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 *2004*

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Table of Contents

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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), 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. Nine 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 PV hybrid systems is now 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

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 ***Trends in photovoltaic applications*** report. This report gives information on trends in PV power applications in the PVPS member and other countries and is largely 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 W 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 'Rated power').

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

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 W 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 to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural 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 to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

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 systems 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

- Installed PV power

Total PV installed in Australia reached 52 MW in 2004, an increase of 15% over 2003. The market growth rate remains steady, as does the proportion of installations in each end use category. Off-grid installations represent 87% of installed capacity and grid installations, including diesel grids, 13%. Direct government support was provided for approximately 30% of off-grid installations, and almost 100% of grid installations.

- Costs & prices

Module costs have risen, in current dollar terms, to around AUD 10 per Wp, reflecting international market prices. Prices for some inverters and for grid systems have also risen. Installation costs have been impacted by increasingly stringent occupational, health and safety regulations associated with insurance.

- PV production

PV cell production capacity in Australia increased to 40MW and is expected to reach 50 MW in 2005. Cell production increased to 35 MW and module production remained at 8 MW. 77% of cells and 50% of modules manufactured in Australia were exported while around 40% of modules installed were imported. A 5 MW pilot line was installed for the new Sliver™ technology and production will commence in 2005.

- Budgets for PV

State and Federal governments provided AUD 4.3 million for PV research and development and AUD 16.1 for market support via the PV Rebate Programme and the Renewable Remote Power Generation Programme. This level of funding is expected to continue through 2005.

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 W 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

The main applications for PV in Australia are for off-grid industrial and agricultural applications. These include power systems for telecommunications, signalling, cathodic protection, water pumping. Significant markets also exist for off grid residential power supplies and increasingly for fuel saving and peak load reduction on community diesel grid systems. Grid connected PV applications have increased in recent years, largely as a result of government grant programs. The main applications are rooftop systems for private residences, schools and community buildings.

2.2 Total photovoltaic power installed

The total cumulative installed PV power by 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 in 4 sub-markets.

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	31 Dec 2003 kWp	31 Dec 2004 kWp
off-grid domestic including recreational market	1 560	2 030	2 600	3 270	4 080	4 860	5 960	6 820	9 110	10 960	12 140	13 590	15 900
off-grid non-domestic[1]	5 760	6 865	8 080	9 380	11 520	13 320	15 080	16 360	17 060	19 170	22 740	26 060	29640
grid-connected distributed		5	20	30	80	200	850	1 490	2 390	2 800	3 400	4 630	5410
grid-connected centralized[2]				20	20	320	630	650	650	650	850	1 350	1 350
TOTAL	**7 300**	**8 900**	**10 700**	**12 700**	**15 700**	**18 700**	**22 520**	**25 320**	**29 210**	**33 580**	**39 130**	**45 630**	**52 300**

1: Includes replacements, but old modules onsold **2**: Includes diesel grids

2.3 Major projects, demonstration and field test programmes

PVRP – Photovoltaic Rebate Programme

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

The PVRP aims to provide government assistance to householders and owners of community buildings, such as schools, to install photovoltaic systems. Other key objectives are to:

- Reduce greenhouse emissions;
- Assist in the development of the Australian PV industry; and
- Increase public awareness of renewable energy.

b) size and main technical and economic data;

878 systems were installed in 2004, amounting to 1.17 MWp. 58% of customers, accounting for 66% of installed capacity, were on grid connected buildings and a total of AUD 3.64 million was allocated in rebates. Since the start of the programme in 2000, more than 5,700 systems, using 6.8 MWp of PV, have been installed and rebates of AUD 30.3 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. Further allocations of AUD 5.8 million were made in 2003 and the programme was extended to 2005. Grants have been reduced to AUD 4,000 for residential systems and 8,000 for community systems.

d) main accomplishments by the end of the reporting year;

Approvals for grid connected systems overtook those for off-grid systems by mid 2002 and now account for the majority of installations. Over 200 systems have been installed on community buildings, including schools. System sizes have remained steady with grid systems averaging around 1.5 kWp and off-grid systems around 1 kWp.

e) problems encountered and lessons learned;

Early uptake exceeded budget allocations, resulting in modification to eligibility criteria and grant amounts.

