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* *2005*

Prepared by

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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 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.

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.

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

Installations of PV in Australia grew at a steady rate of 15% over last year and totalled 8.3 MWp in 2005. The largest PV market, accounting for 3.4 MWp in 2005, is in off-grid systems for industrial, agricultural and telecommunications applications. Off-grid residential systems comprise the next largest market at 2.9 MWp, followed by grid connected (main grid and diesel grid) residential systems with 1.4 MWp. Australia has many small diesel grid systems in remote towns and 0.5 MWp of PV was connected in centralised systems to the main power stations, in addition to distributed systems connected via individual homes which receive power from diesel grids.

- Module and system prices

PV module prices remained steady in 2005 at around AUD 8 per Wp. Prices are largely set on the international market, but are influenced by exchange rates and local delivery costs. System prices vary by location and application but have also remained reasonably steady in 2005. Residential rooftop systems averaged AUD 12-14 per Wp and stand-alone systems for off grid applications AUD 19-22 per Wp, although system types and inclusions vary widely.

- PV production

Australia produced 35.5 MWp of crystalline silicon cells in 2005 using imported wafers. Most of these were for the export market. 6.7 MWp of modules were made locally, of which nearly 50% were exported. Imported modules made up an increasing share of local sales. 0.4 MWp of concentrating PV systems were also manufactured and installed in 2005. This technology continues to show promise, particularly in diesel grids.

- Budget support for PV

AUD 5 million was allocated by Commonwealth and State governments to PV related research and development, the largest portion for university based PV device research. A further AUD 21 million was spent on market stimulation programs, mainly capital cost rebates. Industry funded support for research, development, demonstration and commercialisation is estimated to be over AUD 5 million.

2 The implementation of PV systems

The PV power system market descried in this report is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40W or more. A PV system consists of modules, as well as a selection of inverters, batteries, installation and control components, depending on the application.

2.1 Applications of 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 and lighting. Significant markets also exist for off grid residential and commercial power supplies and increasingly for fuel saving and peak load reduction on community diesel grid systems. Some of this market is supported by government grants aimed at reducing diesel fuel use. PV installations connected to central grids continue to increase steadily, with the majority of installations taking advantage of government grant programs which currently contribute 20-25% of up front capital costs. 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 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 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	31 Dec 2005 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	18 768
off-grid non-domestic	5 760	6 865	8 080	9 380	11 520	13 320	15 080	16 360	17 060	19 170	22 740	26 060	29 640	33 073
grid-connected distributed		5	20	30	80	200	850	1 490	2 390	2 800	3 400	4 630	5 410	6 860
grid-connected centralized				20	20	320	630	650	650	650	850	1 350	1 350	1 880
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**	**60 580**

Note: Both distributed and centralized grid installations include systems in diesel grids

2.3 Major projects, demonstration and field test programmes

2.3.1 Australian Government 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;

1042 systems were installed in 2005, amounting to 1.553 MWp. 65% of customers, accounting for 73% of installed capacity, were on grid connected buildings and around AUD 4.2 million was allocated in rebates. Since the start of the programme in 2000, more than 6,700 systems, using 8.2 MWp of PV, have been installed and rebates of over AUD 35 million have been provided.

c) funding sources and cost sharing;

Australian Government funded, with administration by the State Governments. The programme commenced in 2000 and is currently funded until 2007. Householders are eligible for a rebate of 4 AUD/W capped at 4 000 AUD per residential system. Rebates will be reduced in stages to AUD 3,50/Wp over 2006-2007. Smaller rebates are also paid for extensions to an existing system. Community buildings attract an AUD 4/Wp rebate but have had a higher cap of AUD 8 000. This cap will be reduced to AUD 4 000 from 2006. As part of the Programme, the Australian Government has made available one million Australian dollars to fund projects by residential housing developers and display home builders. A rebate of AUD 3,50/Wp, reducing to AUD 3/Wp by end 2007, is available to developers in AUD 50 000 blocks.

