International Energy Agency

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task I
Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications
Australia
1999

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power systems Programme is one of the collaborative R & D agreements established within the IEA, and since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. Currently nine Tasks have been established.

The twenty members are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), European Commission, Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA).

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

An important deliverable of Task 1 is the annual International Survey Report on PV power applications. This report gives information on trends in PV power applications in the twenty member countries, and is based on the information provided in the National Survey Reports which are produced annually by each Task 1 participant.

iii Definitions, symbols and abbreviations

For the purposes of this report, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV capacity of 40 Wp or more.

PV system: Modules, inverters, batteries and all installation and control components for modules, inverters and batteries with a PV capacity of 40 Wp or more.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic: PV systems installed in households and villages which are not connected to the utility grid.

Off-grid non-domestic: PV systems used for a variety of applications such as water pumping, remote communications, safety and protection devices, etc. which are not connected to the utility grid.

On-grid distributed: A PV system installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers. etc.

On-grid centralised: PV systems used for support of the utility distribution grid performing the function of a centralised power station.

Turn-key price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid system, the prices associated with battery maintenance/replacement should be excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication systems in the interior of Greenland should not be included.)

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems to the general public and potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. They may be implemented by government, the financing industry, utilities etc.

NC: National Currency

Final annual yield is defined as the total energy delivered to the load during the year per kWp installed.

Performance ratio is defined as the ratio of the final yield to the reference yield, where the reference yield is the theoretically available energy per year per kWp installed.

1 Executive summary

Growth in the Australian PV market slowed slightly to 12% during 1999 and reached an installed capacity of 25,320 kWp by the end of the year. Australia's vast size and sparse population have made effective remote area telecommunications, power supplies, navigation aids and transport route signalling critical and expensive. PV continues to provide an important commercial alternative to diesel and central grid supplies for maintaining these links. Other significant off-grid applications include water pumping systems, cathodic protection and street lighting. Off grid applications accounted for around 75% of capacity installed in 1999. Off-grid non-domestic applications still dominate, accounting for around 65% of Australia's cumulative installed capacity (down from 75% three years earlier) and with an annual growth rate of around 8%. Off-grid domestic applications have also enjoyed strong growth over the last decade and will benefit over the next four years from new government support programmes aimed at increasing the use of BIPV and replacing diesel use with renewables.

Grid connected installations continue to increase and now account for 8% of installed capacity, up from less than 1% three years ago. Over the past two years, around 700 kWp of PV have been installed for Green Power schemes, 80 kWp have been installed through a NSW government BIPV support programme and 800 kW has been installed in and around the Sydney 2000 Olympic site. A national BIPV support programme, beginning in 2000, and a renewable energy target for electricity retailers and major users, beginning in 2001, will assist in keeping this market segment growing.

New National Programmes

The Australian Government has recently initiated a number of new measures to support renewable energy in general and, in some cases, PV in particular. Electricity retailers and other large purchasers of electricity will be required to source an additional 2% of their electricity from renewable energy sources by 2010. However, although some PV is likely to installed under this programme, the target is expected to be taken up largely by more commercially competitive renewable energy technologies. The Renewable Energy Equity Fund (AUD 20 million) has been established to provide venture capital for commercialising renewable energy technologies, and a Green Power Investment Programme aims to boost commercialisation prospects. Specific renewable energy projects will be supported through the AUD 10 million Renewable Energy Showcase Fund and the AUD 56 million Renewable Energy Commercialisation Programme.

Programmes which will benefit PV in particular include the AUD 264 million Remote Area Power Supply Programme, for conversion of remote area power supplies from diesel to renewable energy sources, and the AUD 31 million Household PV System Programme for building integrated systems.

R,D&D

Most of the R&D funding for PV comes from Australian governments, both Federal and State (including electricity utilities) and is directed at PV device research carried out within universities. However, private industry investment in PV R&D is increasing, notably the

significant support now being provided to the Australian National University for its Epilift process and private investment in concentrator cells and systems by Solar Systems. Over recent years significantly less government funding has been made available for systems R&D, with most funding now provided by the systems industry itself.

