Australian PV Association

PV IN AUSTRALIA 2011

Prepared for the International Energy Agency

Cooperative Programme on PV Power Systems

BY

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AUSTRALIAN SOLAR INSTITUTE

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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, 2011

ACKNOWLEGEMENTS

This report is prepared on behalf of and with considerable input from members of the Australian PV Association (APVA) and the wider Australian PV sector.

The objective of the APVA is to encourage participation of Australian organisations in PV industry development, policy analysis, standards and accreditation, advocacy and collaborative research and development projects concerning solar photovoltaic electricity.

APVA provides:

- Up to date information and analysis of PV developments in Australia and around the world, as well as issues arising.
- A network of PV industry, government and researchers which undertake local and international PV projects, with associated shared knowledge and understanding.
- Australian input to PV guidelines and standards development.
- Management of Australian participation in IEA-PVPS, including:
  - PV Information Exchange and Dissemination;
  - PV Hybrid Systems within Mini-grids
  - High Penetration PV in Electricity Grids.

The Association receives funding from the **Australian Solar Institute**, to assist with the costs of IEA PVPS membership, Task activities and preparation of this report.

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Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS 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.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

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 system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, electricity utility businesses 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.

Currency: The currency unit used throughout this report is Australian Dollars (AUD).

PV support measures:

Enhanced feed-in tariff	**an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer**
Capital subsidies	**direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost**
Green electricity schemes	**allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price**
PV-specific green electricity schemes	**allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price**
Renewable portfolio standards (RPS)	**a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable energies**
PV requirement in RPS	**a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)**
Investment funds for PV	**share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends**
Income tax credits	**allows some or all expenses associated with PV installation to be deducted from taxable income streams**
Net metering	**allows PV customers to incur a zero charge when their electricity consumption is balanced by their PV generation, to be charged the applicable retail tariff when electricity is imported from the grid and to**

	receive some remuneration for PV electricity exported to the grid
Net billing	**the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle**
Commercial bank activities	**includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems**
Activities of electricity utility businesses	**includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models**
Sustainable building requirements	**includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development**

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 22 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association and the US Solar Energy Industries Association are also members.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Australia's participation in the PVPS is undertaken by the Australian PV Association and is supported by the Australian Solar Institute. The Australian Executive Committee representative is Dr Muriel Watt, IT Power (Australia). In 2011 Australia participated in:

- Task 1: Leader and Operating Agent - Mr Greg Watt
- Task 11: Leader - Mr Wolfgang Meike, Novolta
- Task 14: Leader - Associate Professor Iain MacGill, University of NSW.

Task 1

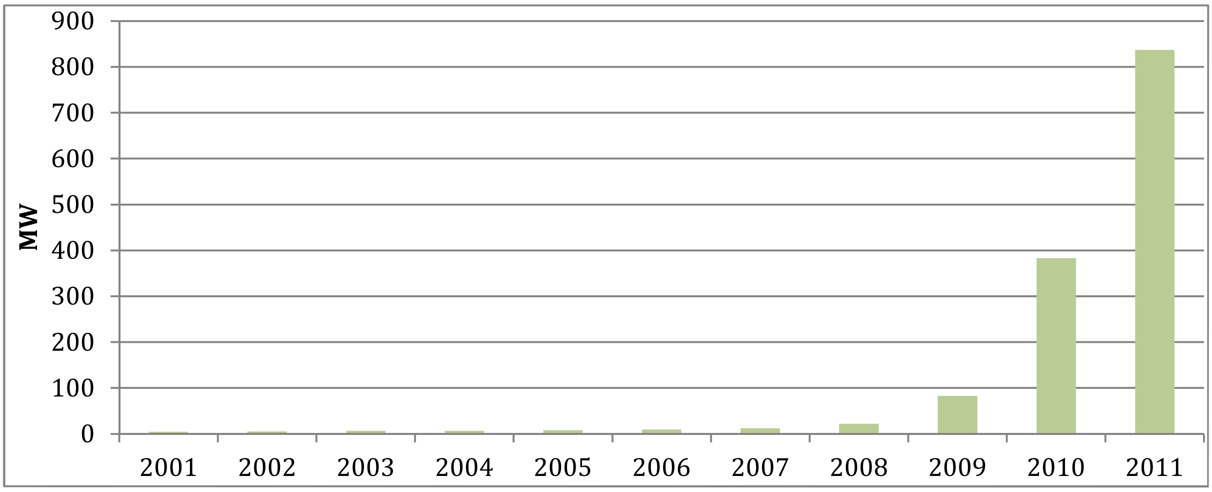
The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the Australian National Survey Report for the year 2011. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org and the APVA website www.apva.org.au also play important roles in disseminating information arising from the programme, including national information.

EXECUTIVE SUMMARY

Installed PV power

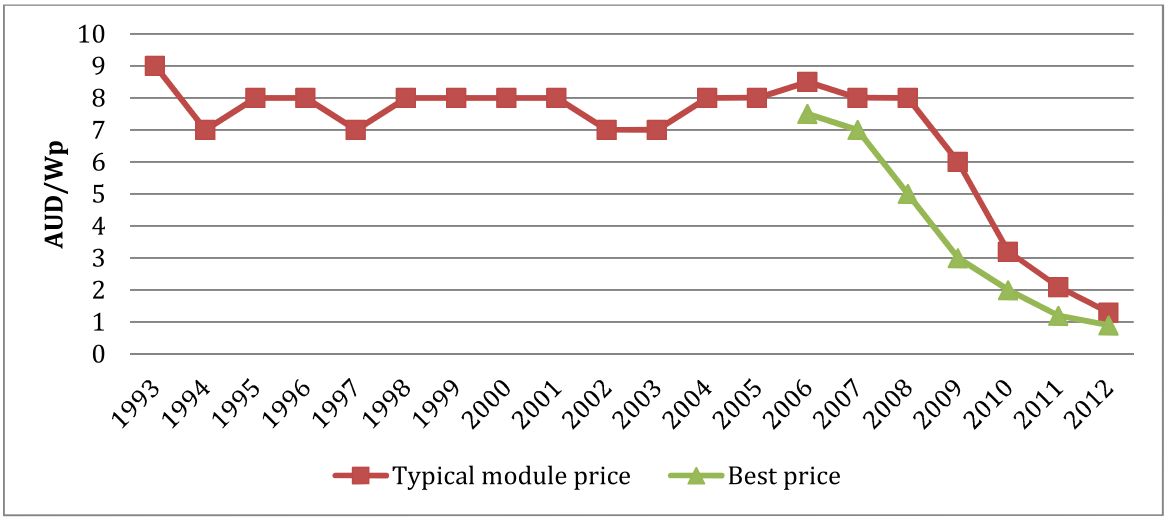
A total of 837 MW of PV were installed in Australia in 2011, more than twice the capacity added in 2010. Of this 91% was grid-connected, taking the cumulative grid-connected portion to 88%, up from 84% last year. Total installed capacity in Australia is now 1.4 GW. PV power has now reached grid parity in many parts areas and government support programs are winding down.



Annual Australian PV installations 2001-2011

Costs & prices

Typical module and system prices continued to fall in 2011. Module prices averaged AUD 2,10/Wp, but were as low as AUD 1,2 by year end. Grid system prices averaged AUD 3,9/Wp, down from AUD 6/W last year.



Australian PV module prices 1993-2011 (current AUD)

The University of Queensland's 1,22 MW PV system

Comprising more than 5000 panels across the rooftops of four large buildings at St Lucia, the array performs a dual role of generating "green" electricity for the University while providing a world-leading piece of research infrastructure.

