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 *Australia* *2007*

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June 2008

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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 IEA work.

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 21 participating countries are Australia, Austria, Canada, Denmark, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, The United Kingdom and The United States of America. The European Commission and the European Photovoltaic Industry Association are also members.

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. Twelve tasks have been established and currently seven are active. Information about these tasks can be found on the public website www.iea-pvps.org.

The objective of Task 1 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. In parallel, National Survey Reports 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.

ii Definitions, Symbols and Abbreviations

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

Demonstration Programme: Programme to demonstrate photovoltaic (PV) electricity production to various potential users/owners.

Field Test Programme: Programme to test the performance (eg yield and reliability) of photovoltaic (PV) systems/components in real conditions.

Final annual yield: Total photovoltaic (PV) electricity delivered to the load during the year per kW of rated PV power installed.

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

Grid-connected distributed PV system: System installed to provide electricity 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 customer (demand) side of the electricity meter, on public and commercial buildings, or simply in the built environment. They may be specifically designed for support of the utility distribution grid.

Market deployment initiative: Set of means to encourage the market deployment of PV through the use of market instruments such as green pricing, feed-in tariffs, tax credits, capital subsidies etc. These may be implemented by government, the finance industry, utilities, etc.

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

Off-grid non-domestic PV 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 a 'stand-alone PV system'.

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 rated PV power.

Photovoltaic (PV) module manufacturer: An organisation carrying out the encapsulation of PV cells in the process of the production of PV modules.

Photovoltaic (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').

Photovoltaic (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 (if any) and all installation and control components with a PV power capacity of 40 W or more.

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

Rated power: Available power delivered by a PV module or array under standard test conditions (STC), written as W.

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, transport to site and other costs incurred for reasons not directly related to the PV system are excluded.

1 Executive summary

- Installed PV power

A total of 12,2 MW of PV was installed in Australia in 2007, 2 MW more than last year. This was largely the result of higher grants for residential systems. Grid systems accounted for 50% of installations and now account for 18% of installed capacity.

- Costs & prices

PV system costs declined for the first time in several years, with module costs averaging AUD8/Wp, residential grid systems averaging AUD12/Wp and off-grid systems AUD22/Wp.

- PV production

PV production in Australia remained steady at 36 MW of cells and 9 MW of modules produced by BP Solar.

- Public budgets for PV.

AUD 7,44 million was spent on PV research and development by State and Federal Governments in 2007, up slightly from last year. However, there was a significant increase in spending on demonstration, AUD 3,72 million, while expenditure on market stimulation doubled to AUD 53,53 million.

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 Application of PV systems

The largest installed capacity of PV in Australia is 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 through the Renewable Remote Power Generation Program (RRPGP) which provides 50% of system costs with the aim of reducing diesel fuel use. There is also a market for recreational PV applications, for caravans, boats and off-road vehicles.

The market for PV installations connected to central grids continues to increase, with the majority of installations taking advantage of a government grant program (the PV Rebate Program, now called the Solar Homes and Communities Plan) which can contribute up to 60% of up front capital costs. The main applications are rooftop systems for private residences, schools and community buildings. Commercial and light industry sector interest is also growing, with support available to selected projects through the Solar Cities Program. All PV systems can benefit from the Renewable Energy Target.

2.2 Total photovoltaic power installed

The PV power installed in during 2007 is shown in Table 1.

Table 1 - The PV power installed in 5 sub-markets in Australia during 2007.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	diesel grids	Total
PV power installed in 2007 (kW)	3 755	2080	6 030	250	75	12 190

The total cumulative installed PV power for each sub-market on the 31 December of each year from 1992 onwards is shown in Table 2.

Table 2 - The cumulative installed PV power in 5 sub-markets - Australia 1992-2007

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	31 Dec 2006 kWp	31 Dec 2007 kWp
off-grid domestic[1]	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	22 138	25 893
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	36 653	38 733
grid-connected distributed		5	20	30	80	200	850	1 490	2 390	2 800	3 400	4 630	5 410	6 860	9 005	15 035
grid-connected centralized[2]				20	20	210	520	540	540	540	540	660	660	760	760	1 010
diesel grids						110	110	110	110	110	310	690	690	1 120	1 745	1 820
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**	**70 300**	**82 490**

Notes

1 including recreational market – caravans, off-road vehicles, boats, holiday homes

2 systems operating as power stations for multiple customers

Key PV market drivers in 2007

- **policy initiatives**

  In November 2007 a new Labor Government was elected in Australia. It has ratified the Kyoto protocol, has pledged to increase the Renewable Energy Target from its current level of 9,500 GWh by 2010 to 45,000 GWh by 2020, to substantially increase the Solar Schools program and to add two new Solar Cities. Most of these initiatives have not yet begun, although some details will be provided later in the report. The following therefore describes existing activities which were impacting on the PV market during 2007.