Commonwealth Government funding for PV R&D, D was about AUD 5.6 million for 1999, including R&D and education funding for PV through the UNSW Centre for PV Engineering, the Australian Co-operative Research Centre for Renewable Energy (ACRE), as well as funding provided through the Renewable Energy Commercialisation Programme. Funding from the State Governments for the year was around AUD 2.6 million, for R&D and market stimulation. Funding from State Government owned electricity utilities is also significant, for instance, AUD 11 million was provided to Pacific Solar in 1999 for development of its thin film ac module.

Industry funded R, D & D is focused on thin film PV, improvements in production processes, balance of system components and system design. Joint industry and research institution activities continue in standards development and associated component testing. Increasing emphasis is being placed on grid-connected systems, with R&D focusing on interconnection systems and building integration. Pacific Solar, for example, has launched a "Plug & Power" ac module, while Sustainable Technologies of Australia is beginning pilot production of a TiO_2 building product.

The increasing need for specialised PV training in all aspects of system design, installation and maintenance has led to the development of trade, undergraduate and professional courses in PV and renewable energy through a number of technical and further education colleges, universities and ACRE.

Industry status

Commercial PV production capacity stands at 11 MWp. The two major Australian manufacturers, BP Solar Australia and Solarex, have been impacted by the international merger of BP and Amoco ~~Enron~~. Over the coming years their production facilities will be merged and expanded. Australia's current production capacity and usage allows for 60% of PV product to be exported.

Other companies are still planning their entry to production phase. These include Sustainable Technologies Australia (using titanium dioxide), and Pacific Solar (with plans for a 20 MW thin film Si manufacturing plant).

Over 200 Australian PV system suppliers design and install off-grid and grid connected systems around the country. Locally produced support frames, array trackers, inverters, maximum point power trackers and charge control regulators are available with varying degrees of sophistication and built-in diagnostics. The export market for PV systems, particularly to the Asia-Pacific region, is also expanding.

Future outlook

The near-term outlook for PV applications in Australia is quite healthy, with a number of new initiatives being introduced for both off-grid and on-grid applications by the Australian Government. The State governments of Queensland, South Australian, Victorian and

Western Australian have also recently introduced new energy policies which identify greenhouse gas reduction strategies as a priority. Local government greenhouse gas reduction initiatives are also increasing and are resulting in supportive regulations and active PV procurement programmes being introduced.

Support for Green Power, introduced under a NSW Government Sustainable Energy Development Authority scheme and now operating nationally, has been enjoying spectacular growth – with sales increasing from 40 to 136 GWh during 1999. By December 1999, 56 777 domestic and 1 898 commercial consumers were signed up for a Green Power product. To date PV output accounts for only 0.1% of total Green Power produced, although output from new installations is higher at 0.5%. Projections are for accelerated growth, however Green Power schemes will be impacted by the now mandated requirement for electricity retailers to purchase renewable energy.

Few, if any PV installations to date have been for grid support or other distributed system benefits. It remains a challenge in Australia, despite its sparse population, high summer peak loads and extensive electricity distribution network, to promote the real value of distributed generation sources such as PV.

2 The implementation of PV systems

2.1 Applications for photovoltaics

PV is widely used in Australia for off-grid telecommunications systems, lighting, navigation and rail signal systems, pipeline cathodic protection, water pumping and domestic power supply. On-grid use is increasing and includes several utility owned generating plants, ranging from 10 to 400kWp, as well as street lights and several hundred rooftop systems on residential, commercial and community buildings.

2.2 Total photovoltaic power installed

The total cumulative installed PV power for each sub-market on the 31 December of each year from 1992 onwards is shown in Table 1.

Table 1 The cumulative installed PV power in 4 sub-markets – Australia 1992-1999.