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 300 systems have been installed on community buildings, including schools. System sizes increased slightly in 2005 with grid systems averaging 1.7 kWp, compared with the 6 year average of 1.5 kWp, and off-grid systems averaging 1.2 kWp, compared with a 6 year average of 1 kWp.

e) problems encountered and lessons learned;

The program has been instrumental in establishing a market for grid connected PV in Australia, but has had a stop-start nature almost since its inception. This market is not cost effective for most customers in Australia, since electricity prices are low, and so is likely to drop significantly if government support ceases. A long term support strategy is required, if a sustainable Australian grid market is to be developed.

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

At present the budget will be exhausted by 2007 after which the Government plans to link PV installations into the Solar Cities trials, which are expected to begin installations by that

time. This program will support only 4 cities and, although market based strategies for PV are expected to be developed, they are unlikely to provide market support across the country until the trials are well underway. Off-grid residential installations will also be impacted once the program ends, since support via the RRPGP (see below) is now only available in the Northern Territory and Western Australia and since diesel fuel excise is to be removed for stationary applications, making PV a more expensive option.

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 and fringe of 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, use direct diesel generation or are at the end of long grid lines.

b) size and main technical and economic data;

2.08 MWp of PV was installed under RRPGP in 2005, bringing the total installed capacity to 5.35 MWp under this programme, of which 0.81 MWp is installed in large utility run diesel grid systems. The latter includes 0.43 MWp of solar concentrating dishes commissioned in the NT, with an additional 0.29 MWp to be commissioned in early 2006. Although it is not PV specific, over 95% of small systems installed under the RRPGP include some PV. The overall programme has funds of around AUD 205 million allocated to it, of which around AUD 141 million had been allocated by end 2005. In addition, AUD 7.5 million has been allocated to industry support activities, including test facilities, standards development, training, feasibility studies and demonstration projects.

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 million has been made for the *Bushlight* 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;

A total of approximately AUD 16.7 million was paid towards PV based renewable energy systems during 2005. Around 69% of the systems installed in 2005 were for residential purposes and 31% for agricultural / industrial uses, including water pumping systems. Under the *Bushlight* programme, 80 communities have been through an energy planning process and 65 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 received very little or no funding, while others had significant funds. By end 2005, the only jurisdictions with significant funds remaining were Western Australia and the Northern Territory. Funding for Queensland was fully committed during 2005, due primarily to the popularity of the Renewable Energy Diesel Replacement Scheme sub-program. 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 States with reasonably sized off-grid PV markets the end of the programme is causing problems for local businesses, since customers have become accustomed to the subsidized prices. In addition, the removal of diesel fuel excise payments for stationary applications from 2006 will reduce diesel costs, thus reducing the cost effectiveness of PV for remote area power generation, although this may be offset by increases in fuel costs, if oil prices remain high.

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.

2.4 Highlights of R&D

2.4.1 Government R&D Programmes

PV and Remote Area Power Systems have been identified by the Australian Government as technologies of strategic importance for Australia and for which Australia has a clear technological advantage internationally. This is reflected in priorities for Government R&D funding and will also be boosted by new R&D programmes:

Renewable Energy Development Initiative (REDI) – launched in October 2005, this programme will provide AUD 100 million over seven years in the form of competitive grants to Australian industry to support early-stage commercialisation; research and development; technology diffusion and proof-of-concept activities in renewable energy technology. Projects are required to demonstrate strong commercial and emissions-reduction potential. Origin Energy received AUD 5 million in the first grant round to assist with commercialisation of its Sliver™ Cell PV technology.

The Low Emissions Technology and Abatement (LETA) initiative is an AUD 26,9 million measure to reduce greenhouse gas emissions over the longer term by supporting the identification and implementation of cost effective abatement opportunities and the uptake of small scale low emission technologies in business, industry and local communities. Support for renewables is provided via an industry development sub-programme and will be available to State and Territory Government agencies and renewable energy industry associations.

Advanced Electricity Storage Technologies, including batteries, electro-mechanical, thermal and chemical storage, will be supported via an AUD 20,4 million fund, as part of the government's push to overcome barriers to renewables and other intermittent energy sources. Expressions of interest were called in late 2005 and funding will be awarded in

2006. The aim is for Australian industry to demonstrate world-leading electricity storage technologies and develop creative solutions that will benefit both the electricity storage and renewable energy industries.