It provides between 5-6% of peak electricity demand at the St Lucia campus, with data available from the website: www.uq.edu.au/solarenergy/

UQ's partners in the project were:

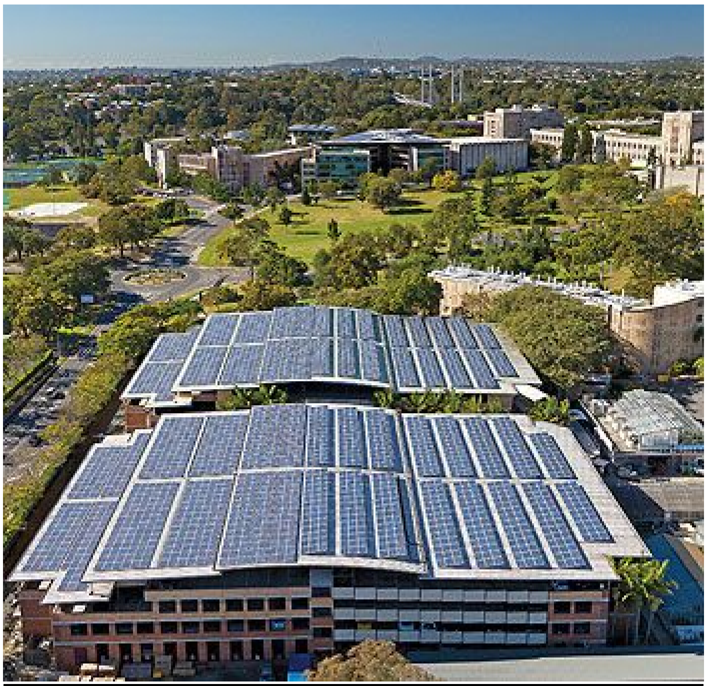
- Brisbane firm **Ingenero**, which installed the array, and worked on its design and engineering
- **Trina Solar**, which supplied the panels and will be part of several research projects
- **RedFlow**, which supplied an industrial-scale bromine battery bank that is connected to a 339kW section of solar panels on one of UQ's multi-storey carparks
- Electricity wholesaler and retailer **Energex**, which donated state-of-the-art equipment to allow monitoring and analysis of the power feed from the UQ solar array
- The **Queensland Government's Office of Clean Energy,** which provided AUD1,5M towards the overall cost of the UQ Solar Array

PV production

Australia's only flat-plate PV cell and module producer, Silex Solar, ceased production in 2011. Several companies have announced an interest in module manufacture, while Dyesol Ltd produces dyes for dye solar cells. A range of array frames, switch-gear and inverters are manufactured in Australia.

Budgets for PV

A total of AUD 99,5 million was spent in 2011 by the Australian and State & Territory Governments on PV R&D, demonstration and market stimulation, significantly reduced from 2010, due to support moving from government budgets to market mechanisms, funded via electricity prices.



The 1,22 MW PV System at the University of Queensland's St Lucia campus (Photo: University of Queensland)

1 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.

1.1 Applications for photovoltaics

The market for PV installations connected to central grids in Australia continues to increase and has represented the largest market for PV since 2009. In 2011, the majority of installations took advantage of incentives under the Australian Government's Renewable Energy Target (RET) mechanisms, with further drivers provided by State and Territory Feed-in Tariffs. The main applications are rooftop systems for private residences. There is also a separate program for installations on school buildings. PV reached grid parity against retail electricity tariffs in many parts of Australia in 2011, with the Levelised cost of PV electricity now equal to or lower than prevailing electricity tariffs. Of course, in those jurisdictions without net metering or enhanced feed-in tariffs, exported PV electricity may not be paid for at the retail rate. The commercial and light industry sector has grown more slowly than the residential sector to date, with support available to selected projects in certain areas through the Solar Cities and State government programs. Commercial sector interest in using PV to displace purchased power is increasing more generally as electricity tariffs increase.

The second largest installed capacity of PV in Australia is for off-grid residential systems where PV displaces diesel in hybrid power systems or provides power directly for lighting. Off-grid industrial and agricultural applications are also an important market. These include power systems for telecommunications, signalling, cathodic protection, water pumping and lighting. Significant markets also exist for fuel saving and peak load reduction on diesel grid systems. There is also a reasonably significant market for recreational PV applications for caravans, boats and off-road vehicles.

1.2 Total photovoltaic power installed

The PV power installed in 4 sub-markets during 2011 is shown in Table 1, with the role of PV in the broader national energy market shown in Table 2.

Table 1: PV power installed in Australia during calendar year 2011 in 4 sub-markets.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2011 (MW)	58	18	757	4	837
Amount of CPV in the above (MW)		0	0	0	
Amount of PV in hybrid systems (MW)	76				

Table 2: PV power and the broader national energy market.

Total Australian PV capacity as a % of total Australian electricity generation capacity	New (2011) PV capacity as a % of new electricity generation capacity	Total PV electricity production as a % of total electricity consumption
3%	36%	1%

Data for the tables above are derived from the Renewable Energy Certificate (REC) Registry of the Australian Government's Clean Energy Regulator, information supplied by PV companies and system data available on the SMA sunny portal websites. Renewable Energy Certificates can be created up to one year after system installation, hence data available by the time of publication of this report may not include all 2011 installations. In addition, data is not broken down by application, so that the separation of domestic and non-domestic markets for the off-grid categories is based industry survey data and may not be correct within ±10%.

Overall Australian electricity generation capacity is derived from ABARE (2011), *Energy in Australia 2011*, but is for the year 2009-10. Electricity production / usage data is from the Mundi Index (www.indexmundi.com/g/g.aspx?c=as&v=81). PV output is derived from the REC registry and a weighted average of the zone ratings.

A summary of the cumulative installed PV Power, from 1992-2011, broken down into four sub-markets is shown in Table 3.

Table 3: The cumulative installed PV power in Australia to 2011 in 4 sub-markets.

Sub-market	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Off-Grid domestic	1,56	2,03	2,6	3,27	4,08	4,97	6,07	6,93	9,22	11,07	12,45	14,28	16,59	19,89	23,88	27,71	32,68	40,76	44,23	101,79
Off-Grid non-domestic	5,76	6,87	8,08	9,38	11,52	13,32	15,08	16,36	17,06	19,17	22,74	26,06	29,64	33,07	36,65	38,73	40,66	43,14	43,57	61,99
Grid-connected distributed		0,01	0,02	0,03	0,08	0,20	0,85	1,49	2,39	2,80	3,40	4,63	5,41	6,86	9,01	15,04	29,85	101,21	479,34	1236,76
Grid-connected centralised				0,02	0,20	0,21	0,52	0,54	0,54	0,54	0,54	0,66	0,66	0,76	0,76	1,01	1,32	2,53	3,79	7,40
TOTAL (MWp)	7,30	8,90	10,70	12,70	15,70	18,70	22,52	25,32	29,21	33,58	39,13	45,63	52,30	60,58	70,30	82,49	104,5	187,64	570,93	1407,94

2 MAJOR PROGRAMMES

Australian Government support programs impacted significantly on the PV market in 2011. Key programs are described below.

2.1 The Renewable Energy Target

The 45 000 GWh Renewable Energy Target (RET) consists of two parts – the Large–scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). Liable entities need to meet obligations under both the SRES and LRET by acquiring and surrendering renewable energy certificates created from both large and small–scale renewable energy technologies. The RET will be reviewed in 2012 and then every two years.

2.1.1 Large-scale Renewable Energy Target (LRET)

The LRET, covering large-scale renewable energy projects like wind farms, commercial-scale solar and geothermal, will deliver the majority of the 2020 target. The LRET includes legislated annual targets, as shown in Table 4.

Table 4: Annual Generation Targets under the Large-scale Renewable Energy Target

Year	Target (GWh)
2011	10,400
2012	16,763
2013	19,088
2014	16,950
2015	18,850
2016	21,431
2017	26,031
2018	30,631
2019	35,231
2020	41,850
2021-2030	41,000

2.1.2 Small-scale Renewable Energy Scheme (SRES)

The SRES covers small generation units (small-scale solar photovoltaic, small wind turbines and micro hydroelectric systems) and solar water heaters, which can create small-scale technology certificates (STCs). Deeming arrangements mean that PV systems up to 100 kWp can claim 15 years' worth of STCs up front. The Clean Energy Regulator has established a voluntary 'clearing house' as a central point for the transfer of STCs at AUD 40, and liable entities are required to surrender STCs four times a year. There is no cap on the number of STCs that can be created.

Because of the large numbers of small-scale PV systems that were installed during 2010 and especially during 2011 (due to rapidly decreasing PV prices, the 5X solar credit multiplier (see below) and generous FITs in some States), there was a significant oversupply of STCs, with the result that the secondary market price dropped to lower than AUD 20 and the Solar Credit multiplier was therefore reduced faster than planned in 2011.