Sub-market/ application	31 Dec. 1992 kWp	31 Dec. 1993 kWp	31 Dec. 1994 kWp	31 Dec. 1995 kWp	31 Dec. 1996 kWp	31 Dec. 1997 kWp	31 Dec. 1998 kWp	31 Dec. 1999 kWp
off-grid domestic	1 560	2 030	2 600	3 270	4 080	4 860	5 960	6 820
off-grid non-domestic	5 760	6 865	8 080	9 380	11 520	13 320	15 080	16 360
on-grid distributed		5	20	30	80	200	850	1490
on-grid centralised				20	20	320	630	650
TOTAL	**7 300**	**8 900**	**10 700**	**12 700**	**15 700**	**18 700**	**22 520**	**25 320**

2.3 Major projects, demonstration and field test programmes

In addition to the programmes described in previous years and summarised in Table 2, the following new programmes have been introduced:

2.3.1 Australian Government Renewable Energy Commercialisation Programme (RECP)

The RECP provides funds for commercialisation and demonstration of renewable energy technologies. In 1999, four PV projects were funded:

- AUD 1 million towards the manufacture of titanium dioxide modules.
- AUD 482 000 towards the upgrade of a polycrystalline Si PV production facility.

- AUD 1 million towards a local government solar development, incorporating 200 kWp of thin film Si PV modules.
- AUD 740 000 towards a high rise commercial office building, incorporating 80 kWp of PV.

The programme also provided funding of AUD 265 000 for a 500 kWh Zinc Bromine battery, AUD 420 000 for an innovative inverter, as well as funding for other non-PV related projects. The programme seeks applications twice a year and has a total budget of AUD 29 million over 5 years.

2.3.2 Queensland Sustainable Energy Innovation Fund (QSEIF)

The QSEIF provides support for the research, development, demonstration and commercialisation of environmentally positive Queensland-based energy innovation technologies and practices. QSEIF funding is intended to overcome technical or marketing barriers that would inhibit commercial undertaking of the project without Government assistance.

The Fund aims to:

1. Allow Queensland to become a market leader in specific areas of energy efficiency, renewable energy or greenhouse reduction,
2. Create business opportunities and employment in sustainable energy industries,
3. Address needs, problems or opportunities relating to energy efficiency, renewable energy or greenhouse reduction that are specific to Queensland,
4. Develop expertise and/or community acceptance of sustainable energy technologies.

Funding for QSEIF is currently AUD 1 million per year. The first round of grants was announced in November 1999 and included the following PV projects:

- AUD 45 500 for a PV powered reservoir mixer.
- AUD 45 000 for a PV powered salt water chlorinator.
- AUD 25 000 for a 5 kW PV shade shelter in a school.
- AUD 50 000 for a PV system in a school science block.
- AUD 56 000 for a PV demonstration system in a sustainable farm community.

Grants totalling an additional AUD 153 600 were provided for PV related projects, including education, lights, inverters and battery sensors.

2.3.3 Integral Energy Community GreenPower Scheme

This GreenPower scheme enables Integral Energy's customers to contribute an amount of money per electricity account to fund the installation of renewable energy projects on community buildings.

Contributors "round-up" their accounts to the nearest whole dollar, thereby giving a small but significant amount of money towards the installation of renewable energy systems. The scheme currently has 16,200 members and has seen PV systems installed on six schools.

The aim of installing the PV systems on schools is to raise the awareness and knowledge of school children with regard to renewable energy. This will assist in building a base of awareness for future, widespread application of solar technologies.

Table 2 summarises the major projects, demonstration and field test programmes operating in Australia in 1999.