  The most important new driver for the PV market in 2007 was a doubling of the residential grant from the PV Rebate Program from AUD4000 to AUD8000 for the first kW installed. This was introduced in May and resulted in significant market growth for the second half of the year, the establishment of many new businesses and a marked increase in PV installer accreditation. AUD150 million was allocated to the program over 5 years, including funding for school and community PV systems, which were eligible to apply for 50% of system costs for up to 2 kW. System installations increased from an average of 300 per month to over 1000, with the higher grant and other incentives resulting in payback times of around 20 years or less, and hence attracting a much broader customer base. A total of 4,6 MW of PV was installed under the PV Rebate Program in 2007, up from 1,8 MW last year. In 2008 the government introduced a means test to reduce demand and keep within its budget limits.

  The second important policy driver was the increased interest in feed-in tariffs. The Northern Territory Power and Water Authority, as part of the Alice Springs Solar City, is offering an AUD 0,45/kWh tariff for all electricity generated from the 225 homes being supported through the program. This is about twice the daytime electricity tariff and the buyback is capped at AUD5 per day (effectively limiting the tariff to 2 kW systems). With the grants and tariffs, system costs are expected to be repaid within 10 years. The South Australian and Queensland governments announced new net export feed-in tariffs of AUD 0,44 and the Victorian government AUD 0,66. The Australian Capital Territory is considering a total export model set at 3.88 X standard tariffs, with the aim of paying back system costs within 10 years. The national government has indicated an interest in a uniform PV feed-in tariff across Australia and is undertaking a review of State, utility and international programs.

- **promotional activities (commercial and non-commercial)**

  The increased PV rebate stimulated competition in the market, as well as new marketing ideas. The latter included bulk purchase options offering 1 kW systems for AUD1000 or less, if 50 or more homes were involved.

  A range of promotional activities, including energy fairs, mailouts and internet based special offers, have been rolled out by the various Solar Cities (see below). This has greatly increased awareness of PV in the target communities. This interest will be reinforced over coming years as an increasing number of high profile community PV systems, as well as more residential systems, are installed in the Solar Cities.

- **other new drivers**

  With the high rebates, PV began to enter the mainstream retail market, with large hardware stores, builders, as well as solar shops and local governments selling or promoting PV. This will increase public awareness and also improve competition over time. It is also improving the ease of purchase as well as the range of system and financing packages available. Several companies offer combined solar water heating and PV packages.

  There has been a noticeable increase in the number of PV systems installed on commercial and public buildings as part of corporate or government green building or greenhouse gas reduction programs. This trend is expected to continue as Solar City installations begin, building energy standards improve and energy prices increase due to international resource prices, infrastructure upgrades and emissions trading.

- **electricity utility and public stakeholder developments**

  Several electricity utilities offered feed-in tariffs, most net export, but one offers a gross generation feed-in tariff for a selected customer base.

  In line with government mandates, electricity utilities are beginning to change over to electronic 'interval' meters, which in turn allow for the introduction of time of use tariffs. The relevance of this for PV depends on the tariff structure. For instance, Energy Australia offers a feed-in tariff for PV systems of AUD 0,28. However, this tariff applies only between 2pm and 8pm, which would favour west facing arrays. In Sydney, a west facing array would produce around 25% less electricity over the year than a north facing array.

2.3 PV implementation highlights, major projects, demonstration and field test programmes

- **Major projects**

A 210 module PV noise barrier has been installed along a new section of the Tullamarine Freeway leading to Melbourne Airport. The total project cost was AUD 700,000, with assistance provided by Sustainability Victoria.