Australian Government annual funding for PV R&D, D (including market incentives) was about 25,5 million Australian dollars during 2005. Funding from the State governments for the same period was around 0,7 million Australian dollars, while funding is also available through various local governments.

2.4.2 University based 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 PV 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. Research into GaAs and DSC solar cells and nanoscale networks is also undertaken by other groups at the University of NSW.

The **Centre for Sustainable Energy Systems** at the Australian National University undertakes research into solar thermal and photovoltaic technologies including cell performance, thin films, efficiency and processing, 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 Centre continues in depth research and development of Sliver cells, concentrating on efficient and cost effective manufacturing processes and designs. Sliver modules with record efficiencies of 20% have been constructed.

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. Fundamental research into supramolecular assemblies, new materials for energy capture and DSC solar cells is also undertaken at Monash.

The **Institute for Sustainable Systems and Technologies**, University of South Australia, undertakes research into PV applications, including commuter cars.

Other university PV programs include:

- Murdoch University - low cost silicon production
- Flinders University - improved dye sensitised solar cells
- University of Queensland - semiconductor biopolymers, anti-reflection coatings
- Newcastle University – nanoscale polymer devices
- Sydney University – TiO2 nanostructures, flexible photovoltaics
- University of Western Australia – Tantalum-Silicon cells
- Adelaide University – Sustainable development strategies
- Melbourne University – organic optoelectronic materals
- University of Wollongong – TiO2 coatings, PV water purification
- Queensland University of Technology – DSC solar cells, carbon nanotubes
- Curtin University – hybrid mini-grids
- University of Technology, Sydney – PV water pumps.

2.4.3 Industry based R&D

BP Solar is the largest commercial PV manufacturer in Australia and continues its development of automated production equipment, improved cell and module manufacture and systems development. It is also active in the development of safe and efficient installation systems and procedures including new frame types, mounting systems, integrated solar water heaters, smart communications and modular pre-designed packaged systems.

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

Dyesol is the industrial research hub for the world's network of researchers into Dye Solar Cell (DSC) technology. Dyesol researches, develops and manufactures DSC materials and components as well as providing research and manufacturing equipment. Through Dyesol's website and online store, the DSC research community has access to the widest available range of DSC components and materials including nanoparticulate pastes and dyes, as well as equipment specifically designed to research and manufacture DSC. Formed in Dec 2004, Dyesol raised seed funds, transferred the key staff and acquired a suite of patents, pilot manufacturing plant and analytical laboratory from the leading Australian DSC team at Sustainable Technologies International, and from Swiss company Greatcell Solar. Dyesol listed on the ASX on 31 August 2005 following an Initial Public Offering (IPO) and is regarded as one of the most successful floats of the year, having traded consistently above its listing price and currently trading at several times listing price.

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 trial 10 W and 70 W modules have been produced. More extensive manufacture is anticipated by end 2006. The pilot plant can be expanded to approximately 25 MW p.a. capacity if pilot production is successful.

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.

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.

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

Federal and State/Territory government budgets for PV related R&D and Market development are shown in Table 2. The bulk of Federal R&D funding is via Australian Research Council grants, which include Centres of Excellence, fellowships and various different types of research grant. Photovoltaics research potentially falls within a number of

the Government high priority research areas: environmental sustainability, frontier technology and safety of critical infrastructure. Several State governments have their own research funding support programs, usually administered via public calls. Market based support includes the PVRP and RRGPG programs described earlier. Some State governments provide additional funds to projects in their jurisdictions.

Table 2: Public budgets for R&D, demonstration/field test programmes and market incentives in Australia 2005 (AUD million).

	R & D	Demo/Field test	Market
National/federal	4.589		20.870
State/regional	0.445		0.285
Total	5.034		21.155

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Cell and Module manufacturing capacity and 2005 production are given in Table 3. There is no wafer manufacture in Australia.

