International Energy Agency

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1
Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in *Australia 2000*

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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 (IEA-PVPS) 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 twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), 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 European Commission is also a member.

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. Eight Tasks have been established, and currently seven are active:

Task 1	Exchange and dissemination of information on PVPS
Task 2	Operational performance and design of PVPS and subsystems
Task 3	Use of PVPS in stand-alone and island applications
Task 5	Grid interconnection of building integrated and other dispersed PVPS
Task 7	PVPS in the built environment
Task 8	Very large scale PV power generation
Task 9	Technical co-operation for PV market deployment

ii Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. 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. These may be used for support of the utility distribution grid.

On-grid centralized: PV systems performing the function of a centralized 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. These may be implemented by government, the finance 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

- General activity

Installed PV capacity in Australia grew by 15% in 2000, with 3.89 MWp installed. A large proportion (over 80%) of this was for installations on residential, commercial and educational buildings, a market stimulated by an Australian Government PV rebate programme. PV used in the Sydney Olympic site and on service stations also contributed to this market area. This was offset by decreased use in the off-grid industrial market, which has previously dominated Australian sales. The telecommunications market has been disrupted by an outsourcing of off-grid power supply installations and maintenance and also by some saturation of that market sector.

The grid-connected PV market continues to grow and now represents 10% of installed capacity. The significant use of PV in the Sydney Olympic site has contributed to this increase, as have various utility greenpower programmes and the Australian government's PV rebate programme.

Australian companies are active in the international PV market, both as suppliers of equipment and of services related to PV system design, installation, monitoring, maintenance and training.

- PV Production

PV cell and module production levels fell slightly in 2000, due to the disruption in production caused by the merger and factory relocations of BP Solar and Solarex. This has contributed to an increase in imports of cells and modules. Although not appearing in the Australian usage figures, there has also been an increase in imports of modules, which are subsequently re-exported in complete systems. Approximately 50% of local production was also exported.

- Government Policy and Programmes

This year's PV installations are dominated by systems installed using the Australian Government' PV Rebate Programme. This has provided 50% of capital costs for building integrated systems. Half of the AUD 31 million allocated to the programme was used in the first year. However, the criteria have now been tightened and applications are slowing. It remains to be seen whether the programme will have any long-term impact on the use of BIPV, the availability of specific BIPV products or on the depth of the PV industry in supplying, installing and maintaining such systems. Eighty percent of installations to date have been on off-grid buildings, perhaps catering for an already reasonably well established remote area power supply market. A new programme aimed specifically at the off-grid market begins in 2001. This has a budget allocation of AUD 264 million, so has the potential to see large increases in PV use, as a replacement for diesel fuel.

Several Government programmes aimed at commercialization of renewable energy technologies have benefited PV. Over AUD 7.5 million in grants was provided in 2000 to a variety of PV production facilities, products and demonstration systems. A further AUD 1.1 million was provided for battery and charge controller development. It is hoped that these projects will improve the products available and their cost effectiveness, as well as providing much needed visible demonstration of the

technology in a variety of applications. A new Australian government mandatory renewable energy target of 9,500 GWh by 2010 will apply to electricity retailers and large users from 2001. Although it is not expected to benefit PV greatly in the short term, if current PV production and cost targets are met, PV could play an important role towards the end of the target period.

- Education and Training

Australia now has a degree course specifically in PV Engineering, at the University of NSW, as well as one in Renewable Energy Engineering, at Murdoch University, which includes PV topics. Trade level courses are also being provided through the national Technical and Further Education sector. Short courses, diplomas and other post graduate education are also offered, many of which are supported by the Australian Cooperative Research Centre for Renewable Energy. Students from around the world avail themselves of these courses. Locally, some of Australia's top students have chosen PV Engineering, which augurs well for the future of PV development and use.

- The Future

Production of multi and single crystalline PV cells and modules from the new BP Solar plant is expected to increase significantly in coming years, initially doubling to 15 MWp capacity and then increasing to 40 MWp. A 500 kWp pilot production line for Sustainable Technologies International Titania dye sensitized solar cells will begin operation in 2001, while full-scale production of Pacific Solar's thin film poly crystalline silicon cells is expected to begin in 2004.

All PV manufacturers, as well as some other companies and utilities are involved with the development of new module types or frames specifically for the PV buildings market. Several concentrator PV systems are also in the demonstration phase, with commercial production expected to follow in the next year or two. Both university and industry R&D continues on improving cell efficiencies and production processes. Research is being undertaken on a-Si, TiO_2, two types of thin film silicon as well as on conventional multi and single crystalline silicon.

Although the relative importance of Australian PV R&D and production may be declining as international efforts increase, there is still considerable PV activity at all levels in Australia. The internal market is small, so that the emphasis is on export market development for cells, modules, complete systems, as well as on back-up maintenance and training.