The system consists of a 24.4 kWp PV power system forming the upper one metre of a 500 metre long and 4m high sound barrier on the Tullamarine-Calder Freeway Interchange. This project is the first application in Australia of Building Integrated PV technology as part of a required element (sound barrier wall) for a road construction project. The electricity generated by the PV system will in part supply power to the freeway lighting and traffic management electrical circuits.

Based on the historical solar radiation data for Melbourne, the electrical characteristics of the PV panels, assumed electrical circuit losses, and shading due to Freeway gantries, the average energy generation from this project is expected to be at least 18.75 MWh/year, with greenhouse pollution abatement of 26 tonnes CO2-e per year.

The PV system uses five inverters to provide single phase 235V AC electricity. A switchboard then gathers the three single line phases together, for a combined three phase line voltage of 410VAC. A two way power meter measures the PV system power exported to the lighting circuit. The 410VAC circuit is then connected through a transformer into the nearby electricity distribution network.

- **demonstration and field test programmes**

The Solar Cities Program includes funding and promotion of energy efficiency and solar options (PV and solar water heating). Residential PV systems are funded through the PV Rebate Program while separate funding is available for larger systems on community, commercial or industrial premises. The aim is to test a variety of marketing strategies and tariff structures which support the uptake of energy efficiency and solar and can be used in the wider Australian community in future. AUD 75 million was allocated to the Program from the Commonwealth Government, for 5 Cities. The new government has indicated support for another two. State Governments, local utilities and other businesses are also involved so that the program is expected to generate wide community interest.

The Alice Springs Desert Knowledge Cooperative Research Centre, which is involved with the Alice Springs Solar City, is to build a solar demonstration and test facility at its Desert Knowledge Precinct.

- **market stimulation programmes**

The two main market stimulation programs in 2007 were the PV Rebate Program, described above, and the Renewable Remote Power Generation Program (RRPGP). Additional funding under the Residential and Medium Scale sub-program of RRPGP was allocated from July 2007 to States which had exhausted or never had RRPGP funding. A total of 1,37 MW of PV was installed under RRPGP in 2007. The Bushlight sub-program has now installed more than 100 sustainable energy systems for remote aboriginal communities. A recent maintenance survey of all systems found reliability to be 99.5%. More than 50% of communities now use no diesel at all and system costs have decreased to around AUD15/Wp. A long term maintenance and monitoring program is now being introduced and training courses and educational resources have been developed with funding through the Low Energy Technology and Abatement program. Bushlight has been awarded an Engineers Australia National Engineering Excellence Award for its work.

The Solar Cities Program is gathering pace and will provide more stimulus in the coming years, along with the Solar Schools and other programs introduced by Commonwealth and State governments.

- **discussion on the strengths and weaknesses of the above**

The Australian PV market is now heavily dependent on grant based support. This leaves it vulnerable to government election and budget cycles which have resulted in constant changes over the past decade. Such uncertainty makes it very difficult for businesses to invest in product development, facilities, supply chains and training, all of which are essential for a robust market in future.

The Solar Cities Program, with its investment in community information, demonstration and new approaches to energy service provision, may see longer term benefits, although the current low electricity prices in Australia will continue to provide a challenge for grid connected PV over the next decade. Rapidly rising diesel prices will, however, continue to improve the cost effectiveness of PV in off-grid and diesel grid applications and this market is likely to strengthen regardless of grant support.

The increased Renewable Energy Target is providing stimulus to larger scale renewable systems, as well as to solar water heating, but has not been a large driver of PV to date. However, as the need for new renewable generators continues to grow to meet the significantly higher new target, and as PV prices are reduced, the mechanism may drive PV installations. The new Australian Government has indicated an interest in standardised feed-in tariffs for PV across all States. If well structured, such a support mechanism may provide the long term certainty needed by the PV industry. However, at present there is no indication that a gross feed-in tariff for PV will be implemented.

2.4 Highlights of R&D

Photovoltaics research and development is undertaken across a range of university, government and industry facilities. University research groups largely undertake fundamental device research, while industry-based and collaborative research involves PV manufacturing processes and PV systems. In 2007, government funding of AUD 7.4 M was provided for research at universities, research institutes and industry. The following describes some of the largest research programmes.

University and Research Centre Activities

The Photovoltaics Centre of Excellence, University of NSW undertakes research in three interlinked strands aimed at near-term "first-generation" product based on silicon wafers, medium-term "second-generation" thin-film cell technology and long-term "third-generation" solar cells with both high-efficiency and thin-film.

