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 2002*

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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 five are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning urban-scale deployment of PV systems is being developed.

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. The public PVPS website also plays an important role in disseminating information arising from the programme, including national information.

iii Definitions, symbols and abbreviations

For the purposes of the National Survey Reports, the following definitions apply:

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

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25^{o}C, AM 1,5 solar spectrum – (also see 'Peak power').

Peak power: Amount of power produced by a PV module or array under STC, written as Wp.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power 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 power system: System installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: 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.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are 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 system in a remote area are excluded).

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 and their application to 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: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

1 Executive summary

- Introduction

PV is one of the best-established renewable technologies in Australia, with 3 decades of technology and market development. The overall market expanded by 27% in 2002, with the grid connect segment growing 95%, production doubled and production capacity trebled. Australian researchers continue to lead the world in PV cell development and commercialisation. Several new technologies are on the verge of commercial production. A new generation of university and trade trained graduates are entering the job market and are set to enhance community acceptance and use of PV.

The Australian PV industry is beginning the development of a PV Roadmap, to coordinate and focus its activities over the coming decade. The Roadmap will cover research priorities, industry infrastructure needs and customer requirements and will set industry targets for deployment. It will facilitate the introduction into the market of several new Australian PV manufacturers, with new PV technologies and new market aims. It will also assist PV to benefit more from generic renewable energy support mechanisms available in Australia and to establish itself as a technology of choice with energy and non-energy benefits for specific applications in the electricity sector. The Australian PV Roadmap will complement work to be undertaken in IEA PVPS Tasks 9 - PV Deployment in Developing Countries and 10 – Urban Scale Grid Connected PV Applications.

- Installed PV power

Cumulative installed PV power in Australia is now 39 MWp, up by 5.5 MWp from 2001. 58% of installed capacity services the off-grid non-domestic market, comprising industrial and agricultural applications such as telecommunications and water pumping. 31% of installed capacity services off-grid domestic applications. The on-grid market grew strongly during 2002, with sales increasing 95% over 2001 levels, in response to Government grant programmes. Grid systems now account for 11% of PV installed in Australia.

- PV Module and system prices

PV module prices averaged AUD 7 per Wp in 2002, a drop of around 10% from 2001 prices, in real terms. Prices ranged from AUD 6.5-7 per Wp for large orders and AUD 7-9 per Wp for small orders. Off-grid system prices ranged from AUD 13-20 per Wp for systems larger than 1 kWp and AUD 20-23 per Wp for smaller systems. Grid system prices ranged from AUD 12-15 per Wp.

- PV production

Cell production doubled in Australia in 2002 to 20.5 MWp and production capacity trebled to 30.5 MWp. In addition, a new concentrator system manufacturer commenced operation, with a 5 MWp facility and 0.2 MWp of production in 2002. Over 70% of Australian PV cell production was exported.

- Public budgets for PV

Public expenditure on PV research, demonstration and market development totalled AUD 20.6 million in 2002. This was matched by private company expenditure. The major portion of public expenditure (73%) was for market based incentive programmes. There has been a clear trend in public support from R&D to market incentives over the past six years, as shown in Figure 1.

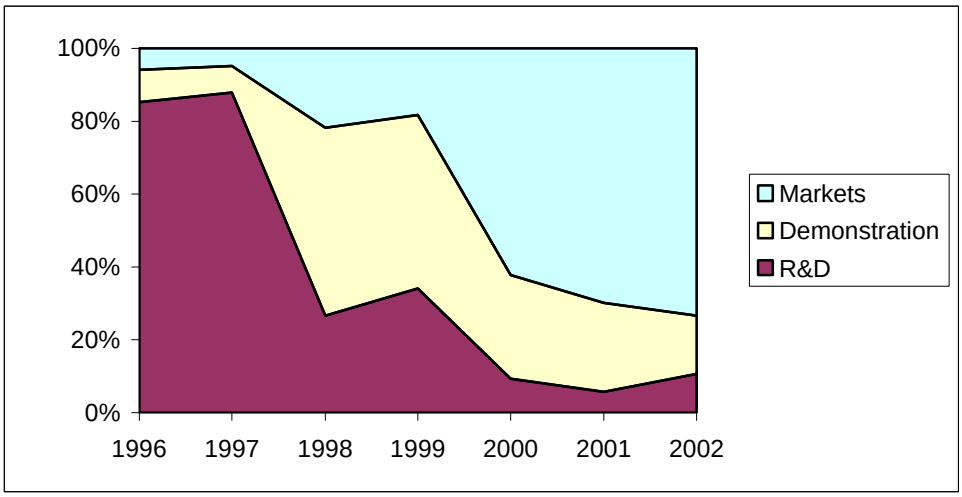

Figure 1: Trends in Australian public expenditure on PV.

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

Annual PV sales in Australia increased by 27% in 2002, stimulated by government grant programmes for rooftop applications and off-grid diesel replacement. Australia's established off-grid PV market in industrial, agricultural and commercial applications such as telecommunications, signalling, water pumping, electric fences and cathodic protection continued to dominate the PV market, accounting for 64% of the 2002 applications and 58% of cumulative installations. The on-grid market grew strongly during 2002, with sales increasing 95% over 2001 levels, and will hopefully be able to maintain momentum with the lower grant levels available from 2003 to 2005. Grid connected applications for household, community and commercial buildings accounted for 14% of installations. Grid systems now account for 11% of PV installed in Australia.