Graduates from the various PV and renewable energy trade and degree courses will soon begin to come on stream, providing Australia with qualified and enthusiastic personnel to supply the expanding manufacturing sector, as well as the local and international service sectors.

2 The implementation of PV systems

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 Wp or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

2.1 Applications for photovoltaics

PV applications in Australia continue to be dominated by off-grid installations for industrial use and private dwellings. Important industrial uses include telecommunications systems, shipping, rail and road signalling, water pumping, cathodic protection, billboards and electric fences. Although increasing, the percentage of PV used in grid connected systems is still small, representing 10% of installed capacity. Year 2000 grid connected installations typically comprised systems on residences, the 2000 Olympic Village, service stations and schools.

2.2 Total photovoltaic power installed

Table 1 The cumulative installed PV power in Australia by sub-market.

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	31 Dec. 2000 kWp
off-grid domestic	1 560	2 030	2 600	3 270	4 080	4 860	5 960	6 820	9 110
off-grid non-domestic	5 760	6 865	8 080	9 380	11 520	13 320	15 080	16 360	17 060
on-grid distributed		5	20	30	80	200	850	1490	2 390
on-grid centralized				20	20	320	630	650	650
TOTAL	**7 300**	**8 900**	**10 700**	**12 700**	**15 700**	**18 700**	**22 520**	**25 320**	**29,210**

2.3 Selected projects, demonstration and field test programmes

CitiPower Solar Pioneers Program

Aims: To demonstrate the viability of residential and commercial grid connected PV systems, to accelerate uptake and increase sales volumes, to enable customers to participate in greenhouse gas reduction activities.

Funding: Customers, Citipower (a Victorian based electricity retailer) and the Australian Government via its Renewable Energy Industry Program (REIP).

During 2000, fifty systems, with a capacity of 57.6 kW, were installed. Most of the systems were rated at 1 kWp. One system was installed on a secondary school, the remainder were on residential properties.

The systems installed utilised components with as much Australian content as possible. The majority of systems incorporated photovoltaic laminates in SunFrame, a CitiPower/Allied Solar powder-coated galvanised steel framing system.

Issues encountered included:

- Difficulties with sourcing suitable inverters (local or imported) for 0.5 kWp systems.
- A hesitancy amongst the electrical inspection authorities unfamiliar with the technology.
- Specific requirements (supplementary to the Australian Guidelines) from the Victorian Office of the Chief Electrical Inspector to enable the commissioning of systems. These included DC isolation at the solar panels and labelling.
- Metering / billing: interim electro-mechanical metering that ran both ways is now progressively being replaced with electronic metering that is compatible with modern billing systems.
- More generally, a lack of well established work systems also slowed installations.

As the installations have become more commonplace, these issues are slowly being resolved.

Australian Government PV Rebate Program

Aim: To encourage the development and use of building integrated PV.

Funding: Australian Government with administration by the State Governments. AUD 31 million has been allocated over 4 years. Grants of AUD 5,000 per kWp are provided, to a maximum of AUD 7,500 per residential system and AUD 10,000 per community building system.

Over 2,600 systems were installed in 2000, amounting to 2.8 MWp. 81% of systems were on off-grid buildings. There has been high public interest in the program, with AUD 14 million allocated during 2000. Funding has been brought forward from future years to accommodate this initial demand and grant sizes have been reduced for the coming years.

Solar Kogarah:

The Kogarah Town Square redevelopment includes a central Town Square, a new public library, Australia's largest solar power supplemented medium-density residential development, tertiary treated stormwater systems and a suite of energy and water conservation measures.

The PV component of the project includes:

1. Installation of a Building Integrated Photovoltaic (BiPV) system of at least 160 kWp on the Kogarah Town Square development in order to:

   a. Demonstrate BiPV technology in mainstream urban renewal projects to the general public and the development industry.

   b. Support and hasten the development of BiPV technology into a more user-friendly, builder friendly and cost effective product which maintains building / roof integrity

   c. Demonstrate the effectiveness of BiPV technology as a power source in energy efficient housing.

2. Development of generic training materials and programmes for professionals, tradespeople, and the education sector in the installation of BiPV technology;

3. Systematic documentation and recording of the lessons learnt from the process of the design, installation and monitoring of the BiPV systems, and of the training and education of the building industry;

4. Monitoring of the BiPV installation to provide publicly available data on the performance of the entire BiPV system for the life of the system

5. Provision of a public display showing the performance of the BiPV system and creating awareness of the technology's potential.

6. Fitting out of the residential apartments with energy-efficient electrical fittings and appliances in keeping with the sustainable nature of the development.

7. Development of an ownership and management scenario for the BiPV installation which maximises the ownership benefits and provides a starting framework for other BiPV owners.