The Centre for Sustainable Energy Systems, 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 PV-thermal systems.

Murdoch University has an amorphous silicon research group, investigating cell designs which improve performance. New cell designs, using a combination of nanocrystalline and amorphous silicon alloys are being developed and improved methods of producing solar grade silicon directly from metallurgical grade material are being investigated.

Murdoch University also hosts the *Research Institute for Sustainable Energy (RISE)*, which in turn runs *ResLab*, a renewable energy test and standards centre. RISE is actively involved in PV module testing, PV based remote area power supply system modelling and development and PV standards development and verification.

University of Melbourne, with partners Monash University, Securency, BP Solar, Merck, Blue Scope Steel, and NanoVic, is undertaking research into organic "plastic" PV cells with the possibility of producing flexible solar cells, or coatings that function as sunlight harvesting paints on roofs or as an integral part of fabrics. The *Universities of Wollongong*, *Sydney* and the *Queensland University of Technology* all host research into aspects of organic and dye sensitised solar cells.

The Commonwealth Scientific and Industrial Research Organisation has a growing research programme in organic photovoltaics, with expertise in synthesis of light-harvesting molecular materials, organic device fabrication and characterisation of photovoltaic performance. It is working in collaboration with the Melbourne University based team described above as well as with international partners as part of the International Consortium for Organic Solar Cells.

Curtin University and the *University of Tasmania* undertake PV systems research, focussing on central and diesel grid integration.

Industry Research and Commercialisation Activities

Origin Energy continued its development of SLIVER technology, based on initial research at ANU and has built its research team to over 50. The 75W Sliver panel produced on the pilot manufacturing line at Regency Park in South Australia was IEC certified by TUV in Germany. In-house testing has demonstrated the robustness of the unique module architecture with test panels now having completed thousands of hours of various tests including thermal cycling and damp heat. Through 2008 the development focus will be on refining the manufacturing processes for them to be ready for large-scale implementation.

BP Solar received funding from the Renewable Energy Development Initiative for three engineering developments to the existing cell manufacturing processes. These are expected to result in significant yield increases from available silicon, which will reduce manufacturing costs, increase competitiveness for the Australian BP Solar business and make more efficient use of resources.

Solar Systems continues development of its PV concentrator technology, focussing on higher efficiencies, better mirror technology, reduced losses, improved manufacturing processes, operational reliability and control, and data acquisition during operation. Silicon-based cells have been replaced by multi-junction III-V photovoltaic cells, increasing output by more than 50%. The company is now developing technology for a 142 MW heliostat PV system to be installed in 2009.

CSG Solar continues research at its Botany laboratories in Sydney on Crystalline Silicon on Glass, a thin film PV technology based on initial research form the University of NSW, which is now manufactured 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, including nanoparticulate pastes and dyes, as well as equipment specifically designed to research and manufacture DSC.

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

Table 3 provides figures for 2007 on budgets from the State and Federal governments for R&D, demonstration/field test programmes and market incentives. Funding for demonstration and research was higher than in 2006, while expenditure on market incentives doubled from 2006, due to the higher PV rebate and corresponding higher uptake, as well as increased PV expenditure through the Remote Renewable Power Generation Program.

Table 3 – 2007 Australian Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test	Market
National/federal	6,91	3,58	53,53
State/regional	0,53	0,14	
Total	**7,44**	**3,72**	**53,53**

3 Industry and growth

3.1 Production of photovoltaic cells and modules

There is only one module manufacturer in Australia – BP Solar. Solar Systems manufactures concentrator PV systems using imported cells, but is in the process of setting up cell manufacture in Australia. BP Solar produces its own cells from imported wafers. 75% of cells produced at the BP Solar Sydney plant are exported and 52% of modules. In 2007, standardisation of products continued and larger kit systems were marketed. Improved anti-reflect coatings on glass were introduced.

Table 4 – 2007 Production and production capacity information for Australian manufacturers

Cell/Module manufacturer	**Technology**	**Total production (MW)** Cell	Module	**Annual maximum production capacity (MW)** Cell	Module
Silicon wafer based manufacturers					
BP Solar	c-Si mc-Si	36	9	50	10
TOTALS		**36**	**9**	**50**	**10**

* using imported cells

Table 5 - Typical module prices (excl GST) 1992-2007 (Current AUD)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Typical module price(s)	9	7	8	8	7	8	8	8	8	7	7	8	8	8.5	8
Best (minimum) price														7.5	7

3.2 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain.