Table 3: Production and production capacity information for the year 2005 for each Australian 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	2.91	0.38		50	10	
BP Solar	mc-Si	32.62	6.33				
Concentrators							
Solar Systems	sc-Si			0.43			5
TOTALS		**35.54**	**6.72**	**0.43**	**50**	**10**	**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.

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

BP Solar: PV cells processed in Australia are made from imported wafers.

c) An indication of the amount of production exported.

BP Solar: Cell exports for 2005 were 28.8 MW, 81% of total production. Module exports were 3.2 MW, 48% 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 2005 but not yet in production.

Origin Energy has installed a 5 MW pilot line for production of Sliver™ cells, which will begin production in 2006.

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 50 MW, depending on wafer availability, with the major portion of product exported.

Origin Energy's Sliver™ cells and modules will enter the market in late 2006 with trial product.

Table 4 shows that module retail prices in current Australian dollars over the past 11 years has remained essentially constant indicating that real prices have fallen more or less in line with inflation.

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

Year	1994	1996	1998	2000	2002	2004	2005
Module price(s): Typical	7	8	8	8	7	8	8

Notes: These prices are as sold by module suppliers, but do not include system and installation costs. Module prices reflect international market prices, local manufacturing and distribution costs and exchange rates.

3.3 Manufacturers and suppliers of other components and systems

Balance of system component manufacture and supply is a critical part of the PV system value chain. There are a number of Australian manufacturers of inverters, battery charge controllers and inverter/chargers, particularly catering for the off-grid system market, including Selectronics, Plasmatronics, Latronics and Solar Energy Australia. Some of these manufacturers also supply inverters suitable for grid interconnection, although the industry is constantly looking for new ideas, improved products and reduced prices. Inverter prices range from AUD 1-2 per W.

Although some battery components are made in Australia, only a few manufacture complete solar batteries. These include Exide's Energystore products and Battery Energy's Suncycle range. Battery Energy, in conjunction with the Commonwealth Scientific & Industrial Research Organisation (CSIRO), has also developed a new solar gel battery, Sungel.

There is an increased interest in the use of trackers for off-grid pumping and power supply systems. Passive gas and electronic controlled trackers are used and expect to increase power output by up to 40% compared with non-tracked systems.

As the PV component market becomes more global, expertise is increasingly being built up at the systems design level. There a several hundred companies around Australia which distribute and install solar systems. A number of these have now become significantly sized systems houses, providing products and systems for a range of applications in Australia and worldwide. These include:

Solar Sales, a Western Australian based company, celebrates its 25th year in the renewable energy industry in 2006. The company designs, supplies and installs

predominately in the industrial and commercial sector, with a growing distribution network both in Australia and key overseas markets.

Victorian based **Going Solar** has been operating since 1978 and has grown to become a Renewable Energy and Sustainable Living specialist company with Retail, Wholesale, Projects, Environmental and Consulting Divisions.

In South Australia, the **Solar Shop** designs and installs off-grid and grid connected renewable energy systems of all types.

Conergy, one of the largest international solar systems houses has recently established an office in Australia, particularly with the aim of developing the local grid market, but also with an interest in solar water heaters and off-grid systems.

Bushlight is an organisation established to provide sustainable energy services to remote aboriginal communities. It has developed educational materials, technical solutions, customer interactive displays and energy management units relevant to its client base. One of its recent developments is a modular, scalable renewable energy power supply system consisting of an equipment enclosure that houses solar regulators, an inverter and all electrical control equipment in a high quality, dust free, temperature controlled cabinet. The enclosures have been tested to ensure they maintain acceptable temperatures under all possible operating conditions. The Bushlight systems can supply loads between 2 and 32 kWh per day, with provision for a diesel generator to cater for higher loads if required. Bushlight has also developed an energy management unit (EMU) for use in conjunction with the modular renewable energy systems. EMUs are installed at each residence in a community and place a daily limit on the amount of energy each house can draw from the central system. This protects the system from overuse by any one house and ensures supply is maintained for the whole community. Once the daily limit is reached, power is cut to all but essential loads (refrigeration, lights and smoke detectors). Other loads are reconnected once the system is reset at midday each day.