Expected project outputs include:

- Annual Greenhouse Gas Reduction: 4120 Tonnes CO2 equivalent
- Annual Energy Output: 206 MWh
- Power Capacity: 0.16 MWp

The project has been supported by the Australian Greenhouse Office, the NSW Sustainable Energy Development Authority and Kogarah Council.

Solar in Schools:

A NSW “Solar in Schools” programme brings solar energy to schools across the State. The programme is about generating clean, green electricity and raising awareness of

the benefits of renewable sources of power. 10,000 students across 18 schools are already participating.

Each school solar system is rated at 2 kWp and saves 2.5 tonnes of greenhouse gases per year. The program is now being offered to all NSW schools, representing a potential greenhouse gas saving of 110,000 tonnes of greenhouse gases.

Each school in the programme receives a grid-connected solar power system and a hands-on teaching resource kit, providing a effective real life example of renewable electricity. As well as reducing greenhouse gas emissions, each school in the program saves around $250 annually in electricity costs. Solar in Schools has changed the way teachers teach about global warming and is generating true awareness of the link between individual electricity use and climate change.

Solar in Schools provides an excellent example of renewable energy use, which could easily be transferred to homes, businesses and public buildings. The program is a partnership between industry, government and the education sector, all of whom have embraced the project with enthusiasm.

The programme has cost approximately AUD 0.5 million and is jointly funded by the NSW Sustainable Energy Development Authority, the Department of Education and Training and Integral Energy.

The Australian Government Renewable Energy Commercialisation Programme (RECP)

RECP supports the demonstration and commercialisation of innovative, substantially Australian renewable energy equipment, technologies, systems and processes. This 5-year, $55.6 million competitive grants program is designed to foster the development of a renewable energy industry in Australia and to reduce greenhouse gas emissions. Two funding rounds are conducted each year. The programme has two separate components: technology commercialisation, and industry development.

Commercialisation: Grants, usually between AUD 100,000 and AUD 1 million, are available to support competitively selected projects which can demonstrate:

- strong commercialisation potential (or, for feasibility studies and/or prototype development, a clear pathway to commercialisation);
- contribution to the wider development and diversification of Australia's renewable energy industry, domestically and/or internationally; and
- reduction of greenhouse gas emissions.

Applicants must fund at least 50% of the project costs, and demonstrate their capacity to raise capital funds to support the ongoing commercial exploitation of the project outcomes.

Industry development: Competitive grants of usually not more than AUD 300,000 are offered for industry development projects where applicants will not obtain significant individual financial or commercial benefit, and where the project outcomes will be disseminated to the wider Australian industry. The industry development component of RECP is targeted to industry associations and community organisations,

although demonstration of industry support for proposals is required. Projects are expected to have a clear industry development outcome and include:

- mechanisms to address barriers to the uptake of renewable energy;
- assessment of renewable energy resources;
- development of standards for the renewable energy industry; and
- promotion of renewable energy use.

Renewable Energy Action Agenda

An Australian Renewable Energy Action Agenda was developed in 2000. The Agenda aims to develop the renewable energy industry at a rate of 25% per year, to annual sales levels of $4 billion by 2010. A Renewable Energy Industry Implementation Group, comprising government and industry representatives, has been established to implement the key initiatives included in the Agenda. These are: leveraging government support, promoting renewable transport fuels, increasing community commitment, improving reliability and quality of products and services, improving access to capital and finance, establishing a peak industry forum and developing an innovation strategy. Although little funding has been allocated to resource its detailed development and implementation, it is hoped that the Action Agenda will provide much needed long-term policy support for further development of all renewable energy industries in Australia.

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 2000/problems and lessons learned	Funding	Project management	Remarks
PV Rebate Programme 2000	Grants of AUD 5 000 per kWp, up to AUD 7,500 for households and AUD 10,000 for commercial buildings. During 2000, 2.8 MWp installed on 2 600 systems with AUD 14.1 Million provided in grants	To stimulate the use of PV on residential and commercial buildings	81% of installations have been on off-grid buildings	Australian Government funded, with State Government administration	Australian Greenhouse Office	Little development of specific BIPV product has occurred, nor has there been as significant a demand in the grid-connect market as anticipated.
Citipower Solar Pioneers Programme 2000	$60,000 REIP grant plus contributions from customers and Citipower.	- To install 50 grid-connected rooftop systems at reduced prices in Victoria using Australian technologies. - To demonstrate the viability of such systems in domestic and small scale commercial usage - To help accelerate the commercialisation and uptake of PV and assist in increasing sales of Australian made equipment - To enable participating	During 2000, fifty systems, with a capacity of 57.6 kW, were installed. Most of the systems were rated at 1 kWp. One system was installed on a secondary school, the remainder were on residential properties.	Citipower, customers, Australian Govt - Renewable Energy Industry Program	Citipower	- Difficulties with sourcing suitable inverters for 0.5 kWp systems. - Hesitancy amongst the electrical inspection authorities unfamiliar with the technology. - Additional requirements from the Victorian Chief Electrical Inspector to enable the commissioning of