Table 2: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 1999/problems and lessons learned	Funding	Project management	Remarks
Queensland Sustainable Energy Innovation Fund. 1999 - 2005	AUD 1 million per year for 3 years for R,D,D&C grants for sustainable energy projects	To allow Queensland to become a market leader in sustainable energy, create business opportunities, employment, address needs, problems or opportunities, develop expertise & community acceptance.	9 PV related projects funded in the first grant round.	Queensland government. Total of AUD 375 000 for PV related projects.	Queensland Department of Mines & Energy.	Projects must bring benefits to the State.
Sydney Superdome Solar System 1999	70 kWp a-Si roof integrated array, comprising 1176 X 77 Wp modules on a steel frame with an 8º tilt, 19 X 4 kW inverters and optic fibre monitoring link.	To demonstrate a large roof-integrated array and supply 1000 of EnergyAustralia's *Pure**Energy*** customers.	Largest roof integrated PV system in Australia.	EnergyAustralia, via contributions from *Pure**Energy*** customers	EnergyAustralia in conjunction with SEDA, Abi Millenium, Olympic Co-odinating Authority	Will save 85 t of greenhouse gas emissions per year.
Olympic Boulevard PV Lights 1999	1520 laser grooved c-Si modules on 19 towers. Grid connected.	To provide lights, signage, shelter and shade, plus a high profile demonstration of PV power.	Won the Inst of Eng 1999 Eng Excellence Award for Project Development. Will provide 160 000 kWh/an	Australian Olympic Co-ordinating Authority	EnergyAustralia	Very high visibility site, with innovative design features.
Newington Solar Village 1998-2000	62~~965~~ X 1 kWp grid connected rooftop systems (c-Si cells) in a high density residential estate.	To develop and demonstrate standardised, easy to install BIPV systems in commercial housing. To investigate network issues involved with a high density of small PV arrays.	200 systems installed by end 1999. Valuable trade and professional experience, understanding and skill development. Need for dc wiring guidelines for PV systems.	PV costs included in house prices.	Pacific Power, BP Solar~~in conjunction with Mirvac Lend Lease and SEDA~~.	High profile site for international demonstration of BIPV during the 2000 Olympic Games.

NSW SEDA BIPV Programme. 1998 ?	Subsidies of AUD 2 400/kWp (4 800 for community & education buildings) for 500W to 5 kW BIPV systems	To expand the BIPV market, increase acceptance and improve products.	154 grants provided, 60% off-grid. Slow start-up & impact of new Commonwealth govt programmes.	SEDA subsidies range from 13-29% of total system cost. Total provided ~AUD 500,000	SEDA	Av. system size 1.3 kW, 36% of systems 500-750Wp, 67% residential, 14% community, 16% education.
Green Power Programmes 1998 ?	Customers elect to contribute an additional amount on each electricity bill. Contributions vary by utility.	To allow customers the option of purchasing electricity from renewable sources.	Over 56 000 customers Australia-wide. All electricity retailers now offer a scheme. 22 PV systems installed to date.	Customer Green Power contributions.	Individual utilities, with overall quality control by SEDA	A very successful programme to date, but may be impacted from 2001 by the introduction of mandatory renewable energy targets for electricity retailers.
Western Plains Zoo 1998	Grid connected 50 kWp mc-Si array.	To demonstrate PV for its Green Power customers and gain installation & operational experience.	Trees surrounding site.	Advance Energy via its Green Power customers, SEDA.	Advance Energy	High profile toursit site.
Queanbeyan Energy Depot 1998	Grid connected 50 kWp mc-Si array, comprising 720 X 77 Wp modules.	To gain installation & operational experience with larger scale PV systems.	Difficult sloping site, with non-ideal orientation.	Great Southren Energy via its Earth Saver customers and SEDA.	Great Southern Energy	
White Cliffs Solar Power Station. 1998	Grid connected 42 kWp concentrating array with 14 X 20 m^2 tracking dishes.	To refurbish a concentrating solar thermal system with PV.	Produces 70 000 kWh/an.	Advance Energy & Solar Research Corporation, with contributions from Advance Energy's Solar Fund green power scheme.		Popular tourist site. The PV system operates at 55 ºC.
Wilpena Pound Solar Power Station.	100 kWp ground mounted mc-Si array in hybrid configuration with 440 kW diesels, 400 kWh	To gain experience with and demonstrate a stand-alone community sized PV based power system.	The PV/battery system typically supplies all daytime load.	South Australian government, Electricity Trust of SA.	ETSA Power	Remote monitoring and control via modem link using a Hybrid Station Control Module, which