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 Australia to December 2002, 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	31 Dec. 2001 kWp	31 Dec, 2002 kWp
off-grid domestic	1 560	2 030	2 600	3 270	4 080	4 860	5 960	6 820	9 110	10960	12140
off-grid non-domestic	5 760	6 865	8 080	9 380	11 520	13 320	15 080	16 360	17 060	19170	22740
grid-connected distributed		5	20	30	80	200	850	1490	2 390	2800	3400
grid-connected centralized				20	20	320	630	650	650	650	850
TOTAL	**7 300**	**8 900**	**10 700**	**12 700**	**15 700**	**18 700**	**22 520**	**25 320**	**29 210**	**33 580**	**39130**

2.3 Major projects, demonstration and field test programmes

Some of the major programmes operating in Australia during 2002 are described below:

PVRP – Photovoltaic Rebate Programme

a) reasons for, and goals of, embarking on the programme or project;

To encourage the development and use of building integrated PV.

b) size (installed capacity to date and target installed capacity for the whole programme, kWp) and main technical and economic data;

Over 950 systems were installed in 2002, amounting to 1.2 MWp. 40% of customers, accounting for 48% of installed capacity, were on grid connected buildings and a total of AUD 5.8 million was allocated in grants. Since the start of the programme in 2000, 3,760 systems, amounting to 4 MWp, have been installed and grants of AUD 21.3 million have been provided.

c) funding sources and cost sharing;

Australian Government funded, with administration by the State Governments. An initial amount of AUD 31 million was allocated over 4 years, with grants of AUD 5,000 per kWp provided, to a maximum of AUD 7,500 per residential system and AUD 10,000 per community building system. A further allocation of AUD 5.8 million has been announced and the programme has been extended to 2005. Grants will be reduced to AUD 4,000 for residential systems and 8,000 for community systems.

d) main accomplishments by the end of the reporting year or end of operating period (system efficiency, operating cost, etc.);

Approvals for grid connected systems overtook those for off-grid systems by mid 2002. System sizes have remained steady with grid systems averaging 1.5 kWp and off-grid systems 1 kWp.

e) problems encountered and lessons learned;

The Programme was initially accessed largely by off-grid customers installing new systems or expanding existing ones. The rules were changed to limit availability of funding for system expansion and off-grid sales declined. At the same time, PV industry development and promotion of grid connect products increased and this market segment grew, to the point where grant funds for 2002/03 were overcommitted. Grant funding was restricted for some months, until an extension to the programme was made.

f) planned continuation of the programme and plans for new activities.

The Programme budget has been increased by AUD 5.8 million and the finishing date has been extended to 2005. Grants will be slightly lower, at AUD 4,000 per kWp for residential systems and AUD 8,000 for community systems.

Remote Renewable Power Generation Programme

g) reasons for, and goals of, embarking on the programme or project;

To increase the use of renewable energy for power generation in off-grid areas, to reduce diesel use, to assist the Australian renewable energy industry, to assist in meeting the infrastructure needs of indigenous communities and to reduce greenhouse gas emissions.

Each State has established a slightly different programme, to meet the specific needs of local off-grid applications. However, in general, the target groups are indigenous and other small communities, commercial operations, including pastoral properties, tourist facilities and mining operations, water pumping and isolated households that operate within diesel grids or use direct diesel generation.

h) size (installed capacity to date and target installed capacity for the whole programme, kWp) and main technical and economic data;

1 MWp of PV has so far been installed under this programme. Although it is not PV specific, almost all systems installed to date include some PV and PV makes up 92% of installed capacity. The overall programme has funds up to AUD 264 million allocated to it, of which AUD 12 million has been allocated to date.

i) funding sources and cost sharing;

Core funding for this programme is provided to the States by the Australian Government, on the basis of diesel fuel excise collected in the years 2001/02 to 2003/04 from diesel fuel used by public generators not connected to main electricity grids. Grants of up to 50% of the capital cost of renewable energy systems are available for diesel replacement. The programme is administered by State governments, with additional funding provided by some States. Up to AUD 264 million is available over the life of the programme, which will extend to 2009/2010, though some States are likely to expend their allocation before then.

A specific allocation of AUD 8 million has been made to the Aboriginal and Torres Strait Islander Commission (ATSIC) for the *Bushlight* programme to assist with the development of industry capability and local understanding of renewable energy systems in indigenous communities.

j) main accomplishments by the end of the reporting year or end of operating period (system efficiency, operating cost, etc.);

To end 2002, grants of AUD 12 million had been paid for 1036 installed systems, which included 1 MWp of PV. 27% of installed PV capacity is for water pumping systems.

k) problems encountered and lessons learned;

Although the programme took longer than anticipated to begin, due to the complexity of reaching individual agreements with each State and Territory, it is now operating well and expects to receive a continuous flow of applications.

Because the funding is based on diesel fuel rebate levels, some States receive very little funding, which is causing some problems for installation companies based in these States. While the overall budget for the programme is high, applicants must source at least 50% of project costs.

l) planned continuation of the programme and plans for new activities.

The Programme will continue until 2010. While initial applications have mainly been for small systems, a number of larger, community-sized systems are now under development.

New South Wales Solar in Schools Programme

a) reasons for, and goals of, embarking on the programme or project;

To encourage the development and use of building integrated PV by providing schools with a grid-connected solar power system and educational materials.

b) size (installed capacity to date and target installed capacity for the whole programme, kWp) and main technical and economic data;

To end 2002, 43 Solar Schools had been established, with 70.56kWp of PV in total. Total programme expenditure to date is AUD 950,000.

c) funding sources and cost sharing;

Solar in Schools is a NSW Government initiative, jointly funded by the NSW Department of Education and Training and the Sustainable Energy Development Authority (SEDA). The 25 most recent installations attracted rebates from the Commonwealth Photovoltaic Rebate Programme (PVRP).

d) main accomplishments by the end of the reporting year or end of operating period (system efficiency, operating cost, etc.);

There are now 20,000 school children who attend Solar Schools

e) problems encountered and lessons learned;

The first phase of Solar in Schools used a centralized tendering system for installation of equipment, which meant many solar power systems were not easily serviced. This has been rectified for Stage 2 (completed December 2002) by using local businesses to install the equipment. Educational materials are constantly being refined to account for teachers' needs.

f) planned continuation of the programme and plans for new activities.

SEDA plans to create between 25 and 50 new Solar Schools in 2003. SEDA is also working jointly with the Queensland Environment Protection Agency to develop a joint Solar in Schools website and to share other educational materials.