- **PV inverters (for grid-connection and stand-alone systems) and their typical prices**

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. Inverter prices typically range from AUD 0.5 – 1.5 per W.

- **Storage batteries**

Although some battery components are made in Australia, only a few companies 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.

3.3 System prices

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

With increased competition in the market, and increase availability of modules from new Chinese manufacturers, prices have fallen slightly in 2007, with some retailers offering small grid systems at prices as low as AUD9/Wp.

Table 6 - Turnkey Prices of Typical PV Applications in Australia in 2007 (excl GST)

Category/Size	Typical applications and brief details	Current prices per W (typical) AUD
OFF-GRID Up to 1 kW	Water pumps, telecommunications, cathodic protection	20-25
OFF-GRID >1 kW	PV or hybrid PV/diesel power systems, including household power supplies and Bushlight community systems	18-23
GRID-CONNECTED 1-3 kW roof-mounted	1-3 kW roof-mounted systems (modules, roof mounting kit, wiring, inverter)	10-12
GRID-CONNECTED (distributed) Up to 10 kW	Commercial and government buildings	10
GRID-CONNECTED (distributed) >10 kW		10
GRID – CONNECTED (centralized)	Large rooftop or stand-alone systems with dedicated substation	8

Table 7a: 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	2006	2007
Price /Wp:	**24**		**22**		**30**	**30**	**30**	**22**	**22**	**20**	**20**	**20**	**20**	**22**	**22**

Table 7b: Australian trends in typical system prices (current AUD, excluding GST) for grid applications up to 5 kWp

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Price /Wp:	**11**	**12**	**12**	**14**	**14**	**13**	**10**	**12**	**12**	**12,5**	**12**

3.4 Labour places

Labour places predominantly associated with PV in the different sectors are estimated to be:

a) Public research and development (not including private companies);

110

b) Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D;

600

c) All other:

c1) Distributors of PV products;

400

c2) System and installation companies;

500

c3) Utilities and government;

50

3.5 Business value

The estimated value of PV business in Australia in 2007 is shown in Table 8.

Table 8 - Value of PV business

Sub-market	**Capacity installed *in 2007* (MW)**	**Price per W AUD**	**Value AUD M**	**Totals AUD M**
Off-grid domestic	3,75	22	82,6	
Off-grid non-domestic	2,15	25	53,8	
Grid-connected distributed	6,03	12	72,4	
Grid-connected centralized	0,25	8	2,0	
				210,8
Export of PV products				**81,6**
Import of PV products				**-100,4**
Value of PV business				**190,8**

4 Framework for deployment (Non-technical factors)

4.1 Support measures and new initiatives

Table 9 lists PV support measures, including the major ones described earlier, but also other direct and indirect measures that influenced PV uptake in Australia during 2007.

Table 9 - PV support measures

Type of Measure	Ongoing measures	Measures that commenced during 2007
Government Enhanced feed-in tariffs		Several States and Territories investigating FiTs.
Capital subsidies for equipment or total cost	National PV Rebate National Renewable Remote Power Generation Solar Schools 5 Solar Cities	Grants increased to AUD 8000/kW. 2 new Cities added
Green electricity schemes	National GreenPower program	
PV-specific green electricity schemes	Origin – Solar Power (Some States)	
Renewable portfolio standards	National Mandatory Renewable Energy Target 9500 GWh by 2010	Renewable Energy Target (national) 45000 GWh by 2020
PV requirement in RPS		
Funds for investment in PV		
Income tax credits		
Net metering	Most utilities	
Net billing		
Commercial bank activities eg green mortgages promoting PV	Several banks and building societies offer lower interest rates for energy efficient homes and solar inclusions	Special deals available to limited numbers of customers purchasing PV systems through Solar Cities programmes
Electricity utility activities	PV electricity purchases and/or installations to meet GreenPower and MRET obligations	Energy Australia FiT AUD 0,23/kWh for net export between 2pm and 8pm (Some States)
Sustainable building requirements	State of NSW building standard BASIX lists PV as an option to achieve required energy rating	

4.2 Indirect policy issues

The following describes policy initiatives that indirectly influence the implementation of PV power systems in Australia.