1998	battery bank, 125 kVA inverter/charger plus innovative remote monitoring & control system.					allows flexible assembly of renewable & conventional energy sources into an integrated energy supply system.
Singleton Solar Farm 1997-98	Grid connected 400 kWp array of 3312 a-Si and 3456 mc-Si panels on steel frames at 30º N tilt. 5 X 50 kW and 36 X 4 kW inverters are used.	To gain experience with large grid connected arrays and system components.	Largest central PV power station in Australia. Produces 500 000 kWh/an, supplies 6000 PureEnergy customers.	EnergyAustralia, via contributions from PureEnergy customers, with support from SEDA & Singleton Shire Council.	EnergyAustralia	Avoids 500t greenhouse gases/an.
Western Australian Renewable Energy RAPS Scheme. 1997 ?	Subsidies provided from an annual budget of AUD 0.5 million.	To assist in provision of continuous power to remote areas, reduce costs, increase confidence and develop the industry.	36.7 kWp PV installed in 1999, of total 116.7 kWp installed since scheme commenced. Problems with early installations resulted in system inspections being undertaken.	To date, the WA govt has provided AUD 1.47 million (~ 50%) towards the cost of 192 systems	WA Office of Energy	Systems continue to improve. Valuable lessons learned wrt installation & maintenance in remote areas.
Queensland Remote Area Power Supply Rebate Scheme 1997 ?	Subsidies up to 75% of the cost of renewable energy components.	To assist remote area residents to gain adequate power supplies.	Approximately 95 kWp of PV was installed through the scheme in 1999, with array sizes averaging 645 Wp.	Queensland government	Queensland Department of Mines & Energy	The scheme will be added to the Commonwealth Govt BIPV programme from 2000.
Homebush Business Park PV Power Station 1997	11.2 kWp c-Si array, comprising 140 X 80 Wp panels and a 10 kW inverter.			EnergyAustralia via its PureEnergy customers.	EnergyAustralia	

Foreshore Park PV Power Station, Newcastle 1996	6.5 kWp array on a historic railway shed, comprising 80 X 83 Wp and 16 X 64 Wp mc-Si modules with a 5 kVA inverter.	To demonstrate a grid connected building integrated PV system.	Very careful design required to fit heritage listed building requirements.	EnergyAustralia via its PureEnergy customers.	EnergyAustralia	High visibility tourist area, in a heritage listed building.
National Innovation Centre PV Power Station 1996	10 kWp array at Australian Technology Park.	120 X 83 W mc-Si modules and 10 kVA inverter.		EnergyAustralia via its PureEnergy customers.	EnergyAustralia	System used to analyse PV system maintenance requirements.

2.4 Budgets for market stimulation, demonstration and R&D

Table 3 provides figures for 1999 on budgets from Commonwealth, State and Local Governments for R&D, demonstration and market incentives. The figures do not include funding provided through government owned utilities. In 1999, the latter was over AUD 11 million for product development, demonstration and marketing.

Table 3 Government Expenditure (AUD millions) on PV R&D, demonstration programmes and market incentives - 1999.

	R & D	Demo	Market
Commonwealth	1.7	3.9	
State			
New South Wales	0.5		0.5
Western Australia	0.2		0.5
Queensland	0.4		0.5
Total	2.8	3.9	1.5

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Table 4: Production and production capacity information for 1999 for Australian PV module manufacturers

Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MWp) Cell	Module	Maximum production capacity (MWp)	Trends
BP Solar Australia	sc-Si	5	5	6	Manufacturing to merge with production increasing to 20 MWp by 2001.
Solarex	mc-Si	2	2	5	
TOTALS		**7**	**7**	**11**	

a) General description of the main steps of the production process employed for each manufacturer.

Cell fabrication from imported wafers, through to module fabrication as well as total system production.

Some modules are fabricated from imported cells.

b) Whether the manufacturer produces their own cells in-house or whether they are purchased on the international market, or both.

The majority of modules are fabricated in-house from imported single and poly-crystalline wafers.

c) The quantity of PV cell production sold as cells on the international market to other module manufacturers.

Some cell sales to overseas subsidiaries (minor and intermittent).

d) Technical characteristics of standard commercial modules, cell material, typical module output power range, type of encapsulation, length of typical warranty, certification.