The Griffith University Eco Centre

a) reasons for, and goals of, embarking on the programme or project;

The EcoCentre has been designed to provide environmental education programmes to the primary and secondary schools, the public and tertiary level students from Griffith University by using a range of sustainable technologies and concepts, including passive solar siting of the building, photovoltaics, ambient ventilation and lighting, rainwater harvesting with mains water augmentation and non-sewered, wet composting waste disposal.

b) size (installed capacity to date and target installed capacity for the whole programme, kWp) and main technical and economic data;

The 4.3kW PV system comprises 72 solar panels (60 watts peak) and three 1.2kW power inverters connected to the utility Energex's three-phase grid. The system can produce up to 7.8MWh per annum.

c) funding sources and cost sharing;

The total system cost was AUD 33,000 of which 80% was provided from the Federal Government's PVRP programme. Stanwell Corporation provided the remaining funds and was assisted by EnviroPower.

d) main accomplishments by the end of the reporting year or end of operating period (system efficiency, operating cost, etc.);

The PV system has been installed. While it will substantially reduce energy bills at the EcoCentre, the primary purpose is to provide an educational focus. A computer display shows electricity generated by the system and provides a hands-on learning tool for school and community groups.

e) planned continuation of the programme and plans for new activities.

In partnership with CS Energy, an energy researcher is to be employed and based within the Griffith School of Environmental Engineering and the Griffith Ecocentre.

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 2002/problems and lessons learned	Funding	Project management	Remarks
Chadwick Centre 2002	AUD 740 000 grant to Forrestor Kurtz Properties and Integrated Energy Services for a 60kW BiPV array on a commercial building.	To demonstrate the feasibility of using PV as the energy source for a UPS To achieve significant cost offsets through BiPV integration and use of PV electricity for a UPS.	Project completed in 2002. Demonstrated significant reduction in cost of PV through offsets in building integration and UPS hardware.	Australian Government RECP	Integrated Energy Services	
BIPV system for the heritage-listed Queen Victoria Market, Melbourne 2002	AUD 750,000 RECP grant plus Council funds. 200 kWp installed so as not to detract from the heritage buildings 250 MWh of green electricity per year	First large PV array for an industrial market-type building Long term performance monitoring by the University of Melbourne's Green Building Research Group Educational purposes	Concept developed and funding granted in 2000. System installation commenced 2002. Commissioning expected early 2003.	Australian Government RECP Melbourne City Council	Installation by BP Solar Australia Utility – Origin Energy	Commissioning completed April 2003.
Griffith EcoCentre 2001	4.3 kWp system. AUD 33,000, with 80% PVRP rebate.	To provide environmental eduction at the Centre To demonstrate PV on community buildings	The system provides 7.8 MWh per annum.	Australian Govt PVRP Stanwell Corporation	EnviroPower Stanwell Corporation QLD Environmental Protection Agency	Energy researcher funded by CS Energy to be based at Centre.

Queensland Solar Schools Programme 2001	1.96kWp of PV have been installed on 18 schools The Queensland government contributes AUD 7 700 for each system. AUD 92 400 was contributed for 12 systems in 2002	To increase the use of PV and to educate school children about its use and benefits.		Queensland Environment Protection Agency	Energy utility Stanwell Corporation	
CSIRO Energy Centre 2001	SEDA provided AUD 250,000 for 30kW of PV and 250kW of renewable energy generation, plus a loan of AUD 200,000 to STI towards a demonstration DSC array.	To assist in the commercialisation of renewable energy technologies.	The building is largely complete and PV system installation has commenced. Commissioning expected in 2003.	SEDA - NSW Renewables Investment Programme CSIRO	CSIRO Sustainable Technologies International BP Solar Pacific Solar	Difficulties experienced with some aspects of the PV installation by building sub contractors. Need for certified installers.
Renewable Remote Power Generation Programme 2001	Up to AUD 264 million available to 2010, allocated on the basis of diesel fuel excise paid by public generators in each State. Grants up to 50% of costs, for renewable energy generation components.	To substitute renewable energy generation for diesel use in off-grid areas and reduce greenhouse gas emissions To assist the Renewable Energy Industry To meet infrastructure needs of indigenous communities	Sub-Programmes are now operational in all States and Territories. 1036 systems installed to end 2002, including 1 MWp of PV.	Grant funding provided by Australian Greenhouse Office, topped up in some States.	Separate programmes operating in each State and managed by the State governments.	Funding is also available to assist the industry in training and accreditation. 27% of PV installed is for water pumping.
Demonstration thin-film CSG technology	AUD 2 million project, of which AUD 1 million provided by RECP	To demonstrate CSG technology in 4 grid-connected rooftop systems	Project is running to programme.	Pacific Solar Pty Ltd Australian	Pacific Solar Pty Ltd	

2001				Govt RECP		
Full commercialisation of Plug&Power™ 2001	AUD 1 million (RECP – AUD 0.5 million) Balance of systems (BoS) hardware to be configured for mass production & sale.	To develop new packages & hard tooling for BoS components To develop Plug&Power™ for cyclonic regions To develop sales & marketing tools To monitor six Plug&Power™ sites	Project is running to programme.	Pacific Solar Pty Ltd Australian Govt RECP	Pacific Solar Pty Ltd	
Caboolture Regional Environmental Centre 2000	5 kWp system, costing AUD 52 000. PVRP rebate of 60%. 3X1.6 kW grid interactive inverters	To assist the Centre's environmental education programmes. To demonstrate use of PV on community buildings and reduce fossil fuel use.	The system is roof mounted and provides around 7.3 MWh per annum.	Stanwell Corporation Australian Govt PVRP	Choice Electric Company Stanwell Corporation QLD Environmental Protection Agency	Electricity sold to Energex for its earth's choice Greenpower programme.
Titania Dye Sensitised Solar Tile and Wall Panel manufacturing facility 2000	AUD 2.5million (RECP-AUD 1 million) The facilities will be capable of producing 10,000 sq.m of Solar Wall Panels annually.	To validate manufacturing processes To enable the first phase (500kWp) start-up	World's first DSC manufacturing facilities installed in Queanbeyan.	Sustainable Technologies International Pty Ltd, Australian Govt - RECP	Sustainable Technologies International	Commercial exploitation of the facilities commenced in 2002
BIPV cladding of the Melbourne School of Energy and	AUD 755,000 RECP grant + University funding.	To demonstrate the application of building-integrated PV power generation on a large scale.	Systems design completed by STI.	Australian Govt RECP Melbourne University Private Ltd	Melbourne University Private	Contractual issues concerning project interfaces required extensive effort. Commissioned early 2003.