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

In late 2007 Australia ratified the Kyoto Protocol and so will now be formally held to the targets agreed in 1997. This also allows Australian companies to operate in the CDM and AIJ markets.

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

In 2007 the Australian Government agreed to re-examine the introduction of an Emissions Trading Scheme. The new Government has commissioned a review to consider details, but has indicated an intention to introduce emissions trading by 2010.

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

The Asia-Pacific Partnership has resulted in agreements between Australia and India and China to assist with renewable energy projects, programs and education. This includes an agreement to facilitate engineering students to study renewable energy courses in Australia.

Austrade hosts trade delegations and provides other assistance to Australian companies wishing to establish contacts in non-IEA countries.

Australia hosts the South East Asia and Pacific regional secretariat of the Renewable Energy and Energy Efficiency Partnership (REEEP), with funding from the Australian Government. Technical expertise and assistance is available to ensure capacity building in the region. The Secretariat also acts as a clearing house for best practice in policy and finance to promote renewable energy and energy efficiency, and a service centre to support its partners in making renewable and energy efficient power a reality.

d) education and training

An appropriately skilled workforce is critical to the successful development of the PV market. Australia commenced the world's first PV Engineering degree at the University of NSW (UNSW) in 2000, followed by a Renewable Energy Engineering degree in 2003. Other institutions now also offer Renewable Energy Engineering degrees, as well as a range of undergraduate and postgraduate photovoltaics, renewable energy and climate change courses.

Enrolments in the UNSW courses increased substantially in 2007, in line with community interest in renewable energy and climate change. More than 100 students have graduated since courses commenced and more than 250 are currently enrolled. Numbers will be boosted from 2008 with students from China, India and Korea studying in Australia under the Asia-Pacific Partnership on Clean Development and Climate.

The electro-technology training package, which is followed by all technical colleges within Australia and relates to the curriculum's and qualifications for the electrical trades, was updated during 2007, for use from 2008. The new package includes qualifications for

renewable energy and units which can be taught within the electrical trades courses prior to obtaining their Clean Energy Council accreditation for designing and installing systems.

In May 2007 there was only one registered training organisation in Australia offering grid-connect training. By the end of the year, 15 institutions, mostly technical and further education (TAFE) colleges, were offering courses, in response to the overwhelming demand. The number of accredited PV installers increased from 230 to 500 in 2007, with 95% of these grid-connect accreditations, mostly licensed electricians. There is also considerable interest in the Grid-connect Design and Supervise accreditation pathway. One private company Global Sustainable Energy Solutions (GSES) developed and launched an on-line training course in November 2007 and also constructed a new training centre in Pambula NSW for conducting practical training sessions.

GSES has also been helping to develop training centres and deliver training courses in developing countries for the last 8 years. During this year GSES developed a solar water pumping training course at the Deng Solar Training Centre in Accra, Ghana, a training centre GSES helped to develop over the recent years. The solar water pumping course was conducted twice in 2007. In 2007, GSES completed their work with Pusat Tenga Malaysia (PTM) to develop a training centre offering grid connect training for the Malaysian market.

4.3 Standards and codes

New developments relating to Standards and Codes of Practice in 2007 include:

a) Technical regulations for PV plant construction and operation;

International standards development relevant to Australia

IEC TC82 WG3 –"Systems" and WG6 –"Balance of systems Components" are now working on significant international standards for safety and installation.

- a new PV array installation standard which is a derivative of Australia's AS/NZS5033 is currently under development as a full international standard. It will be edited to include the latest safety features including the need for dc arc detection on PV arrays. Special requirements are under consideration for building integrated systems. This document is only in the first stages of development and because of a need for strong interaction with TC64 will take a considerable time to get agreement between all parties. Many of the interim safety decisions may be brought back to Australia for updating of AS/NZS5033.
- IEC 62109-1, -2, Safety of power converters for use in photovoltaic power systems. Part 1 is general safety and part 2 is specific to inverters. This document is nearing completion. Part 1 will soon be a final draft international standard for voting and part 2 will soon be a committee draft ready for voting. This standard is extremely important as it defines safety requirements and marking requirements for inverters and classifies the inverters for electrical separation between input and output.
- It was reported that Underwriters Limited was in the process of developing an arc detector and test methodology for dc arcs in photovoltaic systems.
- There are developments in standards for dc plugs under discussion which will improve safety in PV systems

