CASE STUDY 1

Christie Walk, Adelaide

Christie Walk is a multiple award-winning medium density residential development. It is located at 105 Sturt Street in downtown Adelaide. It was designed by architect Paul Downton and initiated by Urban Ecology Australia Inc. A total of 27 dwellings consisting of cottages, townhouses and apartment blocks are built on a T-shaped 2000 m^2 site housing 42 people altogether. A 5 storey apartment block containing 13 apartments and a community area with a kitchen, meeting room, library, toilet and laundry at ground level was completed in 2006. This building has effectively and innovatively used translucent photovoltaic panels over the light well. This allows natural light in the building and at the same time generates solar electricity. More photovoltaic panels will be installed on pergolas over the roof garden of a 3 storey block of six apartments. These grid connected PV systems in Christie Walk aim to supply surplus power back to the mains grid and sell electricity to the local energy utility.

Courtesy of Paul Downton

Crystalline panels include mono-crystalline silicon and poly-crystalline silicon. These are currently the most efficient, operating at about 25% efficiency, however they need to be kept cool to maintain optimum efficiency. They consist of crystalline silicon cells (the semiconductor material) covered by a grid of wires to help electricity flow to the terminals. A glass covering and an ethylene vinyl acetate (EVA) substrate protect the cells from moisture.

Thin film technologies, such as amorphous silicon, can be applied as a film to low-cost substrates such as glass or plastic, without the need for a glass covering. Advantages include easier production and assembly and suitability to a broad range of applications. They are generally cheaper than crystalline panels, although prices can vary depending on the manufacturer. However, the efficiency of thin film technologies such as amorphous silicon is lower than crystalline panels, at around 10%.

Building Integrated Photovoltaic (BIPV) panels incorporate photovoltaic panels as components of buildings, for example, as roof tiles, façade cladding materials, skylights or awnings. The panels may be either crystalline or thin film technology. Transparent crystalline modules are often used in shading devices, glazing and skylights. The BIPV panels displace the need for those building materials, but must fulfill the necessary requirements of strength, watertightness, etc. Careful design detailing is required.

Inverters

Inverters convert electrical currents from DC to AC, for use within a building. AC is essential for operating common electrical appliances and for connecting to the main grid.

The PV panels are connected directly to the inverter, which provides AC output to the building's electrical switchboard. The inverter can be installed in any suitable location between the panels and the switchboard.

Inverters weigh up to 60kg and can be either wall or shelf mounted. They need to be installed in dust-free locations and need good ventilation, as they can get hot when operating at large power outputs.

Batteries

Batteries are only required for stand alone PV systems where there is no access to the electricity grid. They store excess electricity for use when the PV panels cannot provide enough electricity (after dark, for example).

Lead acid batteries are the most common types used and can be either 'wet' or valve-regulated 'sealed' batteries. Long lasting Nickel-cadmium batteries, though expensive, are also used. Most batteries are composed of a number of individual 2V cells. Battery banks of 12V, 24V, 48V or 120V are used for stand alone systems, and their life span depends on the average daily depth of discharge. Batteries emit a corrosive and inflammable gas at the final stage of charging and must be installed in a well-ventilated space away from the house.

CASE STUDY 2

North Terrace Solar Precinct

The Government of South Australia and Adelaide City Council have established a solar precinct at North Terrace in downtown Adelaide as part of the Adelaide Green City initiative. Four public buildings - the South Australian Museum (20 kW), the Art Gallery of South Australia (20 kW), Parliament House (20 kW) and the State Library (18.6 kW) - have recently installed photovoltaic (PV) systems on their roofs. These four solar systems have the potential to save 129,265 kWh of electricity and 143 tonnes of CO^2 emissions each year.

Other system components

Grid connected systems also require a bi-directional metering system, to calculate the amount of mains electricity drawn from the grid and the amount of solar electricity supplied to the grid. A PV system is an electricity generating system, and therefore needs to include the necessary switches, circuit breakers and fuses to ensure appropriate safety precautions for the users.

SIZING PV SYSTEMS

The electricity generation capability of a PV system is largely dependent on the amount of solar energy available in a particular geographic location and how much shading affects the solar panels. The Business Council for Sustainable Energy estimates that a 1 kW photovoltaic system can supply around 3.74 kWh per day in Adelaide. To provide for a typical Adelaide household's total electricity demand, the system would need to be at least 1.5kW.

The following table is based on estimates from an Adelaide-based installer of solar systems:

Table 1: Output potentials of Grid connected PV systems

Size of PV Systems	Estimated Output (kWh/day)	Approximate total area of panels (m^2)
0.6 kW	2.6	9.5
1.0 kW	4.4	8 - 16
1.5 kW	6.6	12 - 24
2.1 kW	8.9 - 9.3	16 - 33
3.0 kW	12.1 - 13.0	23 - 47

Source: http://www.adelaidesolar.com.au/ accessed from http://www.dtei.sa.gov.au/

Table 2: Average annual energy and consumption figures

Building	Energy Usage	Solar PV required
All electric house	7600-10100kWh/annum	5.35 – 7.1 kW (peak 53-71 sqm)
1000sqm Office	166,000kWh/annum	117kW peak (1,200sqm)
15,000sqm Office	2,490,000 kWh/annum	1755kW peak (18,000sqm)