Environment building 2000						
PV Rebate Programme 2000	Grants of AUD 5 000 per kWp for households and AUD 10,000 for community buildings. To date, 4 MWp installed on 3 760 systems with over AUD 21 Million provided in grants	To stimulate the use of PV on residential and community buildings	40% of installations, comprising 48% of installed PV capacity, have been on grid connected buildings.	Australian Government funded, with State Government administration	Australian Greenhouse Office and State energy agencies	Demand in the grid-connect market picked up quickly. The programme was over subscribed and money was rationed for some months. The Government has announced continuation of the programme for 2 years, with lower grant levels.
Wetlands Project - Homebush Bay 64kWp 2000	64kWp PV grid-connected and battery backup system sited on the Homebush Bay wetlands. 800 SX80 Solarex PV modules, three 20 KVa AES string inverters, 240 volt DC 1000 Ampère battery backup	To pump water from 40 ponds once every three days during the summer and less frequently in the winter to mitigate mosquito infestations and the build up of algae blooms. The tilt of the array is 15 degrees, to maximise summer output.	Positioned slightly east of north, a carefully constructed galvanised steel custom-made frame was designed on a 45 degree slope without detracting from the historic munitions building.	Waste Services and Olympic Co-ordination Authority (OCA)	Waste Services and Olympic Co-ordination Authority (OCA) Advanced Energy Systems (AES) of Perth Solar Technology Australia (SOLARTECH).	System operational.
Citipower Solar Pioneers Programme 2000	$60,000 REIP grant plus contributions from customers and Citipower.	To help accelerate the commercialisation and uptake of PV, assist in increasing sales of Australian made equipment and to enable participating customers to make their own contribution to the reduction in Australia's	50 systems, with a capacity of 57.6 kW, are installed. Most of the systems are rated at 1 kWp. One system is installed on a secondary school, the remainder on	Citipower, customers, Australian Govt - Renewable Energy Industry	Citipower	Difficulties with sourcing small inverters, need for electronic meters, unfamiliarity of electrical inspection authorities and lack of established work practices.

		greenhouse emissions.	residential properties.	Programme		
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.		Australian Govt RECP BP Solar Battery Energy South Pacific CSIRO	BP Solar	
220 kWp Diesel Grid Feed Sun Farm for the Anangu Pitjantjatjara Lands, South Australia. 2000	AUD 1 million RECP grant + funding from ATSIC and SA Government 10 x 22kWp PV concentrator dishes, which operate and feed power directly into the local grid, supplying 20% of the daily load	To reduce diesel 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.	Installation largely completed in 2002. Commissioning expected in 2003	Australian Govt RECP Pitjantjatjara Council Inc South Australian Division of State Aboriginal Affairs	Pitjantjatjara Council	Further systems are contracted for other emote community sites.
Peak lopping in off-grid diesel systems using PV. 2000	AUD 0.5 million RECP grant + 1.25 million via the RRPGP programme and funding from NT PAWA Flat-plate PV panels at Bulman Aboriginal community (55kWp) and Kings Canyon tourist site (225kWp), connected to diesel-powered grids via	To demonstrate the large scale commercial viability of PV peak lopping in remote diesel grid systems To lower operating costs and reduce greenhouse gas emissions To reduce diesel consumption.	Early studies have shown good correlation between peak load and solar insolation, which will allow maximum benefit to be gained by addition of PV.	Australian Govt. RECP, RRPGP. Power and Water Authority of the Northern Territory. NT Centre for Energy Research	PAWA	The first stage of the project, 55 kW at Bulman, was completed late 2002. Work is underway on the Kings Canyon site.

	inverters.					
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.	The new Solar Tile is already being used in Sydney, using BP Solar's 85 Wp Saturn cell PV laminates, under a contract to developer MIRVAC for the Newington Solar Village stage 2. 79 homes are now being built, each with 12 tiles, making a 1 kWp PV system.	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. 108-seat multi-purpose catamaran capable of running on solar and wind energy with CNG or LPG back-up	To construct, test and demonstrate commercial viability 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	Solar Sailor is operated commercially on Sydney Harbour and is in high demand.	Australian Govt. RECP Solar Sailor Holdings Ltd	Solar Sailor	Orders for additional vessels have been received.
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, lower unit costs and develop effective marketing strategies and materials.		Australian Govt. RECP Plasmatronics Pty Ltd	Plasmatronics	
Solar Kogarah 2000	AUD 1 million RECP grant, AUD 200,000 from NSW SEDA + Council funding 148 kWp of UniSolar	To establish a major building demonstration site for specific solar energy products and BIPV in an inner city town centre. On-site marketing and promotion	The PV systems been installed and will be commissioned April 2003. The utility EnergyAustralia is responsible for the PV	Australian Govt RECP NSW SEDA Kogarah	Kogarah Council	

	PV modules on the roof and 12 kWp glass/glass BP Solar modules over the entrance and lobby. 59 SunPower 1.5 – 2.5 kW inverters are used.	of solar energy in urban environments Renewable energy training services.	component of the building.	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	To increase awareness and knowledge of PV systems.	18 schools were provided with 1 to 1.5 kWp roof mounted PV systems.	NSW SEDA Dept of Education & Training Integral Energy	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 energy onto a line of high efficiency PV cells.	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 commissioned.	ANUTECH	Australian Govt. REIP, ANUTECH Pty Ltd, Solahart Industries 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.		EnergyAustralia, via contributions from *Pure**Energy*** customers	EnergyAustralia in conjunction with SEDA, Abi Millenium, Olympic Co-odinating Authority	Saves 85 t of greenhouse gas emissions per year.
Olympic Boulevard PV	1520 laser grooved c-Si modules on 19	To provide lights, signage, shelter and shade, plus a high profile	Won the Inst of Eng 1999 Eng Excellence Award for	Australian Olympic Co-	EnergyAustralia	Very high visibility site, with innovative design features.