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

It is anticipated that the budget will be extended to 2007 to link into the Solar Cities project, which is expected to begin installations by that time.

Renewable Remote Power Generation Programme

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

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 long-term greenhouse gas emissions.

This is an Australian Government programme, administered by State and Territory Governments. Each participating jurisdiction 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.

b) size and main technical and economic data;

1.4 MWp of PV was installed under RRPGP in 2004, bringing the total installed capacity to 3.8 MWp under this programme, of which 0.28 MWp is installed in large utility run diesel grid systems. Although it is not PV specific, most small systems include some PV. The overall programme has funds of around AUD 200 million allocated to it, of which around AUD 40 million had been allocated by end 2004. In addition, AUD 5.9 million has been allocated to industry support activities, including test facilities, standards and certification.

c) funding sources and cost sharing;

Core funding for this programme is provided to the participating jurisdictions by the Australian Government. Grants of up to 50% of the capital cost of renewable generation and essential enabling equipment that displace diesel generation are available, with additional funding provided by some States.

A specific allocation of AUD 8.4 million has been made for the *Bushlight* sub-programme to assist with the development of industry capability and local understanding of renewable energy systems in small indigenous communities and to install household and community systems.

d) main accomplishments by the end of the reporting year;

To end 2004, grants of AUD 40 million had been paid for systems with 3.8 MWp of PV. Around 70% of the systems installed in 2004 were for residential purposes and 30% for agricultural / industrial uses, including water pumping systems. Under the Bushlight sub-programme, 40 communities have been through an energy planning process and 30 PV powered household systems have been installed, with specifications developed in consultation with the end-users. Training is also provided for both end-users and local maintenance personnel. System performance and user satisfaction is being monitored.

e) problems encountered and lessons learned;

Because the funding provided to each participating jurisdiction is based on diesel fuel excise paid by public power generators in remote areas, some States receive very little or no funding, while others have significant funds. While the overall budget for the programme is high, applicants must source at least 50% of project costs, which poses a

barrier to implementation in some remote communities. In the Bushlight programme, the use of old, inefficient electrical appliances has been an issue in some site, once the new PV powered systems are installed.

Changes recently announced by the government to diesel fuel excise payments for stationary applications will reduce diesel costs and hence the cost effectiveness of PV for remote area power generation.

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

The Programme will continue until 2012, although commitments must be made by 2010. While initial applications have mainly been for small systems, an increasing number of larger, community-sized systems are now being installed. Several community systems will also be installed through Bushlight during 2005.

Changes to the guidelines in late 2004 include allowing fringe of grid installations to be eligible for RRPGP grants. Installations are expected to be less than 2MW and will be assessed on

a) the line distance from the nearest relative generation point;
b) distribution and transmission losses;
c) the number of regional supply outages;
d) the frequency of use of backup diesel (or other fossil fuel) generation systems; and
e) the remote community benefits provided by the Project.

Projects which displace fossil fuels other than diesel will also be allowed and selected solar thermal and energy efficiency measures will be eligible for grants. To counter the impact of diesel excise removal in 2006, selected projects may be eligible for grants up to 70% of system cost. Details of these changes are yet to be reflected in the rules for each jurisdiction.