CASE STUDY 3

Solar City, Adelaide

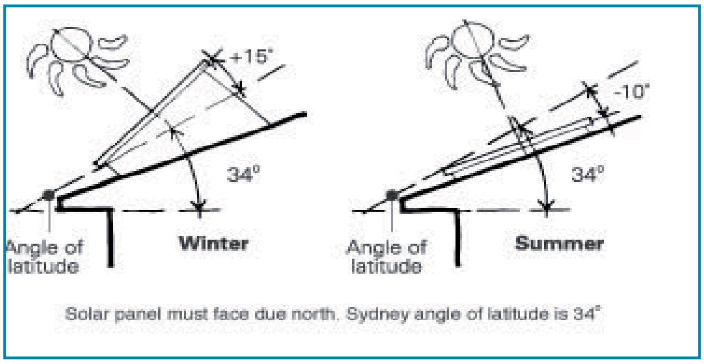
Adelaide has been selected as Australia's first 'Solar City' as part of the Australian Government's 'Solar Cities Programme'. Solar PV panels will be installed in more than 1700 homes in north Adelaide. Five iconic buildings - the Central Markets, the Playford Aquadome, the Bus Depot, the SA Water Building, and the Sustainability Interpretive Centre - will showcase large solar cell displays in order to represent Adelaide as a 'Solar City'. Consumers purchasing PV systems are eligible for special offers and packages. The Solar City Consortium is working with industry, businesses and local community to achieve energy savings and solar electricity generation targets.

ORIENTATION, INSTALLATION AND MAINTENANCE

PV systems can be set up on the ground or on building walls, pergolas, carports and roofs. They can be mounted on frames or integrated as a component of the building. PV panels should be installed in locations with access to maximum solar radiation and minimum shade. The recommended orientation of fixed solar panels for Adelaide is about 30 degrees to the horizontal towards north.

PV panels or arrays mounted on frames can be designed and set up on nearly any roof to retain the most favorable orientation and gradient. These frames can be fixed, adjustable or on tracks to follow the sun's path of movement. As a rule of thumb, for maximum efficiency of the solar panels, the tilt angle should be approximately equal to the latitude (Adelaide is 34º55' South) plus 15º in winter and the latitude minus 10º during summer.

Fig 3: Roof orientation



Courtesy of Your Home

Choosing the right system will depend on the electricity demand, number of occupants, budget, location, rebates and space availability. Accredited designers and installers need to install PV systems. The inverter in a grid-connected system should be located in a protected place, for example, in a garage. The solar panels require little maintenance, however they do need to be kept clean. Operating efficiencies can decrease as a result of poor maintenance and accumulation of dirt on panel surfaces.

FINANCIAL SUPPORT

Rebates and incentives

The Australian Government's Photovoltaic Rebate Programme (PVRP) provides cash rebates for PV systems installed in homes, schools and community buildings. For new residential systems of 450W or more, the rebate is $8 per watt up to a maximum of $8000. For extensions to existing residential systems, the rebate is $5 per watt up to a maximum of $5000. Schools and community buildings can apply through competitive grants for a 50% rebate on PV system costs, for system sizes of 450W to 2KW.

Installation of PV systems should be essentially carried out by accredited designers and installers in order to be eligible for rebates under these programs.

BP Solar and Origin Energy are offering special discounts on PV systems to Adelaide City Council residents and businesses as part of the Australian Government's 'Solar Cities' initiative. ANZ Bank is financing the purchase of 1.5 kW solar PV systems through an ANZ home loan in Adelaide.

The SA Solar Schools Program, an initiative by the South Australian Government, managed by the South Australian Department of Education and Children's Services (DECS), provides grid-connect PV power at government schools and preschools.

The Government of South Australia is currently investigating a feed-in tariff scheme. Participating energy retailers will offer a minimum guaranteed tariff of 44 cents per KWh of PV electricity fed back to the grid, making it easier for owners of grid-connected PV systems to end up in credit for some, or all, billing periods.

Renewable energy certificates

Renewable Energy Certificates (RECs), an electronic form of currency, can be earned for every tonne of greenhouse gas saved by a PV system. RECs require internet registration, are validated by the Office of the Renewable Energy Regulator and can be traded (in a similar way to shares) between registered parties.

EMERGING TECHNOLOGIES

New and improved PV technologies are currently under development. For example, Origin Energy's innovative SILVER technology allows production of cost efficient single crystal silicon thin solar cells, with claimed efficiencies of over 19%. BP Solar's new cell processing and enhanced cell coating techniques for crystalline cells have also enabled efficiency improvements.

ADELAIDE (CITY) DEVELOPMENT PLAN PRINCIPLES

The Adelaide (City) Development Plan provides development opportunities, particularly in the Central Business Area and Mixed Use Zones in the City centre, for growth in residents, workers, visitors and students. At the same time, across the City, a high quality of design is expected, in particular regarding energy, noise, apartment design and built form. Thus, buildings are required by the Development Plan to be sustainable, to minimise use of resources and to make use of innovative energy systems.

The Development Plan supports development that minimises consumption of non-renewable resources and uses efficient energy generation systems such as solar photovoltaic panels. In addition, the principles seek to ensure that the orientation and pitch of roofs facilitate the efficient use of solar collectors and photovoltaic cells.

FOR FURTHER INFORMATION

Your Home Technical Manual
http://www.yourhome.gov.au

BDP Environment Design Guide, available for purchase at:
http://www.architecture.com.au/edg

Information booklets on PV systems and list of accredited designers and installers of PV systems:
http://www.bcse.org.au

Australian Government Photovoltaic Rebate Programme (PVRP) http://www.greenhouse.gov.au/renewable/pv/index.html

Renewable Remote Power Generation Programme (RRPGP)
http://www.greenhouse.gov.au/renewable/rrpgp/index.html

Adelaide Solar City
http://www.adelaidesolarcity.com.au/how-can-i-be-involved/products-and-services/solar-packages.aspx

Government of South Australia's Feed-in-Tariff Scheme:
http://www.climatechange.sa.gov.au/news/news_5_2.htm

SA Government PV rebates and grants information:
http://www.dtei.sa.gov.au/energy/rebates_and_grants/photovoltaic_rebate_program.html#install