2.1.3 Solar Credits

Solar Credits work by multiplying the number of renewable energy certificates that these systems would generally be eligible to create under the standard deeming arrangements. They apply to the first 1,5 kilowatts (kW) of capacity for systems connected to a main electricity grid and up to the first 20 kW of capacity for off-grid systems. Output from capacity above 1,5kWp is eligible for only 1 STC per MWh. The currently anticipated changes to the multiplier, including changes applied in 2011, is shown in Table 5, and the annual caps for off-grid STCs and LGCs are shown in Table 6.

Table 5: Past and Anticipated Reduction in Solar Credit Multipliers

Date installed	**9 June 2009 – 30 June 2011**	**1 July 2011 - 30 June 2012**	**1 July 2012 - 30 June 2013**	**From 1 July 2013 onwards**
Multiplier	5	3	2	No multiplier (1)

Table 6: Annual Caps for Off-grid STCs

Period of small generation unit installation	Number
1 July 2010 to 30 June 2011	250,000
1 July 2011 to 30 June 2012	250,000
1 July 2012 to 30 June 2013	250,000
1 July 2013 to 30 June 2014	150,000
1 July 2014 to 30 June 2015	100,000

2.2 Solar Homes and Communities Plan (SHCP)

The SHCP provided upfront rebates for small-scale PV systems, and although the program ended on 9 June 2009, a very large number of pre-approval applications were received in the closing days, and installations under the program occurred through to 2011 – see Figure 1. A total of 155,62 MW of PV had been installed under this program, with only 200 kW installed during 2011. The vast majority of this was for grid-connected installations, with only 4,946 MW off-grid installations (none in 2011).

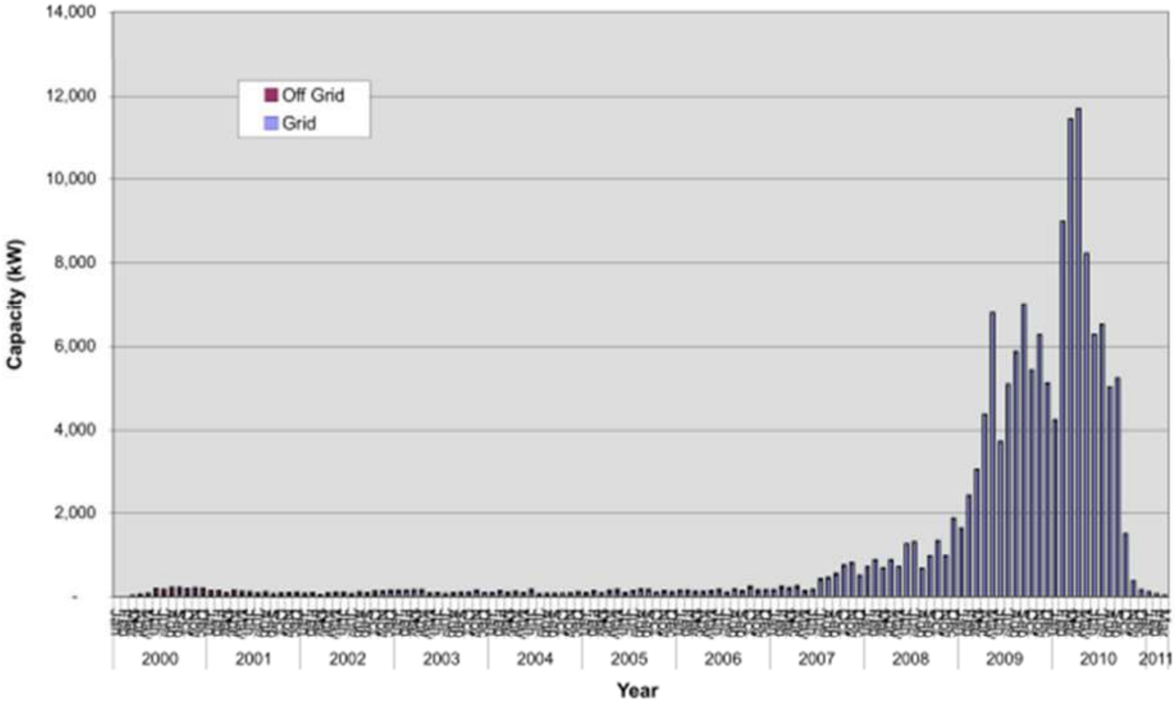


Figure 1 PV Installations under the Photovoltaic Rebate Program and the Solar Homes and Communities Program, 2000 to March 2011.

2.3 Solar Cities

All seven Solar Cities are entering the final reporting and analysis phase of their projects. The Department of Climate Change and Energy Efficiency is collating energy use data from the various trials and will be publishing the results of that analysis during the next 12 months. One key finding has been the benefit of community engagement campaigns that promote behavioural change. Through this, the financial and environmental benefits derived through the use of renewable energy can be maximised.

Figure 2: Solar skate park on Magnetic Island with a 100 kW PV array which provides lighting in the evening, but doubles as shade during the day.

Magnetic Island residents have installed over 675kW of solar photovoltaic (PV) across the island and saved more than AUD 900,000 on electricity bills since the **Townsville Solar City** www.townsvillesolarcity.com.au project began. Consumption levels are now 12 per cent below the peak annual usage, having returned to 2007 levels. This means the project has bettered one of its key project aims of deferring the installation of a third undersea cable. Initially due to be installed in six years at the beginning of the project, it has now been deferred until 2017.

Perth Solar City www.perthsolarcity.com.au has continued to pursue the installation of residential solar PV as part of their trial. Significantly they have now completed a total of five iconic solar PV projects. These projects have resulted in the installation of 465 kW of solar PV which is realising an estimated AUD 205 000 per year in savings on energy bills for the facility owners.

Endeavour Energy (formerly Integral Energy) commercialised its Thermoswitch pool timer as part of the **Blacktown Solar City** www.blacktownsolarcity.com.au project. The pool pump operations trial reduced peak demand by over 20% by using a pool timer that switches off pool pumps early in the morning and/or at night.

Central Victoria Solar City (CVSC) www.centralvictoriasolarcity.com.au established two 300kW Solar Parks in Bendigo and Ballarat. In 2010/11 the parks produced a total of 450 MWh of accredited GreenPower each year. CVSC is currently developing an offer to transfer ownership of the park to the community at the end of the program in 2013.

In June 2011, the 4th **Alice Springs Solar City** www.alicesolarcity.com.au iconic project, the Uterne (pronounced 'u-turn-ay') Solar Power Station, was commissioned. It is the largest tracking solar power station in Australia at just under 1 MW capacity, enough to supply the electricity needs of 288 average Alice Springs homes.

Adelaide Solar City www.adelaidesolarcity.com.au has commissioned 'Tindo', the world's first solar-powered electric bus, ferries passengers around the city each day, and advertises its energy, cost and greenhouse gas savings on a real-time display erected in a prominent position at the central ticket office.

2.4 National Solar Schools Program

The Australian Government's National Solar Schools Program (NSSP) offers eligible primary and secondary schools the opportunity to apply for grants of up to AUD 50 000 to install solar and other renewable power systems, solar hot water systems, rainwater tanks and a range of energy efficiency measures. Funding is capped in each financial year and annual funding rounds are held. Applications are assessed against three criteria – value for money, environmental benefit and educational benefit. Additionally, to allow funding to be directed to schools in most need, applications from schools located in remote or low socio-economic areas receive additional weighting.

Schools across Australia have responded with great enthusiasm to the NSSP. Since the program commenced on 1 July 2008, over 8 000 schools have registered their interest to participate. By April 2012, more than AUD 190 million in funding had been awarded by the Australian Government to over 4 600 schools for PV and other measures. Several State Governments provide additional funding.

Around 90 per cent of approved schools have chosen to install a PV system with their NSSP funding. In the 2011-12 funding round, 784 schools have shared in over AUD 25 million. Almost 2 000 applications were received in the 2011-12 funding round. In 2012 approximately AUD 25 million in funding will be available under the program for the final round, which closes on 4 May 2012. By the end of the program it is expected that approximately 60% of all eligible primary and secondary schools in Australia will have received an NSSP grant.