Combined Heat and Power Solar Demonstration System

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

The Centre for Sustainable Energy Systems at the Australian National University (ANU) has installed a demonstration Combined Heat and Power Solar (CHAPS) system on a 90 bed student accommodation building at the ANU campus in Canberra. The major reason for embarking on the project is to reduce the cost of energy services from solar energy technologies. By maximizing the mirrors and minimising the number of concentrator cells the dollars/watt of electricity supplied is reduced.

b) size and main technical and economic data;

The CHAPS system consists of 8 parabolic troughs of 1.2m width and 24m length which provide a X30 sun concentration onto a receiver comprising photovoltaic cells and integral heat pipe behind. Water in the heat pipe removes the heat from the cells, maintaining their internal cell temperature at close to optimum. The output of the CHAPS system is 20kWe and 200kWth in Canberra's solar regime and provides 100% of the domestic water heating, approximately 40% of the space heating (via an in-slab

hydronic heat distribution system) and approximately 40% of the electrical load of the building via a grid interactive 40kVA inverter. The overall efficiency of the system is about 70%.

c) funding sources and cost sharing;

The project was supported by the ANU and a $1million grant from the Australian Greenhouse Office.

d) main accomplishments by the end of the reporting year or end of operating period;

The demonstration system had just been commissioned, so no performance data is available to date.

e) problems encountered and lessons learned;

The only significant problem encountered is the use of a research facility to fabricate sufficient 30 sun concentrator cells. This task would be much better suited to a commercial cell manufacturing plant, once the technology has been transferred.

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

Intellectual property from the project is being transferred to industry partners who will continue commercial production of CHAPS systems. A study will shortly be undertaken to identify potential markets for CHAPS systems. The most likely market at this stage is the remote area market in the Northern Territory, Queensland and Western Australia to reduce reliance on diesel fuel.

Bruny Island Lightstation Photovoltaic Project

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

The Cape Bruny Lighthouse, within South Bruny National Park in Tasmania, was built in 1838 and is the second oldest lighthouse in Australia. The light is now automatically operated and powered by a PV system. The adjoining Lightstation is a popular tourist destination and consists of two lighthouse keepers' quarters, museum, workshop and powerhouse. 24 hour power was supplied by two 25 kVA diesel generators which consumed about 18,600 litres of diesel fuel per year. The average daily load of the Lightstation was around 135 kWh per day with a peak demand of about 25 kW. Much of this load was attributed to appliances (such as bar radiators) being deliberately left on in order to provide sufficient loading for the diesel generators.

A feasibility study was carried out by Hydro Tasmania on behalf of the Tasmanian National Parks and Wildlife Service. The major recommendations included replacing the existing system with a photovoltaic/diesel hybrid RAPS system and replacing old inefficient appliances with more energy efficient equipment.

b) size and main technical and economic data;

The recommended RAPS system consisted of:

- 4.8 kW photovoltaic array;
- 10 kW generator interactive sinewave inverter / battery charger;
- 1000 Ah (C_{100}) 120 volt battery bank; and
- 16 kVA diesel generator.

c) funding sources and cost sharing;

The initial feasibility study was undertaken as part of an Australian Government Renewable Remote Power Generation Programme (RRPGP) funded study examining the feasibility of renewable generation across 5 National Park sites and costing $15,500. The upgrade to the RAPS system and purchase of energy efficient appliances cost $156,794 in total. This was funded by the National Parks and Wildlife Service, with a contribution of $67,151 from the RRPGP.

d) main accomplishments by the end of the reporting year or end of operating period;

The system was installed in September 2004 and is expected to result in annual diesel savings of approximately 15,700 litres per year once the energy efficiency options have been fully implemented. It will reduce greenhouse gas emissions by over 47 tonnes per year.

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

The initial feasibility study also reported on renewable energy options at four other remote National Parks and Wildlife sites. Projects proposals for these sites are expected to be developed over the coming years.

2.4 Highlights of R&D

The **Centre of Excellence in Advanced Silicon Photovoltaics and Photonics**, University of NSW has research streams focussed on short, medium and long term technology needs. Research undertaken includes cost reduction and efficiency improvements for wafer based silicon cells, improved silicon thin film processes and all-silicon tandem cells.