Lights 1999	towers. Grid connected.	demonstration of PV power.	Project Development. Provides 160 000 kWh/an	ordinating Authority		
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.	Valuable trade and professional experience, understanding and skill development.	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 tourist 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 Southern 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 Systems.		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	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

	monitoring & controls					
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 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 Highlights of R&D

The UNSW Centre for PV Engineering continues its world leading research into high efficiency wafer and thin film silicon cells. Other areas of research include buried contact cells, silicon light emission, silicon-based quantum wells and superlattices, new energy up- and down-conversion concepts and energy collection using optical-frequency antennas.

BP Solar significantly increased both its mono and poly silicon cell efficiencies by installation of new plasma enhanced chemical vapour deposition (PECVD) Silicon Nitride systems on its production lines. BP continues its development of automated production equipment.

Pacific Solar is developing and commercialising a thin film PV technology called Crystalline Silicon on Glass (CSG) based on initial research at the UNSW. In addition to its R&D on CSG modules, Pacific Solar has developed and commercialised its own module inverters and roof mounting systems. CSG module manufacture is scheduled for 2005.

The Centre for Sustainable Energy Systems at the ANU, in conjunction with energy utility Origin Energy, has developed a new thin film PV technology to be known as “Sliver cells”. Origin Energy plans to commence construction of a Pilot Plant to commercially demonstrate the potential of the Slivers TM technology in 2003. The plant is to be constructed in Adelaide, and is being designed to be expandable to approximately 10MW p.a. capacity.

The ANU team is also developing parabolic trough and paraboloidal dish PV concentrator systems, and a Combined Heat and Power Solar System.

Murdoch University is developing methods of producing low cost silicon from a number of new sources for both wafer based and thin-film silicon solar cells.

Sustainable Technologies International (STI) has commenced the world’s first pilot production of titania dye sensitized solar tiles and panels after many years of research. Demonstration systems are being installed.

Solar Systems Ltd. continues development and commercialisation of its PV tracking concentrator dishes for off-grid community power supplies or end of grid applications. Current systems achieve 500 times concentration and use air or water cooling. System efficiencies of 20 per cent have been achieved. The systems are currently based on silicon cells, but work is continuing on development of non-silicon devices, which are expected to achieve 40 per cent efficiency.

PV Solar Energy Pty Ltd has developed and demonstrated a new PV roof tile, based upon a versatile extruded aluminium frame. The tile uses a new low cost pluggable PV junction box, developed by Tyco Electronics and monocrystalline solar cell laminates.

2.5 Public budgets for market stimulation, demonstration/field test programmes and R&D

Public spending on PV R, D&D totaled AUD 5.5 million in 2002, with a further AUD 15.1 million spent on market incentives and grant programmes, as shown in Table 3. In addition to this public funding, the PV industry expenditure on R, D&D and market development totaled over AUD 20 million.

Table 3: Public budgets (in AUD) for R&D, demonstration/field test programmes and market incentives in 2002.

	R & D	Demo/ Field test	Market
National	2.2 M	3.0 M	15.1 M
State		0.3 M	
Total	2.2 M	3.3 M	15.1 M

3 Industry and growth

3.1 Production of photovoltaic cells and modules

BP Solar remains the major PV manufacturer in Australia, with STI operating a small production line for dye sensitised PV cells. Cell production doubled in Australia in 2002 and production capacity trebled. Imported cells and modules are also used in the Australian market.

Table 4: Production and production capacity information for 2002 for each Australian manufacturer

Cell/Module manufacturer	Technology	Total Production (MWp)			Maximum production capacity (MWp)		
		Cell	Module	Conc. System	Cell	Module	Conc. System
1 BP Solar	c-Si	7	3		10	4	
2 BP Solar	mc-Si	13	4		20	8	
Thin film manufacturers							
1 STI	TiO2	0.5			0.5		
Concentrator systems							
1 Solar Systems	concentrator			0.2			5
TOTALS		**20.5**	**7**	**0.2**	**30.5**	**12**	**5**

a) General description of the main steps of the production process employed for each manufacturer (feedstock, ingot crystallization, wafer cutting, cell fabrication, module fabrication and other appropriate steps).

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

STI: In-house manufacturing of all the key materials for DSC technology: titania paste, dye, electrolytes, catalytic paste, interconnecting material and internal sealants. The manufacturing process includes laser isolation of the conductive glass screen-printing of working electrode (titanium dioxide, a range of electrodes per substrate) and counter electrode (catalytic layer, 6 electrodes per substrate), deposition of sealants and interconnection on the substrates, bonding the substrates and filling with a proprietary electrolyte. External sealing finalises manufacture of tiles (180x100mm).

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

BP Solar: Cells manufactured in-house from imported wafers.

STI: Cells manufactured in-house.

c) An indication of the amount of production (cells, modules, other components, systems) exported from the country.

BP Solar: Of the 20 MW of cells produced in Australia, approximately 13 MW were exported to the rest of world. In addition, of the 7MW of modules manufactured 1.5MW was exported.

STI: nil

Inverter, battery and other balance of system component manufacturers also export, although on a relatively small scale.

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

BP Solar: All commercially produced modules use sc-Si or mc-Si. Modules range in size from 2 - 150 Wp. There is increasing emphasis on large area (72 cell / 1.6m X 0.7m) high power modules (150Wp+). 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 and building applications, eg. for hazardous areas, small area / low power systems or for building cladding purposes.

Warranties range from 20-25 years, depending on the application, as well as on the level of manufacturer involvement in system design.