2.5 Solar Flagships

In May 2009 the Australian Government announced a call for 1 GW of solar generation via 4 solar power stations (solar thermal and PV). The Solar Flagships program is split over two funding rounds with the first round to target 400MW of electricity generation. From the 52 proposals for funding in Round 1 of the program, 2 were selected in June 2011: the 150 MW Moree Solar Farm (PV) and the 250 MW Solar Dawn (solar thermal) projects.

The projects were given until 15 December to meet financial close but were unable to do so. Solar Dawn's financial close deadline was extended until 30 June 2012. The four shortlisted Round 1 PV applicants (AGL, BP Solar, Infigen-Suntech and TRUenergy) were asked to submit updated applications by 7 February 2012, and all did so. There is no indication yet as to which project will be selected or when construction will begin.

2.6 Renewable Remote Power Generation Program (RRPGP)

The RRPGP closed in 2009 but some large-scale projects are completing construction and expect to be finished by the end of 2012. The program provided rebates of up to 50% of the capital cost of renewable energy and related components used for diesel displacement in stand-alone power systems. Typical applications included off-grid households, indigenous communities, community organisations, retail/roadhouses, tourism sites, pastoral stations and other off-grid business and government facilities. Components eligible for the rebate included renewable generation equipment, inverters, battery banks, enclosures, other supporting equipment and installations costs. For water pumping, only the renewable energy components were eligible (not pumps, pipe, concrete footings etc). Stand-alone power systems varied from 100% renewable to less than 50% renewable, with the diesel generator providing the majority of the load. Some systems included both PV and wind. System upgrades were also funded.

Program achievements include:

- $300 million committed to renewable energy generation in remote and regional areas
- more than 9000 residential and medium-scale projects up to 20 kilowatts in size
- residential and medium-scale projects plus renewable energy water pumps with a total power capacity of more than 10,600 kilowatts of solar, wind and micro-hydro that are estimated to save more than 24 million litres of diesel fuel each year
- 31 major projects with AUD 52 million in funding, saving more than seven million litres of diesel fuel each year as well as other fossil fuels
- installation of more than 170 renewable generation systems for Indigenous communities under the Bushlight scheme (see below), and
- support for industry training, accreditation, inspections, testing and standards development.

2.6.1 Bushlight

Bushlight (www.bushlight.org.au) is an Australian Government-funded national, non-profit project that installs renewable energy systems in remote Indigenous communities (known as homelands) throughout central and northern Australia. Each system installation is preceded by, and carried out in conjunction with, a comprehensive program of community engagement, education and training. Bushlight is mainly funded by the Australian Government. It also receives funding from a range of other sources, including fee-for-service work for discrete projects.

In 2011, Bushlight installed 5 new renewable energy systems, with a combined total output of 91.2 kWp of PV. Bushlight upgraded 4 systems with an additional 9.51 kWp. The total installed capacity was 100.71 kWp. Bushlight's Maintenance program provided scheduled servicing and ongoing support to 265 renewable energy systems located in 220 communities.

2.7 State and Territory Feed-in Tariffs

A range of State based feed-in tariffs applied across Australia in 2011, as shown in Table 7. Note that these show the status of feed-in tariffs in 2011 and that some States have announced changes for 2012.

The changes that occurred in 2011 were:

- The Victorian feed-in tariff (called the Premium Feed-in Tariff) closed from 30 Sept 2011 as it had reached its cap. It will be replaced by the Transitional Feed-in Tariff as of 1 Jan 2012, which will guarantee a minimum of AUD 0,25/kWh for systems up to 5kW. Net metering (called the Standard Feed-in Tariff) continued to be available for systems up to 100kW.
- The South Australian Feed-in Tariff was reduced from AUD 0,44/kWh to AUD 0,16/kWh as of 1 Oct 2011 (which is less than the retail tariffs), and eligible systems receive the payment only until 30 Sept 2013. As of 27 Jan 2012, systems will also be eligible to receive what has been called the Premium Feed-in Tariff, which is meant to represent the value of the exported electricity to the retailer. This is set at AUD 0,071/kWh for 2011-12, rising each year to AUD 0,112 by 1013-14, when it will be reviewed.
- In the ACT, systems up to 30 kW were eligible for an AUD 0,457/kWh feed-in tariff until 31 May 2011. Systems from 30 kW up to 200 kW were eligible for a feed-in tariff of AUD 0,3427/kWh from April 2011. It was capped at 15MW. From 12 July 2011, both size categories became eligible for the AUD 0,3427/kWh feed-in tariff, and so the 15MW cap was reached by 13 July 2011 and the scheme was closed for all systems. For systems up to 30kW that are not receiving any feed-in tariff, the electricity retailer ActewAGL provides net metering.
- The New South Wales AUD 0,20/kWh gross feed-in tariff was closed to new applications as of midnight 28 April 2011. After that date new installations may receive payments from retailers that are meant to reflect the value of the exported electricity to the retailer.
- The Western Australian AUD 0,40/kWh net feed-in tariff was reduced to AUD 0,20/kWh from 30 June 2011, then closed to new applications from 1 Aug 2011. System owners are paid between AUD 0,07/kWh and AUD 0,61/kWh (depending on location, retailer and if is residential or commercial) by retailers under the Renewable Energy Buyback Scheme.

The changes that will occur in 2012 are summarised in Section 5.

Table 7: Australian State and Territory Feed-in Tariffs in 2011

State	Start Date	Size Limits	Rate AUDc/kWh	Duration Years	Type	CAP	Eligibility
Victoria (no longer available)	1 Nov 2009	5 kW	60	15	Net	100MW	Residential, community, small business
Victoria	-	100kW	Various	-	Net metering	-	Residential, community, small business
South Australia (no longer available)	1 July 2008	10 kVA 1ø 30 kVA 3ø	44	20 years from scheme start	Net	Finished 30 Sept 2011	A facility that consumes less than 160MWh/yr
South Australia	1 Oct 2011	10 kVA 1ø 30 kVA 3ø	16	5 years from scheme start	Net	Ends 30 Sept 2013	A facility that consumes less than 160MWh/yr
ACT (no longer available)	1 March 2009	≤ 200 kW	34,27c to 45,7c depending on size and date	20	Gross	15MW	Residential, business
ACT	-	30kW	Retail tariff	-	Net metering	-	Residential, business
Northern Territory	-	30 kVA	Retail tariff	-	Net metering	-	NT wide
Queensland	1 July 2008	10 kVA 1ø 30 kVA 3ø	44	20 years from start of scheme	Net	Review at 8 MW	Consumers with less than 100MWh/yr
New South Wales (no longer available)	1 Jan 2010	10 kW	20	7 yrs from start of scheme	Gross	Finished 28 April 2011	Residential
Western Australia (no longer available)	1 Aug 2010	5kW (city) 10kW 1ø 30 kW 3ø (country)	40 to 30 June 2011 20 from 1 July 2011	10	Net	Finished 1 Aug 2011	Residential
Western Australia	2005	5kW to 50kW	7 to 29,45	-	Net	-	Residential, Commercial (Horizon Power)

3 HIGHLIGHTS OF RESEARCH AND DEVELOPMENT

3.1 ASI

ASI is an AUD 150 million commitment by the Australian Government to keep Australia at the forefront of solar innovation. ASI invests in research and development projects to accelerate innovation in photovoltaic and concentrating solar power technologies that have the potential to significantly reduce the cost of solar energy compared to other existing energy sources. Other program activities include support for skills development and capacity building, knowledge management and strengthening collaboration between Australian and international solar researchers and industry.

At the end of 2011, the Australian Solar Institute (ASI) was managing a portfolio of over 30 research and development and pilot demonstration projects with an aggregate value of approximately AUD 220 million, including over AUD 160 million in photovoltaic projects. ASI is also supporting eight PhD Scholars and Postdoctoral Fellows investigating photovoltaic technologies. In addition, in late 2011 the ASI made offers of support for R&D projects and further PhD Scholarships and Postdoctoral Fellowships that will be announced in 2012.