The **Centre for Sustainable Energy Systems** at the Australian National University undertakes research into solar thermal and photovoltaic technologies including parabolic trough and paraboloidal dish PV concentrator systems, and associated concentrator cells, trackers, controllers and mirrors, as well as a Combined Heat and Power Solar System. It is also undertaking research into thermochemical storage and phase change energy storage materials.

The **Solar Energy Applications Research Group** at Monash University undertakes research into renewable energy power systems design, analysis and storage. It works with off-grid and grid applications.

The **Sustainable Energy Centre, University of South Australia,** undertakes research into PV applications, including commuter cars.

Origin Energy is commercialising the "Sliver cell" PV technology developed by the Australian National University. The technology promises crystalline Si cell performance with significantly lower wafer requirements. A 5 MW Pilot Plant was installed in Adelaide in 2004 and pilot 10 kW modules produced. Larger scale production is expected in 2005. The pilot plant will be expandable to approximately 25 MW p.a. capacity if pilot production is successful.

BP Solar continues its development of automated production equipment and is working with research groups in Australia and elsewhere on improved cell and module manufacture plus systems development.

CSG Solar (formerly Pacific Solar) undertakes R&D on Crystalline Silicon on Glass (CSG), a thin film PV technology based on initial research at the UNSW. CSG cell and module manufacture is scheduled for 2006 in Germany.

Sustainable Technologies International (STI) continues manufacture from its pilot facility in Queanbeyan and plans manufacture of STI DSC Façade panels in Europe.

Solar Systems Ltd. continues development and commercialisation of its PV tracking concentrator dishes for off-grid community power supplies and 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.

PV Solar Energy Pty Ltd continues development of its PV roof tile which uses a low cost pluggable PV junction box and monocrystalline solar cell laminates. Installation options include active air flow in the roof space below the modules to keep them cool and allow for warm air circulation into the building during winter months.

Other university PV programs include:

- University of NSW - GaAs solar cells
- Murdoch University - low cost silicon production
- Flinders University - improved dye sensitised solar cells
- University of Queensland - semiconductor biopolymers
- Newcastle University – nanoscale polymer devices
- University of Western Australia – Tantalum-Silicon cells

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

Table 2 provides figures for 2004 on budgets from the public authorities for R&D, demonstration/field test programmes and market incentives (public subsidies, fiscal incentives, and amounts collected) on the national and on state level. Additional funding is made available via Local Governments across Australia, mainly through the Cities for Climate Protection programme.

Table 2: Public budgets (in million AUD) for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test	Market
National/federal	3.929		15.512
State/regional	0.339		0.620
Total	4.268		16.132

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Table 4: Production and production capacity information for 2004 for each manufacturer

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)			Maximum production capacity (MW/yr)		
		Cell	Module	Concentrators	Cell	Module	Concentrators
BP Solar	sc-Si	5	8		40	12	
BP Solar	mc-Si	30					
Thin film manufacturers							
STI	DSC	0.1	0.1		0.5	0.5	
Concentrators							
Solar Systems	sc-Si			0.7			5
TOTALS		**35.1**	**8.1**	**0.7**	**40.5**	**12.5**	**5**

a) General description of the main steps of the production process employed

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

STI: In-house manufacturing of all 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, filling with a proprietary electrolyte and external sealing (180x100mm). Modules are glass-glass using liquid lamination.

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

BP Solar: The majority of cells used in Australia are made from imported wafers and are processed in-house.

STI: produces its own DSC cells.

c) An indication of the amount of production exported.

BP Solar: Cell exports for 2004 were 27 MW, 77% of total production. Module exports were 4 MW, 50% of production.

d) Availability of specially designed products

BP Solar manufactures modules in the size range 70-180W. It also supplies home system kits to the local market in the range 0.5-2kW.

e) Details of module production capacity under construction at end of 2004 but not yet in production.