		customers to make their own contribution to the reduction in Australia's greenhouse emissions.				systems. - Electro-mechanical metering is progressively being replaced with electronic metering. - A lack of well established work systems slowed installations.
GreenGel battery 2000	AUD 1 Million RECP grant + funding from the companies involved	- Commercialisation of a long life deep cycle lead acid battery for off-grid renewable energy systems - Use of low corrosion electrodes, zero maintenance design and a new battery charging procedure to reduce capacity loss and premature failure - Establishment of state-of-the-art manufacturing to produce batteries at an internationally competitive price.		Australian Govt RECP BP Solar Battery Energy South Pacific CSIRO	BP Solar	
1MW PV concentrator power station, Broken Hill, NSW 2000	AUD 1 million RECP grant, AUD 250,000 from NSW SEDA + funding from the companies involved.	42 x 24kWp dishes, delivering 3-phase AC power to the main electricity grid.		Australian Govt RECP Australian Inland Energy NSW SEDA Solar Systems Pty Ltd	Solar Systems	
200kWp Grid	AUD 1 million RECP	- To reduce diesel		Australian Govt	Pitjantjatjara	

Feed Sun Farm for the Anangu Pitjantjatjara Lands, South Australia. 2000	grant + funding from the Pitjantjatjara Council and SA Government 10 x 20kWp PV concentrator dishes, which operate and feed power directly into the local grid, supplying 20% of the daily load	consumption and greenhouse gas emissions. - To develop an air-cooled concentrator dish technology particularly suited to remote and arid locations where cooling water is in limited supply.		RECP Pitjantjatjara Council Inc South Australian Division of State Aboriginal Affairs	Council	
Peak lopping in off-grid diesel systems using PV. 2000	AUD 0.5 million RECP grant + funding from NT PAWA Flat-plate PV panels at Bulman (55kWp) and Kings Canyon (225kWp), directly connected to the diesel-powered grid via inverters without batteries.	- To demonstrate the large scale commercial viability of peak lopping in remote, stand alone, diesel grid systems - To lower operating costs and reduce greenhouse gas emissions through the use of PV - To reduce diesel consumption by allowing a smaller diesel set to be run close to full capacity, at a lower load		Australian Govt. RECP Power and Water Authority of the Northern Territory	PAWA	
All-plastic PV roof tile 2000	AUD 135,000 RECP grant, AUD 20,000 from NSW SEDA + funding from the companies involved.	- To develop an extruded frame for PV laminates and a low cost pluggable PV junction box. - To market and promote the product to architects, BIPV installers, home renovators and financiers.		Australian Govt RECP NSW SEDA PV Solar Energy Pty Ltd, Utilux Pty Ltd and BP Solar Australia	PV Solar Energy	
Solar Sailor 2000	AUD 1 million RECP grant + company funding.	- To construct, test and demonstrate commercial viability	Solar Sailor commenced commercial operations on Sydney Harbour in July	RECP Solar Sailor Holdings Ltd	Solar Sailor	

	108-seat multi-purpose catamaran capable of running on solar and wind energy with CNG or LPG back-up	- To showcase the solar wing, a solid-aerofoil sail with an embedded array of PV cells that utilises solar and wind energy separately or in combination	2000			
Titania Dye Sensitised Solar Tile and Wall Panel manufacturing facility 2000	AUD 2.5million (RECP-AUD 1 million) The facilities will be capable to produce 10,000 sq.m of the Solar Wall Panels annually.	- To validate manufacturing processes - To enable the first phase (500kWp) start-up	The main manufacturing equipment items are installed.	Sustainable Technologies International Pty Ltd, Australian Govt - RECP	Sustainable Technologies International	Official opening of the World's first Titania DSSC manufacturing facilities is expected for April-May 2001 in Queanbeyan, Australia
BIPV cladding of the Melbourne School of Energy and Environment building 2000	AUD 755,000 RECP grant + University funding.	To demonstrate the application of building-integrated PV power generation on a large scale.		Australian Govt RECP Melbourne University Private Ltd	Melbourne University Private	
Commercialisation of an efficient solar electric charge controller 2000	AUD 125,000 RECP grant + company funding.	- To repackaging the technology in a more commercial form - To develop effective marketing strategies and materials. - To make solar-electric power systems more affordable by lowering the unit cost of the energy delivered.		RECP Plasmatronics Pty Ltd	Plasmatronics	
Solar Kogarah	AUD 1 million RECP	- To establish a major	Tendering for the building	Australian Govt	Kogarah	