During the year, ASI announced approximately AUD 8 million for photovoltaic Foundation projects under the auspices of the United States-Australia Solar Energy Collaboration. A range of funding opportunities and international collaborations were also announced including the:

- opening of the Round 3 funding opportunity
- opening of the Skills Development Program, including PhD Scholarships, Postdoctoral Fellowships and International Research Exchange
- opening of the USASEC Foundation round, Research Exchange, Open Funding Round and Strategic Research Initiative
- call for proposals under the Australia-Germany Collaborative Solar R&D Funding Program.

A number of ASI supported photovoltaic projects were also launched including:

- 'Printing solar cells - a manufacturing proposition for Australia' led by the University of Melbourne
- 'Roof mounted hybrid CST system for distributed generation of heating, cooling and electricity' led by the Australian National University
- 'Industry ready n-type silicon solar cells' led by the Australian National University.

Details about individual projects are available at www.australiansolarinstitute.com.au.

3.2 CSIRO

CSIRO's activities in photovoltaics include both commercially-funded and strategic R&D, conducted under two of its Flagship programs: Future Manufacturing and Energy Transformed. In 2011, CSIRO's PV research involved approximately 32 FTE staff across two locations, the Energy Centre in Newcastle and the Clayton Laboratories in Melbourne.

A major component of the work was toward the development of new printable PV technologies based on organic materials or nanoparticle solutions, with the remainder of the work being commercial development of materials for PV, commercial testing of PV devices and a study of the effect of PV intermittency on electricity grids.

3.2.1 Victorian Organic Solar Cell Consortium

CSIRO is a partner in the Victorian Organic Solar Cells Consortium (VICOSC). VICOSC brings together researchers from partners at the University of Melbourne, Monash University, BlueScope Steel, Securency, Innovia Films and Robert Bosch SEA. The aim of the consortium is to develop materials and processes to facilitate the industrial uptake of OPV manufacturing. In 2011 the VICOSC consortium was supported by funding from the Victorian Government Department of Business and Innovation through the Victoria's Science Agenda (VSA) program. The VICOSC VSA project aims to develop the manufacturing processes required for roll-to-roll fabrication of organic photovoltaic devices. In 2011 the consortium successfully demonstrated large-scale, continuous printing of OPV devices for the first time in Australia. In parallel with this project, funding from the Victorian Government Department of Primary Industries and the ASI supported research into new materials and device architectures for high efficiency devices. Outcomes from this project will be fed into the VSA to enhance the value proposition of OPVs as a manufacturing technology for Australia.

Figure 3: Reel-to-reel printed OPV device fabricated at CSIRO

3.2.2 Newcastle Joint Research Centre for Organic Photovoltaics

This is a jointly-funded collaboration between CSIRO and the University of Newcastle with the aim of developing new and improved architectures for organic solar cells. The research is built around studies of the fundamental processes occurring when light is absorbed in OPV devices, including the influence of material morphology on charge separation and transport as well as lateral and axial device design and understanding the degradation mechanisms in these devices.

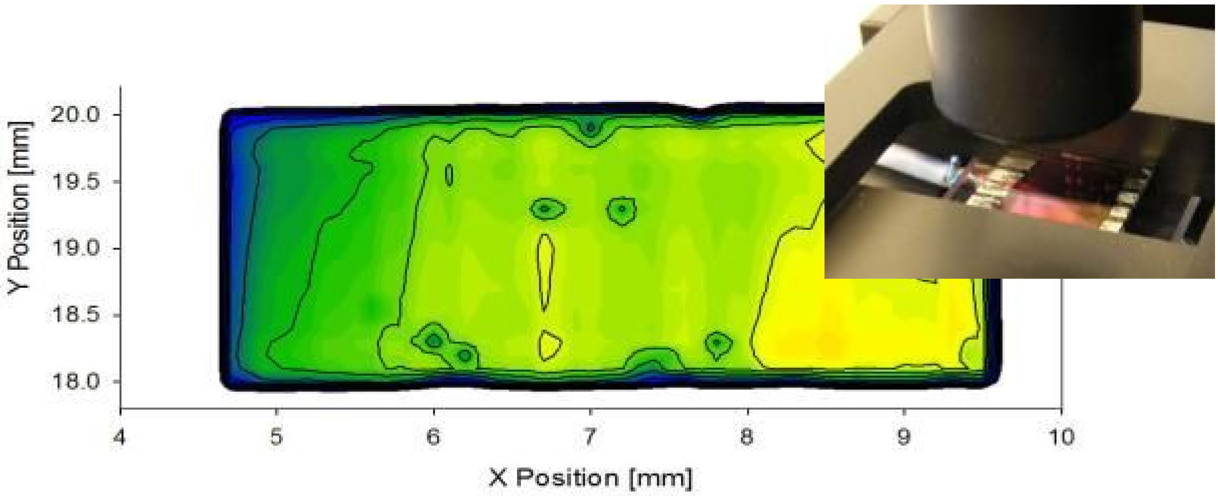


Figure 4: A device photocurrent map of the type used to study degradation pathways in organic solar cells. Inset: Photocurrent mapping experiment.

3.2.3 Nanoparticle inks for solution-processed inorganic solar cells

In collaboration with the University of Melbourne, CSIRO's research into nanoparticle inks aims to develop new, low-cost processes to fabricate solar cells based on known, proven materials. CSIRO's Dr Jacek Jasieniak obtained funding in 2011 from the ARC through a Discovery Grant and from the Fulbright Foundation and the ASI for a year's secondment to UCSB to work with Nobel Laureate Professor Alan Heeger. In 2011, outstanding progress was achieved in this project with lab-scale devices being produced all from solution and all in air, with power conversion efficiencies of over 10%.

Figure 5: CSIRO's Dr Jacek Jasieniak and nanoparticle inks

3.2.4 Dye-sensitised Solar Cells Strategic Project

This project seeks to advance the performance and manufacturability of the dye-sensitised solar cell as a PV technology especially suited to the built environment. CSIRO's research includes the development of:

- dyes that aim to be better absorbing, more durable and lower cost
- redox components that offer higher cell performance through higher voltage
- solvent-less electrolytes to improve durability
- module designs that suit the BIPV application.

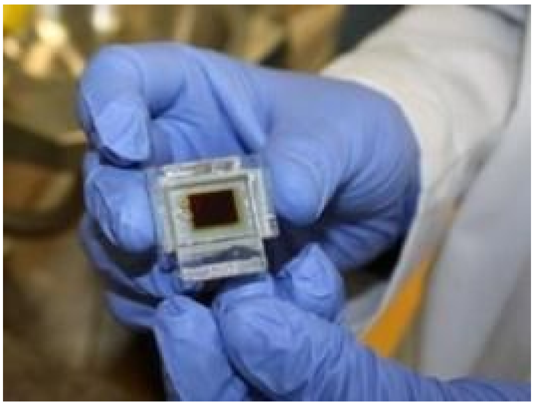


Figure 6: DSC fabrication and standardisation at the CSIRO Energy Centre in Newcastle

3.2.5 Australian Growth Partnerships Dyesol Collaboration

This project involves joint research between CSIRO and Dyesol Ltd and seeks to identify, study and commercialise a range of candidate organometallic dyes for improved lifetime and performance in dye-sensitised solar cells. Stage 1 (completed in 2010-11) focused on the molecular design and creation of novel structures. Stage 2 involves successfully optimising the synthetic chemistries to generate quantities of key precursor materials for ligands and novel Ruthenium based dyes in high purity.

3.2.6 Outdoor testing of PV

Through 2011 CSIRO continued a program of outdoor testing for cell and sub-module scale PV devices made from new materials. The work included participation in an international round robin measurement of OPV devices involving 27 sites around the world.