BP Solar continues to expand its cell production capacity and expects to reach 50 MW capacity by end 2005. Origin Energy installed a 5 MW pilot line for production of Sliver™ cells, which will begin production in 2005.

f) Outlook for manufacturing and products, noting where changes in technology are anticipated, and the source of such information.

Cell manufacturing at BP Solar is expected to increase to 45 MW, with the major portion of product exported. Origin Energy's Sliver™ cells and modules will enter the market in 2005.

Table 4a: Typical module retail price trends (current AUD per Wp)

Year	1994	1996	1998	2000	2002	2004
Module price(s): Typical	7	8	8	8	7	10

Note: Module prices reflect international market prices, local manufacturing costs and exchange rates.

3.3 Manufacturers and suppliers of other components

There are several Australian manufacturers of inverters, controllers, system regulators, maximum power point trackers, batteries and other balance of system components. They include Advanced Energy Systems (AES), EnerTec Australia, Latronic Sunpower, Plasmatronics, Powercorp Australia, Power Solutions Australia, Solar Energy Australia (SEA), Rainbow Power Company, RF Electronics, Selectronic Australia; and Battery Energy South Pacific, Exide and Century Yuasa as major battery suppliers.

Manufacturers are consolidating their product ranges and specializing. Some are concentrating on export markets, others on diesel systems, grid systems or small scale off-grid systems.

3.4 System prices

Table 5: Turnkey Prices of Typical Applications (not including government grants)

Category/Size	Typical applications in your country and brief details	Current prices per W in AUD
OFF-GRID Up to 1 kW	Telecommunications, fences, residential RAPS	18-24
OFF-GRID >1 kW	Water pumps, residential and pastoral RAPS	12-30
GRID-CONNECTED residential	1-3 kW roof-mounted, including PV, inverter, wiring and installation	12-18
GRID-CONNECTED Up to 10 kW	Larger systems on commercial buildings	10-12
GRID-CONNECTED >10 kW	Fuel saving on diesel grids, large building or ground mounted power systems	10-12

Table 5a: Australian trends in average system prices (current AUD) for off-grid applications up to 1 kWp

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Price /Wp:	**24**		**22**		**30**	**30**	**30**	**22**	**22**	**20**	**20**	**20**

Table 5b: Australian trends in average system prices (current AUD) for grid applications up to 10 kWp

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Price /Wp:					**11**	**12**	**12**	**14**	**14**	**13**	**10**	**12**

3.5 Labour places

Approximate labour places in different areas of the PV chain:

a) Research and development (not including companies); 85
b) Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D; 420
c) All other, including within electricity companies, installation companies etc.
   c1) Distributors of PV products; 400
   c2) System and installation companies; 400
   c3) Utilities and government. 30

Data for (a) and (b) collected directly from research groups and manufacturers with estimates for (c) from industry associations and government reports.

3.6 Business value

Table 6 provides an estimated value of PV businesses in Australia in 2004. More details on the structure of the Australian industry can be found in *The Australian Photovoltaic Industry Roadmap* (Australian Business Council for Sustainable Energy, July 2004) under the headings of:

- Research and development.
- PV cell and module manufacturing.
- Balance of System (BOS) manufacturing.
- Distribution, wholesaling and retail sales.
- System integration, including design and installation.
- Electricity supply.
- Education and training.
- Standards and Accreditation.

Table 6: Value of PV business

Sub-market	Capacity installed in 2004 (kW)	Price per W	Value (million AUD)	Totals (million AUD)
Off-grid domestic	2310	20	46.2	
Off-grid non-domestic	3580	20	71.6	
Grid-connected distributed	780	12	9.36	
Grid-connected centralized	0			
				127.16
Export of PV products				140
Change in stocks held				12.0
Import of PV products				-53.69
Value of PV business				**225.47**

Note: Import and export values are calculated on market prices for wafter, cells, modules and systems. In practice, internal company product transfers may not be at market prices.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