2000	grant, AUD 200,000 from NSW SEDA + Council funding for 200kWp of BIPV	building demonstration site for specific solar energy products and BIPV in an inner city town centre. - On-site marketing and promotion of solar energy development in urban environments - Renewable energy training services for professional and tradespeople in the construction industry	and components has been completed.	RECP NSW SEDA Kogarah Council	Council	
BIPV system for the heritage-listed Queen Victoria Market, Melbourne 2000	AUD 1 million RECP grant + Council funds. 3800m^2 PV installed so as not to detract from the heritage buildings 350,000kWh of green electricity per year	- First pv array for market-type buildings - Long term performance monitoring by the University of Melbourne's Green Building Research Group - Educational purposes		RECP Melbourne City Council		
NSW Solar in Schools Programme 1999	AUD 0.5 million provided jointly by NSW SEDA, the Department of Education and Training and Integral Energy			NSW SEDA Dept of Education & Training Integral Energy		
20kWp grid-connected solar PV trough concentrator 1999	AUD 300,000 REIP grant + University and company funds Parabolic trough-shaped mirror to concentrate the sun's	To demonstrate and evaluate the commercial potential of PV concentrator technology, especially for use in diesel powered mini-grids in rural and remote areas.	System is nearly ready for commissioning	ANUTECH	Australian Govt. REIP, ANUTECH Pty Ltd, Solahart Industries	

	energy onto a line of high efficiency PV cells.				Pty Ltd and Western Power Corporation	
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. Provides 160 000 kWh/an	Australian Olympic Co-ordinating Authority	EnergyAustralia	Very high visibility site, with innovative design features.
Newington Solar Village 1998-2000	629 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.	All systems installed by mid 2000. 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.	High profile site for international demonstration of BIPV during the 2000 Olympic Games.
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	Grid connected 50	To gain installation & operational	Difficult sloping site, with	Great Southren	Great	

Energy Depot 1998	kWp mc-Si array, comprising 720 X 77 Wp modules.	experience with larger scale PV systems.	non-ideal orientation.	Energy via its Earth Saver customers and SEDA.	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. 1998	100 kWp ground mounted mc-Si array in hybrid configuration with 440 kW diesels, 400 kWh battery bank, 125 kVA inverter /charger plus innovative remote monitoring & controls	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 & control via modem link using a Hybrid Station Control Module, to allow integration of renewable & conventional energy sources
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, SEDA, Singleton Shire Council.	EnergyAustralia	Avoids 500t greenhouse gases/an.
Homebush Business Park PV Power Station	11.2 kWp c-Si array, comprising 140 X 80 Wp panels and a 10 kW inverter.			EnergyAustralia via its PureEnergy customers.	EnergyAustralia	

1997						
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/field test programmes and R&D

Table 3 provides figures for 2000 on budgets from the Australian and State Governments for R&D, demonstration and market incentives. The figures do not include funding provided through government owned utilities, nor through the private sector. In 2000 the latter was over AUD 15 million for product development, demonstration and marketing.

Table 3: Public Sector Budgets (AUD million) for PV R&D, demonstration/field test programmes and market incentives in 2000 – not including industry R&D.

	R & D	Demo/ Field test	Market
National/federal	2.0	7.5	15.1
State/regional	0.5		1.4
Total	2.5	7.5	16.5

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Table 4: Production and production capacity for the year 2000 for Australian module manufacturers

Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MWp)		Maximum production capacity (MWp)
		Cell	Module	
1 BP Solar	mc-Si sc-Si	4.0 0.1	3.4 2.1	7
TOTALS		4.1	5.5	7

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.

Most cells are produced in-house, some are imported.

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

Significant cell sales to overseas subsidiaries of Australian based manufacturers.

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

All commercially produced modules use sc-Si or mc-Si. Modules range in size from 2 - 120 Wp. Although the most common size is still around 70 Wp, there is increasing emphasis on large area (72 cell / >1m^2) high power modules (120Wp+). Almost all have front glass / EVA internal encapsulant / PVF back sheet, with fabrication by high temperature vacuum lamination. However, special glass/glass modules are supplied for navigation aids and some industrial applications, eg. for hazardous areas or small area / low power systems.

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.

Fabrication facilities are accredited to ISO 9000 Quality Standards, Underwriter Laboratories (UL) and ISO 14000 Environmental Standards.

Modules are certified to Australian standards, plus international standards via US (IEC, Arizona State University) and European (ESTI 503, Ispra, Italy) 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. A 1 MWp plant is now under construction at Broken Hill. The systems are 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) Details of module production capacity under construction at end of 2000 but not yet in production.