Modules range in size from 2 - 90 Wp, the most common being around 70 Wp. Almost all have front glass and EVA rear encapsulation. Warranties range from 10-20 years, depending on the application, as well as on the level of manufacturer involvement in system design.

e) Certification of modules to IEC 1215 or IEC 1646 or equivalent. Certification to ISO 9000, ISO 14000.

Australian standards, plus international standards via ISPRA testing.

f) Availability of modules specially designed for utility applications.

None.

g) New developments and new products.

Several new thin film products are under development:

- Pacific Solar – multi-layer thin film c-Si;
- Australian National University – thin film c-Si using the Epilift process;
- Sustainable Technologies of Australia - TiO_2;

Pacific Solar has introduced a new "Plug & Power" AC module, initially using crystalline Si cells, but eventually to use their new thin film Si product.

A number of new concentrator systems are under development and demonstration:

- Solar Systems are testing and demonstrating a new concentrator system at White Cliffs Solar Power station. The system is currently based on Si cells, but work is continuing on development of non-silicon devices.
- The Australian National University (ANU) is developing parabolic trough and paraboloidal dish concentrator systems. A research system is being operated and monitored near Canberra and a 20 kW system has been built in Rockingham, WA with the aim of commercialising the technology within the next few years.
- The ANU is also developing a Combined Heat And Power Solar System which integrates PV electricity generation and solar hot water production.

h) Trends in Manufacturing / products nationally and by company

The merger of BP Solar Australia and Solarex will see the establishment of a new joint cell production facility at Homebush Bay, Sydney, in 2000. Both mono and poly crystalline cells will be produced. Module production will remain at the existing Solarex plant in Villawood, Sydney in the short term. Output from the new plant is expected to reach 13 MWp by the third quarter of 2000 and 20 MWp by year end. The facility will have the capacity to expand production to 40 MWp.

Pacific Solar commenced prototype production of its thin film "Plug & Power" ac module in 1999 and expects to commence small scale commercial production during 2000.

i) Module prices and trends

Module prices have remained stable over the past year and are not expected to change substantially in the coming year. Retail prices are typically around AUD 7 to 9 per Wp.

j) System prices and trends

System prices have remained steady during 1999, but may be impacted over the next few years by the large number of new government PV and renewable energy programmes commencing in 2000/2001.

3.2 Manufacturers and suppliers of other components

Table 5. Typical prices of inverters for grid-connected PV applications (AUD).

Size of Inverter	<1 KVA	1-10 KVA	10-100 KVA	>100 KVA
Average Price per kVA (NC)	na	1-2	na	na

PV systems installed in Australia use both locally produced and imported balance of system components. Locally produced components include inverters, batteries and battery charge controllers, DC switchgear, array support structures, water pumps and controllers and maximum power point trackers.

Australian manufacturers supply a range of locally developed inverters for both grid and off-grid uses and also supply a growing export market. Similarly, locally manufactured batteries, specifically developed for PV applications, are widely used and include deep cell and gel cell technologies. Over the last few years, local businesses have benefited from the number of PV systems installed for the 2000 Olympic Games and for Green Power schemes around the country. In addition to the standard BOS components, these projects have involved the design and manufacture of a range of new array support structures.

The introduction from 2000 of several PV and renewables market support programmes should see the PV and related BOS markets grow and a larger range of product being offered.

3.3 System prices

Table 6: Prices of typical applications *

Category/Size	Typical applications and brief details	Price per Wp in AUD
OFF-GRID Up to 1 kWp	Lights, telemetry, dc supply for remote houses.	20-40 for complete systems
OFF-GRID >1 kWp	Remote households, remote communities, telecommunications, cathodic protection, water pumping.	14-50 (av 26) for complete systems
ON-GRID NSW SEDA BIPV grants	1-3 kWp building integrated systems	10 installed
ON-GRID Up to 10 kWp	Rooftop systems	10-15
ON-GRID >10 kWp	Ground and roof mounted systems	8-12

* not including recurring charges after installation, such as battery replacement or operation and maintenance, or additional costs incurred due to the remoteness of the site or special installation requirements

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

a) Promotional initiatives (preferential tariffs; tax exemptions; novel financing packages; etc.)