STI: The DSC tiles are interconnected and laminated into Solar Wall Panels (typically 600X900mm) to suit end-user requirements, primarily for façade integration. Most of the materials and components are manufactured at STI.

e) Certification of modules to IEC 61215 or IEC 61646 or equivalent. Certification to ISO 9000, ISO 14000.

BP Solar: Fabrication facilities are accredited to ISO 9000 Quality Standards and Underwriter Laboratories (UL) 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 specially designed products (large size modules, high insulation modules, facade and roof top modules, home system kits etc.).

BP Solar: There was a focus in 2002 on large area modules and laminates (140Wp+). Approximately 80% of local production was large area modules. This reflects the market demand for lower cost per watt compared to the traditional 75 and 80 watt panels.

About 1% of production is for special building modules such as custom glass-glass atrium panels and PV roof tiles. However, there is increasing interest in this area as the grid connect market increases.

Special modules are manufactured to specification for Telstra, Australia's telecommunications utility company.

g) New developments and new products that arrived on the market during 2002.

Solar Systems constructed the first commercial power station, using their new concentrator technology. A 220kWp plant is now operating in the Pitjantjatjara Aboriginal community and several other plants are planned for other remote communities currently reliant on diesel power.

BP Solar introduced a new proprietary "Energiser" roof mounting kit, available in various sizes and configurations.

A new grid connect string type inverters available up to 2kW in size was introduced by BP Solar.

Pacific Solar introduced its Sunlogger interactive system monitor in 2002 and will release its IPC 2 module inverter in 2003 to replace its IPC 1 module inverter introduced in 2000.

International companies Sharp, Kyocera, Shell, Photowatt and Hitachi have established local distribution of modules in Australia and may increase their presence in coming years, if the Australian market remains buoyant.

h) Details of module production capacity under construction at end of 2002 but not yet in production.

Projected production from BP Solar's Homebush Bay factory for 2003 is approximately 30MW, up from 20 MW in 2002.

i) Outlook for manufacturing and products for each manufacturer (where possible) and/or on a national basis, noting where changes in technology are anticipated.

BP Solar is partway through an expansion of its cell and module production facilities at Homebush Bay, Sydney with emphasis on high volume world class manufacturing methodology and a technology move to higher performance screen-printed processing. Both mono and poly crystalline cells and modules are produced. Output from the plant is expected to exceed 30 MWp runrate capacity by end 2003. The facility will have the capacity to expand final cell production volume to around 40 MWp. The main focus is on large area laminates for local use and export, particularly for the fast-growing European & US grid connect markets.

Sustainable Technologies International is working on up-scaling its 500 kWp manufacturing facilities and introducing the next generation designs for its Dye Sensitised PV Tile.

Solar Systems expects to increase production from its 5 MWp concentrator system plant from 0.2 in 2002 to 1 MW in 2003 and 2.5 MWp in 2004.

Pacific Solar continues the development of its thin-film CSG product. Product made on its pilot line is under test and construction of a full scale production facility is scheduled for 2005. It continues to develop and market its Plug&Power™ ac module system for grid-connected rooftop applications and has nationwide sales and distribution. Pacific Solar's Plug&Power™ system has gained US UL (Underwriter Laboratories) listing, allowing it to be marketed in the US.

Origin Energy plans to commence construction of a Pilot Plant to commercially demonstrate the potential of it's Slivers TM technology in 2003. The plant is to be constructed in Adelaide, and is being designed to be expandable to approximately 10MW p.a. capacity.

j) Module prices (indicative) in current Australian dollars for a number of years are given in Table 4a. The price breakdown for large and small orders is as follows:

Large orders (large area panels) – AUD 6.5 - 7 per Wp.

Small orders (large area panels) – AUD 7 – 9 per Wp.

Table 4a: Typical module prices (current AUD) over the period 1992-2002

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Module price per Wp:			7		8			8	8	8	7

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 VA (AUD)	2.2	1.6	1.3	1

Business activities, trends and strategies concerning other component products:-

- PV inverters, controllers and loggers

There are several Australian manufacturers of inverters and controllers including Advanced Energy Systems, Enertec, Latronic Sunpower, Plasmatronics, Powercor Australia, Power Solutions Australia, Solar Energy Australia and Selectronics. Their products cover both grid and off-grid markets and range in size from less than 1 KVA to over 100 KVA. Plasmatronics introduced a new PV system controller in 2002.

During 2002, a new string inverter was released by BP Solar while Pacific Solar's own module inverter IPC1 was used in its Plug&Power™ systems. A new version, IPC 2 will be released in 2003 and is suitable for Australian and international markets.

Pacific Solar also introduced an Australian manufactured Sunlogger, which is installed as a monitoring system and customer interface with each of its rooftop systems.

Century Yuasa has developed a remote electrolyte sensor for batteries in off-grid PV systems.

- Supporting structures

New steel mounting systems were developed and introduced by Pacific Solar for its Plug&Power™ systems. Their manufacture was supported by an Australian Government grant to develop tools which allow rapid stamping out of the systems.

BP Solar also introduced new rooftop mounting systems. A 20% reduction in cost was achieved through the new smarter designs.

PV Solar Energy's plastic extruded frame for solar tiles has been used on 79 homes in the second stage of the Newington Solar Village, using BP Solar's 85 Wp "Saturn" cell laminates.

3.3 System prices

Table 6 shows typical turnkey prices (excluding goods and services tax) in AUD per Wp for the various categories of installation. Prices do not include recurring charges after installation such as battery replacement or operation and maintenance. Additional costs incurred due to the remoteness of the site or special installation requirements are not included.

Table 6: Turnkey Prices of Typical Applications in Australia excluding special installation costs or operation and maintenance.