Figure 7: Small-device outdoor testing at the CSIRO Energy Centre in Newcastle (left) and Clayton Laboratories in Melbourne (right)

3.2.7 Characterising the Effect of High-Penetration Solar Intermittency on Australian Electricity Networks

This 12-month ASI-supported project involved an in-depth analysis of worldwide research and practical results around renewable generation intermittency, examining what common conclusions can be drawn from other efforts in this area, and how these may apply in the Australian context. Some of the findings of the project were:

- Solar deployment is heavily dependent on mitigating intermittency
- Australia's electricity network is unique due to its length, low degree of interconnection and high impedance by world/European standards
- A high penetration of intermittent generation results in greater variability in the net load compared to the variability of the original load alone without solar or wind.
- Large PV systems exhibit significant rapid variations in their output, which puts added pressure on conventional generating resources in the system to vary their output rapidly.
- The amount of solar generation that can be integrated into the utility power system without compromising grid stability and reliability varies widely. The determining factors are the amount of a utility's load fluctuation and the regulating capability of existing conventional generating units. This observation indicates that the effect of solar intermittency is not uniform and is application specific.
- Some ways of managing solar intermittency include the use of short-term energy storage systems, strengthening the existing electricity network, controlling loads in response to network requirements, deploying additional ancillary services, and curtailing the output of renewable generators.
- Accurate solar forecasting at all timescales is essential for network planning, grid and market operation including accurate generator unit commitment scheduling.
- Local research will need to determine the type of ancillary services required and whether existing mechanisms are sufficient for intermittency compensation. A large-scale assessment of the characteristics of generation, load and networks in Australia needs to be undertaken to determine the applicability of international results and the extent to which Australian networks do or do not require special consideration.

Figure 8: CSIRO coordinates the ASI Solar Intermittency Workshop in Melbourne, April 2011

3.3 University Research

3.3.1 Australian National University

PV research at the Australian National University (ANU) involves a group of 60 researchers, research students and support staff who undertake work in the areas of photovoltaic solar cells, solar thermal and combined heat and power systems. The Centre for Sustainable Energy Systems (CSES: http://.cses.anu.edu.au) at ANU was founded in 1991, and is one of the largest and longest established solar energy research groups in Australia. ANU is a core member of the ASI. In 2011 work continued on the following projects funded by the Government and commercial partners:

- Next Generation Sliver Solar Cells
- Roof-top solar concentrators
- Plasmon solar cells
- Sliver flexible modules for soldier integrated power systems and for UAVs
- Back contact solar cells
- Improving conventional silicon solar cells

Activities in CSES span the range from basic R&D through to technology commercialisation. Commercialisation of several technologies is in progress. Research activities include defect detection and surface passivation in silicon wafers; high performance silicon solar cells, including SLIVER solar cells; modelling; plasmons and nano PV technology; PV modules, hybrid PV/thermal parabolic trough concentrator systems; and solar cooling. The research is supported by an extensive PV testing and characterisation facility.

Figure 9: Building Integrated roof-top hybrid concentrators at ANU (courtesy of Chromasun).

Current grants and contracts total AUD 30M. Funding support for CSES comes from the Australian Research Council, the Australian Solar Institute, the Defence Department, DIISR, industrial companies and several other sources.

3.3.2 Murdoch University

PV research activities at Murdoch University in 2011 occurred in three key areas:

- thin film PV devices,
- PV systems and applications and
- sustainable energy in developing countries.

The thin film PV devices group is looking at ways of incorporating silicon nanowires into thin film devices to improve their efficiency and stability. This group also looks at low cost transparent conducting window materials for solar cells and optoelectronic devices, based on nanotechnology. The group has facilities for testing and microanalysis of solar cells and modules.

Research work concerned with PV systems included performance monitoring, evaluation and simulation of grid connected and standalone PV systems as well as an audit into safety aspects of 20 WA School PV system installations.

Murdoch University researchers also perform interdisciplinary research on low emission technologies assessing their appropriateness, cost and environmental impacts as well as analyzing the influence of policies and processes on uptake of low emission technologies including PV applications.

3.3.3 University of Queensland

The key areas of PV research at UQ include:

Centre for Organic Photonics and Electronics: focuses on developing new materials and architectures to push single and multiple junction organic solar cells to the Shockley-Queisser limit. This involves the creation of novel light absorbing and charge transporting materials and geometries with a specific focus on developing a clear understanding of the underlying physics and chemistry of excitonic solar cells and on translating these learnings to manufacturing scale.

Power & Energy Systems Group (School of ITEE): Renewable energy research focuses on the integration of variable energy sources, in particular wind and solar energy, and other base load (geothermal) renewable energy sources into electricity transmission and distribution networks. The research includes voltage stability and reactive power (VAR) management of electricity networks, such as the placement of switched capacitor banks (SVC) and static compensator devices (STATCOMS); increasing penetration of variable energy sources to distribution grids; design of new coordinated control schemes with energy storage systems and electric vehicles, and transmission of energy from renewable energy sources over long distances.

Energy Economics and Management Group (SE): is a national centre for economic research in the field of renewable energy and related environmental questions. To this end, the EEMG has developed two sophisticated models of the national electricity market and other models for policy evaluation and to date has been focusing on solar and wind generation and the impacts of different kinds of carbon mitigation policies on their adoption. The Group is affiliated to the Global Change Institute (GCI) at UQ and played a key role in the development of the very successful UQ Solar Array.

Global Change Institute: is a multi-disciplinary, cross-university organisation which seeks to address and answer some of the major questions facing the globe in an era of rapidly changing climate. One area of key focus is Clean Energy in which it focuses upon opportunities and challenges in the evolving Australian Power System, Utility-scale PV and CST and concepts around distributed and off-grid power. In particular, the GCI manages the research program of the UQ MW Array Project which is concerned with understanding the economics and integration issues associated with commercial-industrial scale PV (storage, power quality, yield, and systems optimisation).

Australian Institute of Bioengineering and Nanotechnology and Chemical Engineering: focuses on the development of new semiconducting nanomaterials as photoanodes for 3rd generation dye-sensitized solar cells and quantum dot sensitized solar cells application. This involves the design, synthesis, electronic and structural modification of metal oxides to facilitate the dye/quantum dot absorption capability, light harvesting and electron transfer efficiency. The research also includes the development of a new class of electrode materials that can have higher specific capacity, quicker charging-discharge rates and longer cycling life for new generations of batteries.

3.3.4 University of NSW

The School of Photovoltaics and Renewable Energy hosts research activities in PV devices, renewable energy systems, policy, combustion modelling, energy efficiency, wind and solar energy forecasting.

Tyree Energy Technologies Building

Construction of the 6-star energy efficient Tyree Energy Technologies Building was continued through 2011 and staff and students of the Australian Energy Research Institute, the School of Photovoltaic and Renewable Energy Engineering, the ARC Photovoltaics Centre of Excellence, School of Petroleum Engineering, Centre for Energy and Environmental Markets, the ARC Cooperative Research Centre for Low Carbon Living, and the ARC Centre for Functional Nanomaterials moved into the building in January 2012. The construction of the building was supported by the Australian Government's Education Investment Fund and a private donor, Sir William Tyree. Research laboratories of the School of Photovoltaics and Renewable Energy Engineering will be transferred into the building over 2012-2013.

Solar Industrial Research Facility

New silicon wafer solar cell laboratories and a silicon wafer solar cell pilot production line are being established separately on the UNSW campus in the ASI-supported Solar Industrial Research Facility. This new facility will permit new industrial scale photovoltaics R&D, technology transfer, training and education. Construction of the building was completed in 2011 and occupation is expected in 2012.

Figure 10: Solar Industrial Research Facility

Photovoltaics Device Research

The bulk of UNSW's photovoltaics research happens within the ARC Photovoltaics Centre of Excellence and encompasses several research areas:

- First-generation research addresses the dual challenges of reducing cost and further improving efficiency while ensuring that designs suit industry. Several distinct technologies have been transferred to industrial production. Two new projects explore different ways to form dual-cell tandem stacks with a silicon wafer cell under a III-V cell.