Grundfos Australia is trialling its SQFlex solar powered submersible well pump in outback Australia as a low maintenance, OH&S friendly, robust alternative to traditional windmills.

Mono Pumps continues an extensive R&D program in developing complete PV pumping systems aimed primarily at the agricultural market for stock watering. Development focuses on improving reliability, system efficiency and addition of 'value-add' options for pumping systems.

3.4 System prices

Table 5 provides typical turnkey prices (excluding Goods and Services Tax) per Wp for 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 also not included, although these are difficult to separate from system costs in some instances.

Trends in the turnkey prices of small off-grid systems are provided in Table 5a and of residential grid connected systems in Table 5b.

Table 5: Turnkey Prices of Typical Applications

Category/Size	Typical applications in your country and brief details	Current prices per W (to one decimal point)
OFF-GRID Up to 1 kW		22
OFF-GRID >1 kW		19
GRID-CONNECTED Specific case	For example: 1-3 kW roof-mounted system, if available	12-14
GRID-CONNECTED Up to 10 kW		10-12
GRID-CONNECTED >10 kW		10

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

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Price /Wp:	**24**		**22**		**30**	**30**	**30**	**22**	**22**	**20**	**20**	**20**	**20**

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

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Price /Wp:					**11**	**12**	**12**	**14**	**14**	**13**	**10**	**12**	**12**

3.5 Labour places

The following provides an estimate of labour places in the key sectors involved with PV. Data is from key organisations and from available reports.

a) Research and development (not including companies); 100

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

3.6 Business value

Table 6 provides an estimate of the value of PV business in Australia in 2005. As the use of imported components increase, the net value to Australia of the PV business is being reduced.

Table 6: Value of PV business

Sub-market	**Capacity installed *in 2005* (kW)**	**Price per W**	**Value**	**Totals**
			AUD million	**AUD million**
Off-grid domestic	**2870**	**19**	*54.5*	
Off-grid non-domestic	**3430**	**22**	*75.5*	
Grid-connected distributed	**1450**	**12**	*17.4*	
Grid-connected centralized	**530**	**10**	*5.3*	
				153
Export of PV products (cells, modules)				**132**
Import of PV products (wafers, modules, inverters)				**-118**
Value of PV business				**167**

Note: The value of exports may be higher, depending on BOS components and services provided from Australia.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

a) Solar Cities

The Australian Government's Solar Cities initiative has stimulated interest in PV, and sustainable energy options more generally, from sectors which have not previously been especially active in the area, such as financial services and local government or, in the case of utilities, which have been active in the past but not been able to pursue useful deployment recently. Consortia were formed to bid for the Solar City funding and comprise a mix of PV companies, banks, local governments, utilities and research groups. The Commonwealth Government is currently evaluating 11 bids from which 4 Solar Cities will be chosen. They will share AUD75 million over 7 years and are expected to include new PV deployment strategies. It is hoped that the interest generated and the knowledge of PV which has been developed within the Consortia will remain even with the unsuccessful bids, thus facilitating new PV deployment strategies in the long term.

b) Utility perception of PV

The rapid growth in electricity demand, and particularly in peak load demand, is dominating utility planning in Australia at present. Increased air conditioner use is the major contributor to both these trends, but particularly to the increase in peak demand. These developments have an indirect bearing on utility attitudes to PV. At substations where PV can be shown to generate during times of peak demand, there is likely to be utility interest. Nevertheless, PV remains a high cost option and there has been no discussion so far on possible utility incentives for PV installation.

At the same time, plans are underway for a national energy regulator to replace the 7 State and Territory regulators. This would encourage more consistent approaches to energy sector regulation in future, and hence to standardisation of procedures, but may not see any direct benefits for PV.

Plans are also underway to progressively roll out interval meters across all customer groups. This would allow utilities to introduce time of use tariffs which may place a higher value on daytime power generation. At present PV's daytime generation profile is not rewarded in the market. Whether or not net metering of small PV systems would continue under time of use tariffs is uncertain. As competition increases in retail markets and margins reduce, some utilities are already removing net metering arrangements and reducing the energy buy-back rates for PV generated in excess of customer demand. With restrictions placed by energy regulators on electricity tariff increases, discretionary expenditure on options such as PV is likely to reduce with time.