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

A number of utilities maintain a watching brief on PV developments with a view to increased use for peak load supply and grid support. Utilities with diesel grids continue to support the addition of PV to their systems, although recent decisions to remove fuel excise for off-grid diesel use will make PV less cost effective. For main electricity grids PV remains a high cost option for utilities and the most immediate areas of interest are in safety and grid reliability issues associated with the interconnection of privately financed distributed PV systems. Nevertheless, Australian utilities are keenly aware of greenhouse issues and seek Government leadership in creating a greenhouse signal in the electricity market which would reduce uncertainty for long term investments. Utilities will be involved with the Solar Cities trials (see paragraph c) below) and may thus develop longer term PV implementation strategies.

b) Changes in public perceptions of PV

PV is gradually being accepted at the local government level, and hence by building developers and householders. PV is increasingly used for street lighting, traffic management, parking meters and other visible applications in urban areas. Building developers have also been encouraged to consider PV through a special component of the PV Rebate Programme. These initiatives will gradually increase public confidence in PV as a mature technology, rather than a promising one for the future.

c) Planned developments

In June 2004 an Energy White Paper "Securing Australia's Energy Future" was released by the Australian Government. It includes a number of new measures targeting renewables, which will have an impact on PV over the coming years including *Solar Cities trials*. AUD 75 million has been allocated over 5 years to demonstrate high penetration uptake of solar technologies, energy efficiency, smart metering and other options aimed at improving the market for distributed generation and demand side energy solutions. Tenders have been called for consortia to install PV and other distributed generation options in four urban sites, with detailed monitoring and associated tariffs, marketing and financing also being supported. Systems are expected to be installed from 2006 onwards.

d) Other new issues

Other initiatives included in the Energy White Paper:

Commercialisation of renewable energy technologies – AUD 100 million has been allocated over seven years to promote strategic development of renewable energy technologies, systems and processes that have commercial potential. A further AUD 20 million will be provided to support development of advanced electricity storage technologies, including batteries, electro-mechanical and chemical storage.

Market Leader Technologies – PV and Remote Area Power Systems have been identified in the White Paper as technologies of strategic importance for Australia and for which Australia

has a clear technological advantage internationally. This will be reflected in priorities for Government R&D funding.

4.2 Indirect policy issues

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

The Australian government has supported PV R&D, as well as demonstration and market development over several decades. Most recently it has selected PV as a strategic energy technology for Australia. Hence the rapid development of PV manufacturing and markets in Europe and Japan is of interest because Australian companies have chosen to commercialise technologies in Europe and also because Australia is no longer at the leading edge of research and technology development. Market developments in the Asia – Pacific region similarly indicate that export of Australian expertise is likely to be more successful in the longer term than export of technology.

b) the introduction of any favourable environmental regulations;

A major review of the Australian Mandatory Renewable Energy Target was published in January 2004. With respect to PV, the recommendations of the review include: extending the deeming provisions for small PV systems from 5 to 15 years and increasing the deeming threshold from 10 to 100 kW. These changed provisions are expected to pass through Parliament by mid 2005 and may have a positive impact on the PV market, since deemed systems can claim their Renewable Energy Certificates (RECs, equivalent to 1 MWh of renewable based electricity) when installed. However, with renewable energy generating capacity now almost able to meet the MRET target, REC prices are likely to fall from their 2004 levels of $30-35.

State based building regulations may act as a driver for PV installations in future. For instance, energy issues are addressed in the NSW BASIX scheme via a *Thermal Comfort* criterion, which addresses the thermal characteristics of the building envelope, and the *Energy Index* criterion, which reflects energy based greenhouse gas emissions with a target reduction of 40% compared to current housing. For large houses in particular, it will be difficult to satisfy the *Energy Index* requirement without installing very aggressive energy efficiency measures, gas cooking, and possibly PV. It remains to be seen whether the building sector will view PV as a good option.