The merger of BP Solar Australia and Solarex saw the establishment of a new joint cell production facility at Homebush Bay, Sydney, in 2000. Both mono and poly crystalline cells and modules are produced. Output from the new plant is expected to reach 15 MWp runrate capacity by end 2001, with significant additional capacity soon after. The facility will have the capacity to expand final cell production volume to around 40 MWp.

Sustainable Technologies International will open the World's first Titania Dye Sensitised Solar Tile and Wall Panel manufacturing facilities in 2001. The first phase will have a capacity of 500 kWp.

i) Trends in manufacturing and products.

BP Solar has focused on consolidation of the existing Solarex / BP Solar cell and module fabrication technologies, with emphasis on high volume world class manufacturing methodology, although a technology move to higher performance screen printed processing is underway.

Sustainable Technologies International is continuing the development of its Titania Dye Sensitised Solar Cells, with small scale production planned for 2001.

Pacific Solar has acquired another major shareholder, Eurosolare, and continues the development of its thin film polycrystalline silicon product. Pilot production is already underway and full scale production is scheduled for 2004.

In addition to their cell development work, all manufacturers are developing new types of modules to suit different market niches, especially the building integrated PV market.

j) A description of year 2000 module prices.

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.

Table 4a: Typical module prices (AUD) 1992-2000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Module price(s) – current AUD			7		8			8	8

3.2 Manufacturers and suppliers of other components

Table 5: Price of inverters for grid-connected PV applications.

Size of Inverter	<1 KVA	1-10 KVA	10-100 KVA	>100 KVA
Average Price per kVA (AUD)	3 000	1 900	1 500	N/a

- PV inverters (for grid-connection and stand-alone systems)

  There are several Australian manufacturers of inverters, typically supplying product in the range 500W to 3000W for off-grid applications. Some are combined inverter/chargers, others offer energy management options. The grid-connected PV market is growing slowly and some manufacturers also provide grid interactive inverters.

  Pacific Solar has developed the world's first two-wire module inverter, which is being used in its Plug&Power™ ac modules. The inverters are rated at 140W. Research and development is continuing on the second generation of this inverter technology to further reduce its cost, increase its performance and adapt it to overseas markets.

  Nevertheless, the current trend is to imported inverters. This appears to be for reasons of price as well as features available. The small Australian market has made it difficult for local manufacturers to compete with the rapid developments in the international marketplace.

- Storage batteries

  Several PV batteries have been manufactured in Australia, however, as with inverters, the trend is to imported products. In particular, there is a trend to the use of sealed batteries for health & safety reasons. This has been to the detriment of local manufacturers.

- Supporting structures

  In addition to standard rooftop and ground mounted array structures, innovative mounting structures include:

  - A tray developed by BP Solar and used for over 600 installations in the 2000 Olympic Village.
  - An extruded frame for use with PV laminates and a pluggable PV junction box, developed by PV Solar Energy.
  - A roof integrated ac module PV system developed by Pacific Solar and marketed as Plug&Power™.
  - A powder-coated galvanised steel mounting frame developed by CitiPower and Allied Solar for use in the Solar Pioneer's installations in Victoria.

- Module components

  Australian PV company Solar Sales supplies low iron glass to France for Photowatt's PV modules. In turn, Solar Sales uses Photowatt modules in its international installations.

3.3 System prices

Table 6: Turnkey Prices of Typical Applications (Installed cost of the PV component)

Category/Size	Typical applications and brief details	Price per Wp in NC
OFF-GRID Up to 1 kWp	Household power systems, lights, telephones, navigation aids.	22
OFF-GRID >1 kWp	Household systems, telecommunication links, water pumping.	16
ON-GRID 1-3 kWp	Household roof-mounted systems.	12-15
ON-GRID 3-10 kWp	Commercial buildings, schools,	12-15
ON-GRID >10 kWp	Commercial, utility.	10-12

Table 6a: Australian trends in prices for stand alone systems (1-4 kWp)

YEAR	1994	1996	1998	1999	2000
Price current AUD/Wp	**20**	**25**	**25**	**25**	**16-22**

Table 6b: Australian trends in prices for grid connected systems (1-4 kWp)

YEAR	1994	1996	1998	1999	2000
Price current AUD/Wp	**10**	**10-15**	**10-15**	**10-15**	**12-15**

3.4 Labour places

Estimated labour places (mainly involved with PV):

a) Research and development (not including companies);
- 60

b) Manufacturing of PV system components, including company R&D;
- 230

c) All other, including within electricity companies, installation companies etc.
- 290 (Note that most installers work with a range of technologies, including PV).

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

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

  The introduction of a Goods and Services Tax in Australia in 2000 removed the sales tax exemptions previously available for solar products. This has had the adverse effect of increasing the cost differential between fossil fuel and PV options, although the PV Rebate Programme was intended to provide compensation for this in the short-term . Some PV installation companies offer finance packages, through standard finance channels, for their systems.