- Second generation researchers have pioneered an approach where very thin silicon layers are deposited directly onto a sheet of borosilicate glass, with the glass providing the required mechanical strength. Collaborative work with Suntech R&D Australia is investigating electron-beam evaporation of silicon and diode laser processing of the deposited films. Newer thin film research strands investigate organic solar cells and "earth abundant" CZTS (copper-zinc-tin-sulphur) solar cell technology. Application of surface plasmons as light-trapping is a rapidly growing area of study.
- Third-generation, thin-film solar cell research aims to significantly increase the efficiency, beyond the fundamental limits that apply to the earlier generations. The program in this area is concentrating on "all-silicon" tandem solar cells, where high energy-bandgap cells are stacked on top of lower-bandgap devices and the material bandgap is controlled by quantum-confinement of carriers in silicon quantum-dots in an amorphous matrix of silicon oxide, nitride or carbide. Another project seeks to collect "hot" carriers before they relax to the band edges.
- The final photovoltaic device related research strand involves the reverse problem of engineering silicon devices that use electricity to produce light in both electroluminescent and photoluminescent devices. A spin-off" company, BT Imaging, has consolidated its position as a supplier of wafer/cell test equipment.

CRC on Low Carbon Living

UNSW will be part of a Co-operative Research Centre (CRC) on Low Carbon Living, announced by the Federal Government in December 2011. Led by Professor Deo Prasad of the Faculty of the Built Environment, the seven year project will receive AUD 28 million from the Australian Government through the Department of Innovation, Industry, Science and Research. The CRC is a multidisciplinary research effort with research expertise in engineering, material science, architecture, town planning, economics, and the social sciences.

Research will be conducted across three major program areas:

i) Integrated Building Systems
ii) Low Carbon Precincts
iii) Engaged Communities

3.4 Industry Research

3.4.1 Dyesol Limited

Dyesol's 2011 R&D objectives have included progressive resolution of technical challenges relating to Dye Solar Cell dyes, materials, design aspects and manufacturing processes. This ongoing R&D work provides input and outcomes used in Dyesol's commercialisation activities for Dye Solar Cell photovoltaic enabled products.

Dyesol's Australian R&D is conducted primarily into dye production and enhancement, conductors and semi-conductors, sealants and barriers, electrolytes, and improved device design. In the Australian facilities, laboratory and small-scale trials are carried out with the objective of achieving manufacturing process improvements and yield improvements which reduce the cost of production and improve affordability. Dyesol is also targeting improved DSC material sets for improved performance, stability and cost. Dyesol's strategy is to achieve proof-of-principle in Australia and then replicate on a large scale in collaborative programs with our partners, such as Tata Steel Europe (in the UK) and Pilkington North America (in Ohio through joint venture DyeTec Solar).

Achievements in 2011 included obtaining a 15% efficiency improvement in commercially representative Dye Solar Cell efficiency – up from 6.9% to 8% on large strip cells. An important point in this on-going research and development into efficiency and product optimisation is that by using larger strip cells a valid representation of commercial product performance is gained. The increase in efficiency was the result of improvements in materials and system design elements.

In 2011, Dyesol has also continued work on its DSC longevity test program. Under this program excellent results on longevity and durability in accelerated testing of DSC devices created in 2009 continued and demonstrated durability equivalent to 50 years in Middle Europe and 29 years in Southern Europe or Sydney. Dyesol's outdoor test facility in the UK continues to measure and gather valuable data showing DSC's benefits compared to other photovoltaic technologies and this work is on-going.

Australian Prime Minister, Julia Gillard, toured Dyesol's headquarters, engineering workshop, DSC laboratory and up-scaling facility on 20 October 2011 – see Figure 11.

Figure 11: Prime Minister Gillard with Dyesol's Materials R&D Manager, Dr. Yanek Hebtig at Dyesol's pilot DSC materials production facility in Queanbeyan.

3.4.2 Speciality Coatings (Australia) Pty Ltd

Specialty Coatings is undertaking development work on the following PV products:

- Applications for Thin Film Amorphous Silicon in Building Integrated photovoltaics materials
- Development of Low cost, light weight, integrated solar roofing materials in large format composite sheeting

The company is developing low cost, light weight building integrated solar roofing materials by combining thin film amorphous silicon cells and UV (light) cure resin impregnated fibreglass in an automated manufacturing process which creates large format roofing materials that will provide home and building owners with a single layer material that is a building's roof as well as possessing built in renewable energy generation. This will do away with the need for property owners to install a roof and then have a second company install solar panels on top of the roof. It also provides an easy to install light weight integrated system designed to eliminate the added cost of PV installation as the roofing materials are delivered to site with encapsulated photovoltaics. The project is a 3 year, AUD 7 million dollar joint industry and research project which has attracted over AUD 4 million in State and Commonwealth funding and draws on the expertise and collaboration of CSIRO, JCU, RMIT, AWTA, Deakin University, and the ACS-CRC.

3.4.3 Suntech R&D Australia Pty Ltd

Suntech R&D Australia is an Australian subsidiary of Suntech Power Holdings, established in 2011 to develop advanced silicon cell technologies, promote quality in manufacture through improved process controls and champion sustainability, to deliver on Suntech's mission to provide everyone with reliable access to nature's cleanest and most abundant energy source. Suntech is currently the world's largest manufacturer of solar modules and has a long history of research and development activity in Australia.

With the acquisition of CSG Solar Pty Ltd, Suntech R&D Australia gains an experienced team of 15 PV scientists and engineers who have been working together on developing thin film and advanced wafer technologies for over ten years. The team includes staff who were instrumental in taking the crystalline silicon on glass technology into manufacturing, and between them hold 10 internationally registered patents and have many years of experience in photovoltaics.

Suntech R&D Australia is active in a number of research areas, including:

(i) direct technical support of Suntech's commercial activities in Australia,
(ii) near term research into manufacturing process optimisation and developing improved process controls
(iii) mid-long term research in low cost silicon material alternatives and
(iv) working on the next generation of high performance, low cost, commercial silicon solar cells with the world-class photovoltaics research at UNSW

In future, Suntech plans to increase its activity with UNSW, and with other research partners in Australia, through the establishment of a working cell line with manufacturing scale tools for the purposes of advanced cell technology research, process development and training.

3.4.4 SunWiz Consulting

SunWiz researches trends in Australian PV installations at a national, state, and postcode level. Key information on average system sizes, cumulative and recent installed capacity, household penetration levels, most popular system sizes, and market share by manufacturer and retail installer are published on a regular basis to industry subscribers. SunWiz also incorporates this information into publications of the Australian PV Association and Clean Energy Council.

SunWiz has analysed the in-field performance of over one thousand PV systems from a wide range of data sources. These are compiled to establish benchmarks and to identify variation by region and manufacturer. Some of this analysis contributed to the interim review of the National Solar Schools Plan.

SunWiz, in collaboration with Solar Business Services prepares forecasts of Australian PV installations by region, sector, and application. These assist industry purchasers to strategically develop robust business plans, are featured at conference presentations, and are useful in educating governments about the real costs and likely deployment of PV. More recently, they have also assisted the AEMO to account for PV deployment in its long-term forecasting.

3.4.5 Surtek Pty Ltd

Surtek's Starsine® STATCOM program is driven by the understanding that the way forward for the electricity supply network lies in the deployment of smart electronic systems and distributed generation that are embedded in the middle and outer sections of the network and that can be remotely parameterized and controlled. Modeling by one Australian power utility demonstrates that the deployment of 5 and/or 20 kVA single phase Statcoms along a given suburban feeder will entirely solve the voltage compliance problem and even permit the connection of more consumers to that particular branch. This is a far less costly alternative to a physical rebuild of that section of the network.

The Starsine® STATCOM has six primary functions

1. Control the network voltage at the point of attachment. This function takes care of the reactive voltage rise or fall by circulating Volt Amperes reactive (VAr's) in a direction that brings the network voltage within the required "window".
2. Inject real power from dc sources. These can be PV or wind or some other form of dc generation such as fuel cells. Real power injection can also come from energy storage systems such as batteries (see below).
3. Extract real ac power into a dc storage system or network. Dc energy storage systems are set to become important as the new Lithium ion and other types of batteries designed for electric vehicles become available for either diversion into embedded domestic load shifting systems or for use while in the electric vehicle itself.
4. Control the power factor downstream from the point of attachment. The addition of a downstream current sensor to the Starsine® STATCOM allows it to control the downstream power factor to close to unity and thus minimize losses.
5. Balance the voltages on 3 phase distribution transformers to remove negative sequence components

The addition of energy storage systems allows the units to both charge and discharge batteries into the network:

- Load leveling systems - energy storage systems that are widely distributed across the network
- Voltage sag mitigation - using both reactive power and real power from a small energy store
- Injection and Re-injection of FI (Ripple control) signals
- Harmonic cancellation.