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

The Clean Energy Futures study, published by the Australian Business Council for Sustainable Energy, investigated the technical potential for reducing CO_2 emissions from the stationery energy sector in Australia by 50% between 2004 and 2040 at a cost commensurate with a business as usual approach. It found this could be achieved by a mix of energy efficiency and changes to the fuel source mix, including:

- changes in the mix of electricity generation technologies, away from coal and towards natural gas and renewable energy;
- introduction of solar heating into the supply of steam and hot water in industrial and commercial applications and widespread use of solar hot water in the housing sector;
- substitution of natural gas for coal in almost all non- metallurgical applications; and

- widespread adoption of cogeneration (the combined production of electricity and heat, using turbines and engines on the site where energy is used).

Under this scenario, PV supplies 4.5% of Australia's electricity requirement, or 10.7 TWh per year.

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

The New South Wales Government has set a state-wide benchmark of reducing greenhouse gas emissions. To achieve the required reductions, benchmark participants purchase and surrender certificates called NSW Greenhouse Abatement Certificates (NGACs) which may be created by any eligible electricity generators (such as grid-connected PV systems) which reduce the average greenhouse intensity of electricity generation.

State Governments are investigating the options for introducing a coordinated State based emissions trading scheme.

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

Australia has undertaken a number of renewable energy trade missions and trade promotions in the Asia-Pacific region and in South America. It is also actively involved with training of local people for installation and maintenance of PV systems.

4.3 Standards and codes

The range of current Australian standards relevant to PV systems is shown in Table 6. A standard for PV array wiring is in final stages of publication and is expected to be available in July 2005. A standard for portable stand alone inverters has been drafted and is expected to be available later this year. This standard is particularly related to safety as some imported product without isolation between the battery and the 240V output has already caused one death in Australia and raises significant safety issues for the industry, not only in Australia but internationally. There is also a need for a safety and performance standard for charge controllers. The standard AS4777 for grid connection which covers installation, inverter requirements and protection requirements including safety of the installation, islanding protection, harmonic and power factor requirements, has been revised and will be available in July 2005.

There is still a need for general agreement on a standard interconnection application and approval process with all utilities in Australia. Having this in place would greatly facilitate diffusion of PV in grid connected applications. A review of current procedures has been undertaken by the Australian Greenhouse Office and options for standardization are currently under discussion with electricity utilities.

For building integrated PV systems, funding was provided by the Australian Government through the Australian Greenhouse Office REID Programme for best practice guidelines explaining PV installation requirements to builders, architects, planners, financiers and electricians. These guidelines will be published by the Business Council for Sustainable Energy. They cover feasibility and evaluation, design, implementation, compliance testing, commissioning, monitoring, maintenance and decommissioning.

RESLab is currently doing commercial testing of renewable energy systems and components. Its facilities include a solar simulator, a large PV array, PV module tester, power quality analysers and extensive systems test beds including configurable battery

energy storage systems and battery capacity test facilities and constant temperature baths, along with other associated test and monitoring equipment.

Stricter Australian occupation, health and safety requirements for insurance purposes are having an impact on small business costs. For PV system installers this has resulted in additional reporting requirements, combined with increased safety and equipment requirements for installation. The associated costs are proportionally higher for smaller systems and have increased overall system costs.