- Utility perception of PV (ownership of and liability for PV systems; non-utility production of electricity; grid support; peak load reduction; etc.)

  Despite years of involvement with PV implementations at different levels, the utility perception is that PV is still too costly for central generation, while the advantages of distributed generation are yet to be fully acknowledged and acted upon in Australia. Although used for public relations purposes, few utilities have an institutional commitment to further development and use of the technology. Early Greenpower programmes included a reasonable amount of PV, since it was readily deployed and could be highly visible. Nevertheless, few utility installations have gone in without additional government support. With utilities now focussing on new mandatory renewable energy targets which must be self funded, little interest is being shown in PV programmes. There are exceptions, including the commitment by Australian Inland Energy to further development of concentrator PV systems for use on main and diesel grids and the CitiPower Solar Pioneers Programme.

  In a country with low cost electricity and a competitive marketplace, the cost of PV is still a major hurdle. However, little, if any investigations are underway into the use or value of PV for peak load reduction or grid support. Access to the main electricity distribution networks continues to be difficult for small, distributed generation systems. Procedures are complex, non-uniform, slow and costly.

  Utilities still struggle with the changed paradigm of customer owned generation systems. Although some utilities offer net metering, there is no uniform Australia wide approach. Some utilities do offer high buyback rates for net exports from PV systems, although there is an annual limit and a cap of 1.5 kWp on system size. Others require detailed and complicated contracts, as well as interconnection requirements in addition to the Australian Standards. Some State electricity regulators also apply additional charges, insurance and interconnection requirements, while some local governments require building development applications and fees for rooftop PV installations. Hence the installation of PV systems is still not a straightforward and accepted practice in Australia and considerable work is still needed to develop uniform installation guidelines, straightforward contracts and long-term buy-back rates which would encourage PV use.

- Changes in public perceptions of PV

  Although there is increasing awareness of greenhouse gas issues and a high interest in solar options, PV is still considered by the general public to be a future technology, or one

suited only to off-grid use. Few retail outlets exist in high population centres and most Australians would not have ready access to information, products or installers. Confusion with solar water heaters is also common.

- Major new projects or initiatives

  In 2000 Pacific Solar released its Australian version of Plug&Power™, a unique modular rooftop solar PV system. Any surplus electricity can be automatically fed into the local electricity supply grid. The system is easily expanded. Plug&Power™ incorporates Pacific Solar's module inverter and modular rooftop mounting system that enables it to be laid over almost any roof. It has been designed to use conventional PV modules until Pacific Solar's thin-film PV technology goes into mass production.

  In 2000, the Federal government released the Renewable Energy Action Agenda, which was the result of an industry-government review process. Nine industry wide initiatives were identified as being required to develop the renewables sector. Implementation of these initiatives is underway and may result in specific actions for the PV industry.

- Planned developments

  BP Solar is expanding its Australian production capacity to 15 MWp by end 2001 and to 40 MWp in future.

  International versions of Pacific Solar's Plug&Power™ system are planned for progressive release starting in the second half of 2001 in Europe through Eurosolare. Expansion in Australia and internationally will be achieved through alliances ranging from licensing and distribution agreements to full joint venture operations. Pacific Solar plans to have its thin-film polycrystalline silicon PV technology in mass production by 2004.

  Sustainable Technologies International will begin production of its Titania dye sensitized solar cells on a new 500 Wp experimental line in 2001.

- Other new issues

<u>Renewable Remote Power Generation Programme</u>

An new Australian Government funded Renewable Remote Power Generation Programme will commence in 2001, providing 50% rebates, up to a maximum of AUD 125,000, for the renewable energy components of Remote Area Power Systems.

The programme aims to increase the uptake of renewable energy technology in remote areas of Australia, which will:

i) help in providing an effective electricity supply to remote users;

ii) assist the development of the Australian renewable energy industry;

iii) help meet the energy infrastructure needs of indigenous communities; and

iv) lead to long term greenhouse gas reductions.

The programme will be administered by State Governments, with some States providing supplementary funding. AUD 264 million has been allocated to the programme over 4 years.

Mandatory Renewable Energy Target (MRET)

From 2001 electricity retailers and large users will be required to supply a portion of their electricity from renewable energy sources. This is in addition to existing renewable energy generation, which is mainly hydro. The amount required starts at 400 GWh for 2001 and increases to 9,500 GWh by 2010, after which it must be maintained until 2020. A system of tradable renewable energy certificates (RECs) is to be set up. Renewable energy generators must be registered and will receive one certificate for each MWh of electricity generated. Liable parties can either generate their own renewable energy or purchase certificates in proportion to their share of the electricity market. A penalty of AUD 40 per MWh will be applied.