- IEC 62253 Ed. 1.0, Equipment and safety specifications for direct coupled photovoltaic (PV) – pumping systems will be sent out for voting by member countries as a CDV.

b)`Standards, wiring codes and grid interconnection rules for PV systems

- AS4509 for Stand-alone systems is in the final stages of significant revision.
- AS/NZS3000, the Australian wiring rules, have now been comprehensively linked with our renewable energy standards AS4777, AS4509 and AS/NZS5033.
- A new stand-alone inverter performance standard has been drafted and is expected to be available during 2009.

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

As the grid market develops and installers try to streamline procedures and installations to reduce costs, the varying local government, utility and State government requirements are becoming an increasing problem. Differences include the need for Development Applications in some local government areas, but not in others, different building insurance requirements in each State on top of PV system warranties, different metering arrangements and different levels of inspection for commissioning. These can add several hundred to over a thousand dollars to an installation as well as lengthening the application process.

The cost of compliance with increasingly stringent workplace health and safety regulations is also increasing installation time and cost.

d) Building codes

Relevant codes are those referring to load bearing limits on roofs and wind ratings. These differ with building types and location and can result in high PV installation costs if structural additions are necessary.

5 Highlights and prospects

- **Key aspects of PV deployment or production in Australia during 2007.**

In 2007 PV entered the mainstream Australian market, with a large increase in grid system sales and a significant growth and diversification of industry participants. This was due to a generous grant program of AUD8000 for the first kW which, combined with Renewable Energy Certificates from the Mandatory Renewable Energy Target, some enhanced feed-in tariffs, and active promotion from PV retailers and through the Solar Cities Program, reduced the payback time of systems to within 20 years in some areas. New businesses, new products and new marketing strategies and retail outlets increased consumer choice and lowered prices for the first time in several years. Whether this momentum can be maintained, with changes to the grant program and increasing resistance to feed-in tariff support from various sectors of industry and the community, remains to be seen. Nevertheless, electricity prices are set to rise consistently over the coming decade across the country so that, if PV prices continue to fall, a more robust market should develop. In the meantime, increasing diesel prices constantly improve the cost-effectiveness of PV in rural and remote areas so that market could expect to improve.

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

Several PV companies have shown an interest in manufacture in Australia, with two new PV manufacturers planning production commencing in 2009.

Concentrator manufacturer, Solar Systems, has plans to commence manufacture of its proprietary concentrator cells in Victoria.

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

There are no specific PV targets in Australia. However, the Renewable Energy Target has been increased to 45 000 GWh by 2020, which will provide some support for PV in the near term and possibly more support in future as the target gets harder to meet with other renewables and PV prices fall. The new Australia Government has a greenhouse gas reduction target of 60% by 2050 compared with year 2000 levels, so the market for PV and other renewables will increase with time.

Annex A Method and accuracy of data

a) Methods used to collect, process and analyse the data given in this report.

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

b) Accuracy of the data

Data in Table 1 is probably accurate to ±200kW.

c) Problems with data gathering.

- Businesses and governments are reluctant to disclose information on sales breakdown, costs or prices. The accounting periods for different companies vary, with most using the Australian financial year (July to June) but others using the Japanese financial year (April to March). This makes data collation for these companies more time consuming.
- 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

This annex provides some background about the national environment in which PV is being deployed. The data are not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data. 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 summer tariffs of AUD 0.20 or more in some jurisdictions and 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 respectively. 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 - 7500 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 most retailers, with some offering higher buyback rates for excess generation, although this is usually capped.
4) average household income - AUD 30 600 per year
5) typical mortgage interest rate – 8 %
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. The Australian Energy Market Commission (AEMC) is the body responsible for energy market rule-making and market development at the national level. The Australian Energy Regulator (AER) performs economic regulation of the wholesale electricity market and electricity transmission networks in the National Electricity Market (NEM). It is also responsible for the enforcement of the National Electricity Law and National Electricity Rules.
8) price of diesel fuel: AUD 1.3-1.7 per litre
9) typical values of kWh / kW for PV systems in Australia: 1000-2000 kWh/kW per year depending on location.