Table 6: Australian PV and System Standards- Existing and Under Development

Area	Standard No.	Title	Current Date of Amendment
Battery	AS4086.1	Secondary Batteries for use with Stand-alone power systems: Part 1 General Requirements	1993
Battery	AS4086.2	Secondary Batteries for use with Stand-alone power systems: Part 2 Installation and Maintenance	1997
General	AS/NZS3000	Wiring Rules	2000
General	AS3100	AS3100 Approval and test specification - General requirements for electrical equipment	2002
Genset	AS3010.1	Electrical Installations- Supply by Generating Set- Internal Combustion engine driven sets	1987
Grid	AS4777.1	Grid Connection of energy systems via inverters: Part 1 Installation Requirements	2002
Grid	AS4777.2	Grid Connection of energy systems via inverters: Part 2 Inverter Requirements	2002
Grid	AS4777.3	Grid Connection of energy systems via inverters: Part 3 Grid Protection Requirements	2002
System	AS1170.1	Minimum design loads on structures – Part 1 Dead and Live Loads and load combinations	1989
System	AS1170.2	Minimum design loads on structures – Part 2 Wind Loads	1989
System	AS1170.3	Minimum design loads on structures – Part 3 Snow Loads	1989
System	AS4509.1	Stand Alone Power Systems: Part 1 Safety Requirements	1999 Under revision
System	AS4509.2	Stand Alone Power Systems: Part 2 System Design Guidelines	2002
System	AS4509.3	Stand Alone Power Systems: Part 3 Installation and Maintenance	1999 Under revision
System	DR03389	Installation of Photovoltaic (PV) Arrays	Due July 2005
BOS Components	DR05919 AS/NZS61558-2-16-2	Safety of Power Transformers, Power Supply Units and Similar Products – Part 2.16.2: Particular requirements for portable inverters	Due late 2005
BOS Components		Safety of Power Transformers, Power Supply Units and Similar Products – Part 2.16.X Particular requirements for stand alone inverters	Under development
BOS Components		Stand Alone Systems Inverter Performance	At committee draft

5 Highlights and prospects

Installed PV capacity in Australia reached 52 MW in 2004, while production capacity increased to 40 MW. The off-grid market remains Australia's key market sector, however the grid market, including diesel grid, now represents 13% of the total installed capacity.

The PV industry released an Australian Photovoltaic Industry Roadmap in 2004, with industry targets and strategies for each market sector. Its Sunrise scenario envisages an installed capacity of 350 MW by 2010, achieved through more aggressive development of the grid market, as well as substantial PV uptake in the diesel grid market. The Roadmap will be used to coordinate industry development strategies and to promote PV to government and the wider community.

The Australian Government released an Energy White Paper which announced new funding for renewable energy R&D, as well as a major new Solar Cities initiative aimed at trials of high penetration PV and other demand side measures in urban areas. The White Paper also classified PV and Remote Area Power Systems as strategic technologies for Australia. However, it also announced removal of fuel excise from diesel used in stationary applications, a decision which will have significant impacts on the off-grid PV market.

- Details from industry of planned increases in PV module production capacity

Australian PV cell production is expected to increase to 50 MW during 2005.

- Any developments in technologies

A new pilot line producing Sliver cells for Origin Energy will begin operation in 2005.

- Long term targets for installed PV power capacity, or future energy scenarios.

The Australian PV Industry Roadmap has set a target of 350MW installed capacity by 2010, up from 52 MW in 2004. This will require significant increases in grid connected and off-grid non residential PV installations and associated supportive policy and development frameworks.

Annex A Method and accuracy of data

When preparing the **Trends** report, 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.

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

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

Annex B Background information on Australia

The following are indicative only. There are often large differences between States and electricity retailers and, for diesel prices, over the year.

1) retail electricity prices range from AUD 0.10-0.15 per kWh for households and AUD 0.05-0.10 for commercial customers, however, various standing charges also apply.

2) average household electricity consumption - 7000 kWh per year. This can be higher in areas where gas is not available.

3) typical metering arrangements and tariff structures for electricity customers – most residential consumers in Australia do not have interval meters, although they are being introduced progressively in some States. TOU tariffs are available, but most households have a flat tariff.

4) typical household income - AUD 50 000 per year

5) typical mortgage interest rate – 6.5%

6) voltage – 240 volts

7) The electricity sector has separate retail, distribution and transmission businesses. Some States have privatized sections of their industry, but most remain publicly owned. Each State has its own regulator, although a National regulator is planned.

8) price of diesel fuel: AUD 0.9-1.5 per litre

9) typical values of kWh / kW for PV systems in Australia: 1500-2000 kWh/kW per year.