4.2 Indirect policy issues

The following summarises policy initiatives which may influence the implementation of PV power systems in Australia:

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

The current tight world market for PV, caused in part by the large demand from Germany, is making it increasingly difficult for Australian manufacturers and distributors to source PV

wafers and modules, since the local market is very small. This situation may worsen in 2006, but will hopefully improve after that as silicon supplies improve and as new manufacture begins from the Origin Sliver cell plant.

Ambitious PV programs in countries around Australia, including Japan, China, India, Malaysia, provide a ready market for Australian technology, products and expertise, even though the local market remains small.

b) the introduction of any favourable environmental regulations;

The Victorian State Government is proposing to introduce a State based mandatory renewable energy target, to extend the current Commonwealth government scheme which is now essentially fully committed. It is difficult to know at this stage whether or not PV would benefit from such a scheme. The current MRET has not been a particularly strong driver for PV. Nevertheless, increased utility uptake of renewables, and the improved public awareness which accompanies this, provides benefits to all technology groups.

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

The State governments are currently exploring the possibility of introducing an emissions trading scheme at State level and are preparing a discussion paper on the structural options available. Of particular interest would be schemes which built on the existing greenhouse gas abatement scheme already operating in NSW.

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

Australia has joined with the USA, Japan, South Korea, India and China in an Asia-Pacific Partnership on Clean Development and Climate (AP6) which is to develop and demonstrate a range of strategies to improve energy security, reduce local air pollution and reduce greenhouse gas emissions in the region. The 6 countries are responsible for approximately half the world's GDP and greenhouse emissions and have just under half the world's population. The Partnership will focus on expanding investment and trade in cleaner energy technologies, goods and services in key market sectors. The Partners have approved eight public-private sector task forces covering: (1) cleaner use of fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminium; (6) cement; (7) coal mining; and (8) buildings and appliances. Details are not yet available but it is understood that opportunities for demonstration of PV and other renewables will be explored.

Australia also has a bilateral climate change partnership with China which includes improving Australian renewable energy business opportunities in China and developing renewable energy training programmes.

4.3 Standards and codes

4.3.1 AS/NZS 5033:2005 "Installation of photovoltaic (PV) arrays" (May 2005)

This Standard was produced by Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment with the assistance of the Australian Greenhouse Office (AGO) and the University of NSW.

The objective of this Standard is to provide guidance for installers of photovoltaic arrays. The standard includes comprehensive installation, safety, wiring, earthing, general construction requirements and protection requirements for PV arrays, including a set of informative appendices which include an extensive set of case studies giving examples of how to achieve compliance with the standard for a number of example systems.

4.3.2 AS4777 -2005 "Grid connection of energy systems via inverters"

This standard was revised and re-published in May 2005. The standard is in three parts:

Part 1- Installation requirements

Part 2- Inverter requirements

Part 3- Grid protection requirements

4.3.3 Revision of AS 4509 "Stand Alone Power Systems" Parts 1-3

Australian Standards Committee EL42 is currently reviewing and revising this standard. It covers design, installation and maintenance of stand alone power systems. The standard is being carefully aligned with the Australian Wiring rules (AS/NZS 3000) and a new revision of AS/NZS 3000 will cross reference the new revised AS/NZS 4509.

4.3.4 ResLab Achieves NATA Accreditation

ResLab, the renewable energy systems testing laboratory at Murdoch University's Research Institute for Sustainable Energy (RISE), has now been accredited by the National Association of Testing Authorities, Australia (NATA) for performance testing of inverters.

The NATA accreditation is part of ResLab's program to support Australia's renewable energy industry. Obtaining the accreditation has involved the development of a quality system that complies with the requirements of AS/IEC/ISO17025-1999 the accreditation standard. This has included the development of procedures and techniques, staff training and the documentation of many of the laboratories activities. Although this initial accreditation is for inverters, ResLab is aiming to expand this accreditation to other products and for testing to international standards. Typically, these accreditations provide industry with the ability to improve their products and make them more competitive, thus providing access to new national and international markets.