Category/Size	Typical applications and brief details	Current av. prices per Wp in AUD
OFF-GRID Up to 1 kWp	Residential, water pumping, telemetry and telecommunications	20-23
OFF-GRID >1 kWp	Community, larger residential and industrial	13-20
GRID-CONNECTED Specific case	1-3 kWp residential and community roof-mounted systems	12-15
GRID-CONNECTED Up to 10 kWp	Community, industrial and commercial buildings	13-14
GRID-CONNECTED >10 kWp	Industrial and commercial buildings	10-13

- Home PV System Kits

Pacific Solar markets Plug&Power, a fully-integrated rooftop PV system for grid-connected applications, throughout Australia, especially through selected retail appliance outlets. Designed as an appliance, Plug&Power comprises PV modules with module inverters, integrated rooftop mounts, plug & socket cabling plus a display/monitoring unit (Sunlogger) and computer access software.

BP Solar retails residential off-grid system kits with PV, inverter, controller, batteries and back-up diesels or containers and module stands if required. PV on-grid residential kits will be launched in 2003. Solar lighting systems with PV, batteries, lights and connectors for black & white televisions, radios or telecommunications systems are marketed internationally.

Table 6a: National trends in average system prices (current AUD) for off-grid applications up to 1 kWp

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Price /Wp:		**24**		**22**		**30**	**30**	**30**	**22**	**22**	**20**

Table 6b: National trends in average system prices (current AUD) for grid applications up to 10 kWp

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Price /Wp:						**11**	**12**	**12**	**14**	**14**	**13**

3.4 Labour places

Estimated labour places, where these are mainly involved with PV, are as follows:

a) Research and development (not including companies);
50

b) Manufacturing of PV system components, including company R&D;
350

c) All other, including within energy companies, distribution, installation and maintenance companies.
450

3.5 Business value

Of the 5.55MWp of PV product supplied into the Australian market in 2002 approximately 4.75 MWp went into off-grid applications, valued at an average of AUD 20 per watt. The balance went into on-grid systems valued at an average of AUD 13 per watt. The local market is therefore worth approximately AUD 105.4 million, not including exceptional installation costs eg. in remote areas or for special building applications.

In addition to local use, 13 MW of cells valued at approximately AUD 4 per watt and 1.5 MW of modules valued at AUD 7 per watt were exported, at a total value of approximately AUD 62.5 million.

The overall net value of PV manufacture and sales in Australia in 2002 is therefore estimated to be approximately AUD 170 million.

This does not include:

- extraordinary installation costs in remote areas or for special building integrated systems
- on-going operating and maintenance costs. Based on installed capacity in Australia to 2001, these costs could add a further AUD 12.5 million to industry value, if off-grid system O&M costs are 2% and grid system costs are 1% per annum of system value at current costs
- balance of system component exports, including inverters, batteries and controllers
- R&D costs at universities and industry. These amounted to more than AUD 33 million in 2002.

However, all wafers were imported, which reduces the net value of the product to Australia by approximately AUD 14 million.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

a) Innovative marketing, financing or promotional initiatives for grid-connected or off-grid PV:

Pacific Solar developed a mainstream marketing chain using 17 distributors and 53 retail outlets Australia wide for sale of its grid connect PV rooftop systems. The systems are now being marketed through both specialist solar shops and standard energy shops. This retail method is supported by local advertising and aimed at increasing customer familiarity and awareness of PV and hence to facilitate customer choice of PV when making energy decisions.

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

Utilities offer a range of tariff structures and net metering for grid connected PV systems. Nevertheless, PV system installers still face unnecessary delays and costs in connecting PV to systems to the grid.

Under the Australian Mandatory Renewable Energy Target (MRET), electricity retailers are required to purchase a specified amount of renewable generated electricity. Hence, although PV remains at the higher cost end of renewable energy options, retailers are maintaining a watching interest in PV for their own use and are also involved in purchasing a small number of renewable energy certificates (RECs) and/or electricity generated from PV systems installed by others. To date MRET has not been a strong driver for PV and the PV industry is keen to see changes in the regulations which might see a larger uptake. In particular, an increase in the deeming period for which PV can earn RECs from 5 to 20 years is being proposed.

Of increasing interest to some utilities is the problem of summer peak loads on distribution networks. A number of utilities are now interested in assessing the potential cost/benefits of utilizing PV in areas where peak loading, largely due to increasing air conditioning use, may otherwise require costly network upgrades. Summer peak loading is also an issue for diesel grid systems and the Northern Territory Power and Water Authority has constructed one 55 kWp PV plant and is partway through construction of a 225 kWp plant to address peak load problems on two of its inland power stations.

c) Changes in public perceptions of PV

For off-grid users, PV remains an important option to diesel generation and continues to become more cost effective. For urban residents, the government's PV rebate programme has raised community awareness. Take up rates increased significantly for residential grid connected systems in late 2002 as marketing programmes came on line. A user survey conducted by the NSW Sustainable Energy Development Authority shows that a large section of this new market is driven by environmental concerns.

The increasing exposure of PV, via a number of landmark commercial building installations is also raising awareness amongst architects, building companies and building operators. Of

note are PV systems at the Queen Victoria Markets, CSIRO's Newcastle Energy Centre, Kogarah Town Square, the Edwards Street building in Brisbane and the South Australian Museum. Details of these systems are provided in Table 2.

Strathfield council in inner city Sydney has introduced a new PV requirement for strata title developments. PV systems must provide power for all common lighting requirements in new multi-unit buildings. This initiative has important implications for solar access and therefore for future use of PV in high-density urban areas.

Public awareness is also being increased through a number of public activities, including Solar Tour Day and Solar House Day, sponsored by the Australian Greenhouse Office and run by the Australian & New Zealand Solar Energy Society and the Alternative Technology Association. These events allow public inspection of renewable energy facilities and solar houses respectively, with associated information materials and assistance, and have generated considerable public interest.