There were no specific promotional initiatives on offer during 1999. However, a number of new initiatives will be introduced from 2000. These are discussed in sub-section (d).

b) Utility perception of PV

Utility Green Power programmes grew significantly during 1999, with 56 777 residential and 1 898 commercial customers by year end. Twenty-two new solar systems were installed in 1998/99, generating 695.5 MWh over the year.

A number of Australian utilities offer net metering for residential PV systems, implying an energy value of approximately AUD 0.10 per kWh for PV generated electricity used by the household. Most utilities offer bulk supply buy-back rates for generation in excess of usage, which are typically around AUD 0.04 per kWh.

Innovative utility programmes which particularly benefit PV include the following:

- As part of its **earth's**choice green power scheme, Energex now offers AUD 0.28 per kWh, up to 1 000 kWh per year, for electricity exported from residential PV arrays.
- Integral Energy's Community GreenPower Scheme uses customer donations, via rounding up of electricity bills, for the installation of PV systems on schools. The scheme has 16 200 customers and has now installed 6 school systems.

c) Changes in public perceptions of PV

The Australian public continue to support the development and use of PV and other renewables, however grid connected customers in particular lack access to information on availability, cost and performance of PV systems. They also have a low level of understanding of electricity supply generally and therefore a limited understanding of the potential role of renewables.

d) Major new projects or initiatives

The Australian Government has announced several new renewable energy programmes to begin in 2000 and 2001. Although not all are PV specific, they can be used for PV systems and will benefit wider industry development.

Commonwealth Government PV Rebate Programme (PVRP)

From 1 January 2000, the Australian Greenhouse Office will provide support for up to 50% of the capital cost of residential building integrated PV systems, with a maximum grant of AUD 8 250. Both grid and off-grid households are eligible. Grant applications will be processed through the States and Territories and in some cases will add to existing State based incentive programmes.

AUD 31 million has been allocated to the programme over four years, which should result in the installation of approximately 6 000 systems.

Commonwealth Government Renewable Remote Power Generation Programme (RRPGP)

From 1 July 2000 the Australian Greenhouse Office will provide support for up to 50% of the capital cost of conversion of diesel based off-grid electricity supplies to renewable energy technologies.

The objective of the RRPGP is to increase the uptake of renewable energy technology in remote areas of Australia, which will:

- help in providing an effective electricity supply to remote users;
- assist the development of the Australian renewable energy industry;
- help meet the energy infrastructure needs of indigenous communities; and
- lead to long term greenhouse gas reductions.

The programme will be funded from excise paid on diesel used to generate electricity by publicly owned generators. States and Territories will be allocated funding on the basis of the diesel fuel excise paid in their region. Up to AUD 66 million per annum will be available during the four year life of the programme.

Renewable Energy Industry Development (REID)

From July 2000 the REID programme will provide funding in such areas as feasibility studies, addressing financial and institutional barriers, developing technical standards for equipment, training, certification, accreditation, resource assessment, education and promotion.

AUD 6 million has been allocated over 4 years.

Renewable Energy Equity Fund (REEF)

REEF will provide venture capital for innovative renewable energy companies. AUD 20 million has been allocated, with the expectation of 2:1 industry:government investments. The fund will be administered by an independent fund manager, with proceeds from successful ventures being shared on the basis of percentage investment.