ResLab is committed to providing independent high quality testing services to the renewable energy industry and specialises in testing inverters, remote area power supply (RAPS) systems and balance of system (BOS) components, solar home systems and battery charge controllers for solar photovoltaic (PV) systems. The laboratory is actively involved in standards development for solar photovoltaic systems and wind turbines, aimed at improving the reliability of renewable energy systems.

ResLab was established in 2003 and is supported by funding provided by the Australian Greenhouse Office (AGO through the Renewable Remote Power Generation Program (RRPGP), which is administered in Western Australia by the Office of Energy, and the Renewable Energy Commercialisation Program.

5 Highlights and prospects

a) Details from industry of planned increases in PV module production capacity

BP Solar is the major PV manufacturer in Australia and expects to maintain its current production capacity of 50 MW for the immediate future.

Origin Energy expects to begin pilot production of its Sliver cell technology and will consider large scale manufacture in future. In 2005 it released prototype 40, 70 and 140 W modules and received an AUD 5 million grant from the Commonwealth Governments Renewable Energy Development Initiative to continue its commercialisation trials.

b) Any developments in technologies

Australia remains a leader in research and development of PV technologies. In 2006, a crystalline thin film technology developed in Australia is to enter commercial production by CSG Solar in Germany and the Sliver cell technology is to enter pilot production by Origin Energy in Adelaide. Patents for a number of new and improved technologies and production processes continue to be developed and licensed to Australian and international companies.

Chinese based PV manufacturer, Suntech Power, which is a joint Chinese - Australian company, continues to improve its production processes in cooperation with Australian researchers. Suntech Power floated on the New York stock exchange in December 2005 and its stock price is currently about twice the listing price. The company has been awarded the contract to supply 130 kW of PV for the Beijing Olympic Stadium.

With a weak local market, Australian companies and researchers are likely to continue to look internationally for commercialisation of their technologies.

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

In 2005 the Australian Bureau of Agricultural and Resource Economics released its long term projections of energy demand and supply for Australia to 2030. It forecasts overall energy demand growing at 2.1% per annum and renewable electricity by 2.4% per year, although largely from biomass and wind. Despite Australia's vast solar resources and world leading technology, PV remains an expensive option when viewed purely on the basis of kWh produced. However, it is hoped that the Solar Cities trials and work being done by the PV industry will better document the values of daytime generation, distributed generation potential, rapid deployment, consumer acceptance and low security risk, compared with carbon sequestration and storage, nuclear or other low carbon options being considered in Australia.

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.

Most data is gathered directly from industry, government agencies and research groups. Other information is taken from annual reports and other publications.

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).

Data in Table 1 is probably accurate to ±100kW.

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

- Businesses are reluctant to disclose information on sales, costs or prices.
- It is difficult to separate out sales, which may be on a long term project basis, from installations actually occurring in any one year.
- It is difficult to separate out component and system costs from overall project costs, since tenders may be on the latter basis and include provision for transport, installation and after sales service.

Annex B Country information

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

1) retail electricity prices vary between retailers and also have different fixed charges and step rates. Typical flat tariffs range from AUD 0.12-0.17 per kWh for households, with off-peak hot water tariffs of around AUD 0.05 per kWh also available. For commercial customers, time of use tariffs are more common and range from around AUD 0.05 to 0.10 to 0.20 per kWh for off-peak, shoulder and peak times. However, various standing charges also apply and increasing numbers of customers are on private contracts. The latter may include packages with electricity, gas and other services provided.
2) average household electricity consumption - 7000 kWh per year. This can be higher in areas where gas is not available and may be twice this level in households with air conditioning.
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. TOU tariffs are available, but most households have a flat tariff. Net metering for PV systems is available from some retailers.
4) average household income - AUD 26 500 per year
5) typical mortgage interest rate – 7%
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 1.2-1.6 per litre
9) typical values of kWh / kW for PV systems in Australia: 1000-2000 kWh/kW per year depending on location.