Education is an important aspect of PV deployment. In conjunction with the various Solar School programmes, course material is provided to teachers for primary and secondary schools. Trade training is available for a complete Renewable Energy Certificate up to Diploma level, and for specific PV system design and installation certification. The University of NSW, Sydney, offers a full PV Engineering degree course, while both the University of NSW and Murdoch University, Perth, offer Renewable Energy Engineering degrees.

d) Major new projects or initiatives

The Bushlight project, aimed at installing PV systems in remote Aboriginal communities as part of the Australian Government's Renewable Remote Power Generation Programme, is expected to begin system installations in 2003. AUD 8 million has been allocated by the Australian Government to cover funding for administration costs and support services such as design, installation and maintenance. System costs can receive funding through a combination of State sub-programmes and Regional Council funds.

e) Planned developments

Several large community PV systems are planned for the Northern Territory, for peak load shaving and fuel savings in diesel power stations. These include a 225 kWp flat plate PV system at Kings Canyon, to follow from the 55 kWp system installed at Bulman in 2002, and a further 750 kWp of PV concentrator systems by Solar Systems, to follow from the 220 kWp plant installed in the Pitjantjatjara lands in 2002.

f) Other new issues

The Australian PV market appears to be at a crossroad at present. Traditional markets, such as telecommunications are flattening out, although the off-grid water pumping, community and residential market is robust. The fledgling grid connect market is gaining momentum, but is somewhat reliant on government policy direction and grant programmes. It is hoped that the new community awareness and higher visibility of grid connected PV, particularly in building integrated applications, will ensure a steady market increase despite policy variations.

4.2 Indirect policy issues

An increasing portion of PV manufactured in Australia is being exported. This reflects growing acceptance of PV as a viable option in developing countries and in developed regions of the world where externalities associated with fossil fuel or nuclear energy have led to strong support for PV. Despite aiming to meet its Kyoto targets, the Australian government has decided not to ratify the Kyoto Protocol. Hence there may not be a strong policy signal towards sustainable energy options in Australia. Australian industries are concerned that they will begin to miss out on key developing country markets, if they are unable to take advantage of mechanisms associated with the Protocol.

Nevertheless, at State government level some new initiatives are providing indirect support for PV development and use, although other renewable energy technologies and energy efficiency are expected to be the major beneficiaries. From 2003, the NSW government will introduce a mandatory greenhouse abatement trading scheme, which requires the electricity sector to reduce emissions by 5% from 1990 to 2007. A penalty of AUD 10.50 per t CO_2 equivalent will apply. Benchmarks are set for each year and eligible activities, which include renewable energy generation, are specified. Other Australian States are interested in emulating this scheme.

Since 1996 a Perth based cooperative research centre for renewable energy (ACRE), funded jointly by government and industry, has provided funds for work on remote area power systems, component testing, technical training and demonstration systems. In late 2002, an application for renewal of funding for ACRE was rejected by the Australian Government, leaving the continuation of some of these programmes in doubt.

4.3 Standards and codes

The following Australian Standards covering PV have now been developed and published:

- AS 4509.2-2002 Stand-alone power systems - System design guidelines
- AS 4509.1-1999 (Amended 2000) Stand-alone power systems - Safety requirements
- AS 4509.3-1999 (Amended 2000) Stand-alone power systems - Installation and maintenance
- AS 4086.2-1997 Secondary batteries for use with stand-alone power systems - Installation and maintenance
- AS 4777.1-2002 Grid Connection of energy systems via inverters – Installation requirements
- AS 4777.1-2002 Grid Connection of energy systems via inverters – Inverter requirements
- AS 4777.1-2002 Grid Connection of energy systems via inverters – Grid protection requirements

Funding has been provided through the Commonwealth Government's Renewable Energy Industry Development Programme (REID) to assist with developing a new PV array standard, an inverter standard for stand alone power systems and standard contracts between installers and stand alone power system owners. The new PV array draft standard

has been extensively reviewed. Workshops around Australia will be held in February 2003, after which public comment will be sought and the standard is expected to be published late in 2003. The inverter standard for stand alone power systems is at the first draft stage. Standards activities relating to the Commonwealth Government grant can be seen at: www.standards.ee.unsw.edu.au. This web site includes drafts, discussion documents and comment forms.

As part of the implementation process for the new PV guidelines and standards, materials for training and accreditation for industry are developed and seminars, short courses and trade certificate courses are arranged across Australia. A limited amount of Renewable Remote Power Generation Programme funding is available for accreditation purposes.

Support for evaluation/modelling, accreditation, and national standards has also been provided through the RECP for a national facility dedicated to testing and accrediting renewable energy systems, ACRELab. The lab will contain a solar simulator, a large PV array, PV module tester, power quality analyser, and other associated test and monitoring equipment.

5 Highlights and prospects

Although still perceived to be a high cost niche market technology, PV is one of the best-established renewable technologies in Australia, with 3 decades of technology and market development. The overall market expanded by 27% in 2002, with the grid connect segment growing 95%, production doubled and production capacity trebled. Australian researchers continue to lead the world in PV cell development and commercialisation. Several new technologies are on the verge of commercial production. A new generation of university and trade trained graduates are entering the job market and are set to enhance community acceptance and use of PV.

The PV industry is beginning the development of a PV Roadmap, to coordinate and focus its activities over the coming decade. This will follow on from a wider Renewable Energy Roadmap developed in 2002 and will provide more detail on PV strategies. The Roadmap will cover research priorities, industry infrastructure needs and customer requirements and will set industry targets for deployment. It will facilitate the introduction into the market of several new PV manufacturers, with new PV technologies and new market aims. It will also assist PV to benefit more from generic renewable energy support mechanisms and to establish itself as a technology of choice with energy and non-energy benefits for specific applications in the electricity sector. The Australian PV Roadmap will complement work to be undertaken in IEA PVPS Tasks 9 - PV Deployment in Developing Countries and 10 – Urban Scale Grid Connected PV Applications.

Annex A Method and accuracy of data

When preparing the ISR, it is necessary to know the accuracy of the data provided in the NSRs. Therefore, in this Annex please give:

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

Data is collected by the author directly from companies and from published reports. A draft report, containing the analyses is circulated to the Australian PVPS Consortium and key PV companies for comment prior to finalization.

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).

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

Estimated average exchange rate 2002: 1 AUD = 0.6 USD