4.2 Indirect policy issues

a) international policies affecting the use of PV Power Systems;

The Australian government has already introduced a range of renewable energy support programmes, as part of the National Greenhouse Strategy. Until the Kyoto Protocol is ratified internationally, is unlikely to introduce further measures.

b) the introduction of any favourable environmental regulations;

The Australian government is considering the introduction of "greenhouse triggers" which would require special approvals for projects which are likely to produce large greenhouse gas impacts, such as coal fired power stations or energy intensive industries. In the long term, such a measure will begin to incorporate environmental externalties into energy planning

c) studies relating to externalities and hidden costs of conventional energy generation when compared to renewable energy;

Although there is general acknowledgement of hidden environmental costs associated with fossil fuel use, such externalities are not yet commonly included in economic analyses of energy systems.

d) taxes on pollution (e.g. carbon tax);

There are no plans for a carbon tax at present, however, the Australian government has examined the implications of an emissions trading scheme. Nevertheless, it appears unlikely that Australia would implement such a scheme unless other countries or regions were also planning to do so. The introduction of carbon taxes or trading schemes would implicitly introduce a value for greenhouse gases and hence assist longer term PV market development.

e) policies and programmes to promote the use of PV in developing countries.

The work of the Centre for Application of Solar Energy (CASE) is specifically directed to projects in developing countries. The Australian PV industry provides components and systems for projects funded by Australian aid agencies, as well as by the World Bank, the Asian Development Bank and other agencies. These activities are likely to continue, combined with an increasing involvement by Australian industries in PV education and training. Government sponsored educational and training activities in developing countries are also provided by the Australian CRC for Renewable Energy.

4.3 Standards and codes

a) Technical regulations for PV plant construction and operation (d.c. working voltage, safety and control devices, supporting structures, etc.);

Currently published standards:

- Australian Standard AS 4509.1 "Stand Alone Power Systems. Part1: Safety Requirements"
- Australian Standard AS 4509.3 "Stand Alone Power Systems. Part3: Installation and Maintenance".

Under development:

- Australian Standard AS 4509.2 "Stand Alone Power Systems. Part2: Design Guidelines".

b) Availability of standards and grid interconnection rules for PV systems (protection; islanding; harmonic distortion, power factor, safety, etc.)

"Australian Guidelines for Grid Connection of Energy Systems via Inverters" is currently on the Internet at: http://ee.unsw.edu.au/~std_mon. These are industry guidelines which are generally accepted by the electricity utility industry in Australia. An Australian Standards Committee is currently working on producing an Australian Standard based on these guidelines. These guidelines only cover the AC side of the inverter.

c) Specific rule problems to be solved in order to facilitate PV system diffusion;

Another Australian Standards sub committee is to be formed to look at standards for the DC side of grid connected systems. There is an urgent need to get standards in place for the DC side, as it is important for safety and will also assist builders to feel confident with the technology.

d) Building and wiring codes

In addition to the above, PV systems are covered under existing building and wiring codes, some of which vary by State, Territory or local government area.

5 Future trends

a) Details of planned increases in PV module production capacity

The merger of BP Solar Australia and Solarex will see the establishment of a new joint cell production facility at Homebush Bay, Sydney, in 2000. Both mono and poly crystalline cells will be produced. Module production will remain at the existing Solarex plant in Villawood, Sydney in the short term. Output from the new plant is expected to reach 13 MWp by the third quarter of 2000 and 20 MWp by year end. The facility will have the capacity to expand production to 40 MWp.

b) Any developments in technologies

Pilot production of thin film silicon and titanium dioxide cells is expected to begin during 2000.

c) Long term targets for installed renewable energy capacity

Renewable Energy Target

From 2001 to 2010, electricity retailers and major users will become liable for an increasing percentage of renewable energy in their generation/usage mix, until a target of 9 500 GWh per annum is reached. The programme will operate using a system of tradable renewable energy credits.

No technology portfolio has been included, so that the implications of this policy on PV implementation are undefined. However, despite the relatively high cost of PV compared to other renewable energy technologies at present, it is expected that several liable parties will install some PV. If new PV technologies are successful in meeting anticipated cost reductions over the next decade, the proportion of PV in the mix could become more significant.

Annex A Exchange rate

1999 average exchange rate ~ 0.60 USD = 1 AUD

Annex B Method and accuracy of data

a) Information was obtained from manufacturers, utilities, government agencies and system suppliers.

b) Production data is accurate to ± 10 %. Installation and cost data may be less accurate in some categories.

c) Much of the information required for this report is normally considered confidential by the industry. Hence detailed information is not readily available.