For PV systems less than 10 kW in size and generating up to 25 MWh per year, the MRET Regulations provide for deemed electricity output (ie: no metering required) based on system size and location. A typical 1 kWp rooftop PV system in Sydney would be deemed to generate 7 MRECs each 5 years.

Although the target is not expected to have a significant benefit for PV, at least in the short term, since liable parties will choose the cheapest renewables on offer, it may serve to reduce some of the institutional barriers still facing small scale distributed generation systems. If PV prices fall over the term of the legislation, PV may make up a larger portion of installations in later years.

4.2 Indirect policy issues

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

As market stimulation programmes gain momentum in other countries, the Australian market and production of PV is decreasing as a percentage of the international market. In addition, product development in other countries is overtaking local products and resulting in the increased use of imported products in the Australian market, particularly balance of system products, but also PV cells and modules.

b) the introduction of any favourable environmental regulations;

None impacting on PV use.

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

No recent work.

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

None which impact on PV use. The Australian Government has indicated that it will not proceed with internal emissions trading but will await international developments.

e) national policies and programmes to promote the use of PV in foreign non-IEA countries.

Although Australian companies continue to develop export markets for PV in developing countries, particularly in the Asia Pacific region, the recent reduction of Australian Government ‘soft loan’ funding for rural welfare has seen other countries take over some of the major regional PV aid programmes.

4.3 Standards and codes

- Grid Connection Standard

  A Standards Australia committee is well advanced in developing a grid connection standard for small (<10kVA single phase an <30kVA three phase) renewable energy systems, including PV connected to the grid via an inverter. The standard is based on a set of interconnection guidelines which have been in place since 1997 and is expected to be published early in 2002.

- Off-Grid Power Systems

  Standards Australia has published:

  - Stand-alone power systems Part 1: Safety requirements.
  - Stand-alone power systems Part 3: Installation and maintenance.

  'Stand-alone power systems Part 2: Design Guidelines' has just been completed through all stages of the committee and will be published later in 2001.

- ACRELab

  A new renewable energy system test laboratory (ACRELab) has been established in Australia. ACRELab, based at the Australian Co-operative Research Centre for Renewable Energy (ACRE) headquarters in Perth, will provide Australia with a world-class testing and certification facility for renewable energy systems and balance of systems components. ACRELab is the only commercially available renewable energy system testing laboratory in Australia. The facility is capable of testing a large range of off-grid systems from small solar home systems (SHS) to community hybrid power systems up to 50kVA, as well as a full range of grid-connected systems. The test facility can also test individual components of a system. These tests can be conducted over a full range of operating conditions and environments. ACRELab has state of the art equipment for monitoring and automated control of testing. Procedures are underway to gain NATA certification for the Lab.

5 Future trends

- Details of planned increases in PV module production capacity

  BP Solar is expanding its Australian production capacity to 15 MWp by end 2001 and to 40 MWp in future.

  Pacific Solar plans to have its thin-film polycrystalline silicon PV technology in mass production by 2004 with a 20 MWp plant.

  Sustainable Technologies International will begin production of its Titania dye sensitized solar cells on a new 500 Wp experimental line in 2001. This will be expanded to 5 MWp for full production in future.

- Any developments in technologies

  Pacific Solar is well advanced in the development of its unique thin-film PV technology, which uses thin films of polycrystalline silicon deposited onto glass. Full scale manufacturing costs are estimated to be only a third of today's conventional PV modules. Pilot line operations commenced in mid 1998.

  During 2001, Sustainable Technologies Australia will begin pilot production of its titanium dioxide based thin film product, with core technology licensed from EPFL, Switzerland, and Australian product designs and manufacturing technology. Pilot line facilities to be commissioned in 2001 will allow 500 kWp production per year.

  BP Solar's new production facilities in Homebush Bay will include process improvements and will produce higher efficiency cells and modules from both multi and single crystal silicon.

- Long term targets for installed PV power capacity.

  There are no firm targets set for installed PV capacity either by government or industry at present. The new 9,500 GWh renewable electricity target by 2010 does potentially provide an overall renewables target, but PV is unlikely to take up a significant portion of this, at least in the early years.

Annex A Method and accuracy of data

a) A summary of the methods used to gather, process and analyse the data given in the NSR.

Information was provided by government and industry personnel involved with PV. This was supplemented by information published in annual reports and on web sites.

b) An estimate of the accuracy of the data if this is worse than 10 %. The accuracy can be given as a tolerance (either 20kWp ± 20% or 20kWp ± 4 kWp) or as a range (e.g. 16kWp to 24kWp).

Specific installation sizes are accurate to 10%. Aggregated information is accurate to 20%.

c) If a country cannot provide the necessary data please give the reason here.

Some data is considered commercially confidential and not available for publication. Hence estimates have been made.

Annex B Exchange Rate

2000 average exchange rate ~ 0.55 USD = 1 AUD