The products are derived from single phase inverters but are specifically designed to be grid connected in the low voltage single phase distribution network (415V / 240V). They can be used in single phase or 3 phase configuration and are self sequencing.

Figure 12: Three 20 kVA Statcoms arranged for 3 phase operation in a single rack mounting case

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

Australian government funding for PV research, development and demonstration, including market incentives, is shown in Table 8 and Figure 13. Budgets decreased significantly in 2011 as Australian Government market incentives moved from budget allocations to market mechanisms, paid for via electricity tariffs. Some State Feed-in Tariffs were still budget funded.

Table 8: Public budgets for R&D, demonstration/field test programmes and market incentives AUD Million

	R & D	Demo/Field test	Market incentives
National/federal	23,7	25,0	1,4
State/regional	6,6	14,1	28,6
Total	99,5		

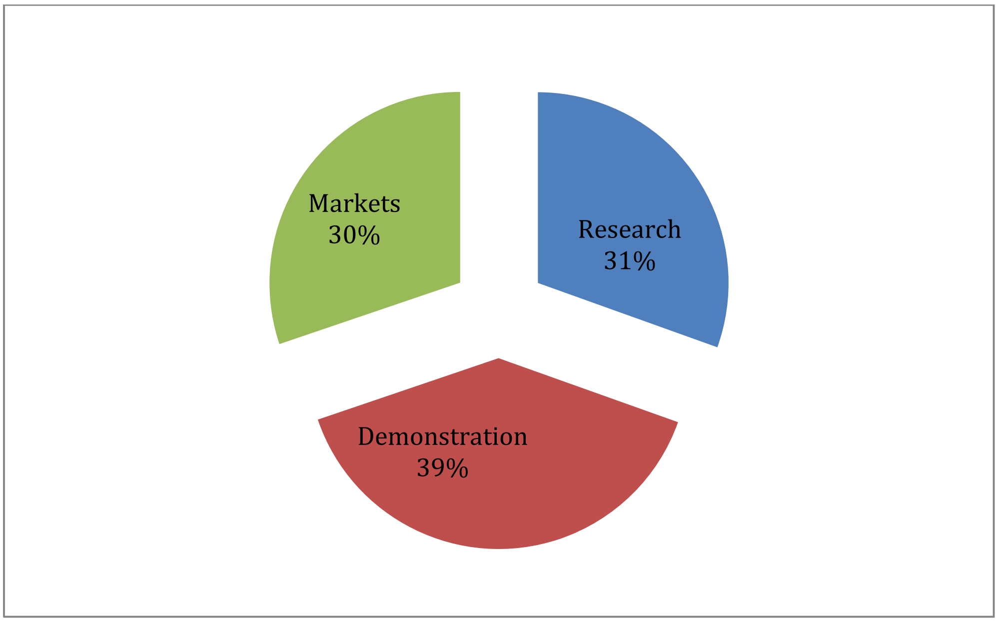


Figure 13: Allocation of Government funded PV R, D & D in 2011

4 INDUSTRY AND GROWTH

4.1 Production of photovoltaic cells and modules

In 2011 Australia had only one commercial-scale flat-plate cell and module manufacturer, Silex Solar, which ceased production mid-way through the year. It may recommence production in 2012, along with two other module manufacturers.

Another Australian company, Solar Systems from Melbourne, is manufacturing Concentrating PV, capable of producing the CPV module and receiver in-house. The concentrating factor is 500 suns and the company imports the III/V multi-junction cells from various suppliers.

Total PV cell and module manufacture together with production capacity information in 2010 is summarised in Table 9 below.

Table 9: PV Production and production capacity information for 2011

Cell/Module manufacturer	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Silex Solar	Mono-Si	4	4	50	35
Cells for concentration					
Solar Systems	CPV (III/V)	0	0.05 (trial)	0	3
TOTALS		**4**	**4.05**	**50**	**38**

4.1.1 Local manufacture

Silex Solar initially produced its own cells and modules using imported wafers, then produced modules using imported cells.

Solar Systems produces the CPV modules using imported III/V multi-junction cells from various suppliers.

4.1.2 Exports

Approximately 8 MW of modules were exported, typically as part of systems installed in the Pacific region.

4.2 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. A range of mounting and tracking systems is made in Australia to suit local conditions. Specialised fuses, switches and off-grid inverters are also made locally.

4.3 Module prices

Table 10 summarises typical module prices in Australia during 2011. It should be noted that prices fell rapidly during the year so the 'typical' price reported reflects a mid-year range, while the 'best price' was more typical at year end. Australian prices were impacted not only by international price reductions, but also by a very high Australian dollar exchange rate.

Table 10: Typical module prices in Australia in 2011 (Current AUD/Wp)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Typical module price	9	7	8	8	7	8	8	8	8	7	7	8	8	8,5	8	8	6	3,2	2,1
Best price														7,5	7	5	3	2,0	1,2

4.4 System prices

Table 11 shows indicative 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.

Additional information showing national trends in the turnkey prices of selected applications is provided in Table 12 and Table 13.

System prices improved due to falls in module prices, a high Australian dollar exchange rate and significant streamlining of system ordering and installation. For residential systems in particular, standardisation became the norm and installation times were reduced from one or more days down to several hours, with little or no prior site inspection.

Table 11: Turnkey Prices of Typical PV Applications in Australia in 2011

Category/Size	Typical applications and brief details	Current prices per W (AUD)
OFF-GRID Up to 1 kW	Remote homes, water pumps, lights	6-15
OFF-GRID >1 kW	Telecommunications, pastoral/mining power systems	7-20
ON-GRID Specific case	1-3 kW residential roof-mounted systems	3-6
ON-GRID up to 10 kW	Larger roof mounted systems on homes, public buildings	3-4
ON-GRID >10 kW	Larger roof mounted systems on public and commercial buildings	2.5-4
GRID – CONNECTED (utility-scale)	Large ground mounted systems in solar farms or at diesel power stations.	2.5-3.5

Table 12: Australian trends in typical system prices for off-grid applications up to 5 kWp (current AUD excluding GST)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUD/ Wp:	24		22		30	30	30	22	22	20	20	20	20	22	22	22	20	12	10.5

Table 13: Australian trends in typical system prices for grid applications up to 5 kWp (current AUD, excluding GST)

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUD /Wp:	11	12	12	14	14	13	10	12	12	12,5	12	12	9	6	3,9

4.5 Labour places

Table 14 shows PV-related employment in Australia during 2011. There was a large increase in installers over the period 2009-2011, as the grid connect market grew rapidly, but employment in this sector is no longer growing as government support programs end and the market stabilises. A number of installation companies, both large and small, have ceased operation and consolidation is expected to continue.

As interest grows in development of the larger-scale market, both commercial roof-top systems and ground-mounted utility systems, there is an increase in consulting, legal and financial sector interest in PV. With the major government PV support mechanism now operating through the renewable energy certificate (REC) market, there is also employment of REC traders and market analysts covering PV.

Most Australian universities, and other research organisations, such as the CSIRO, undertake PV research, so research remains a significant employer.

Table 14: Estimated PV-related labour places in Australia, 2011

Research and development (not including companies)	300
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	500
Distributors of PV products	600
System and installation companies	6000
Electricity utility businesses and government	200
Other (financial, legal, market analysts, consultants, REC traders, education and training etc.)	3000
Total	**10600**

4.6 Business value

Table 15 provides an estimate of the value of PV business in Australia in 2011, based on the installation types and system and component prices reported above. Although installations doubled from 2010 levels, the value of business remained steady, due to the significant fall in component and system prices achieved in 2011.

Table 15: Value of PV business AUD 2011

Sub-market	Capacity installed	Price per W	Value AUD million	Totals
Off-grid domestic	57562	10.5	*604*	
Off-grid non-domestic	18418	14	*258*	
Grid-connected distributed	757418	3.9	*2954*	
Grid-connected centralized	3605	3	*11*	
				3827
Export of PV products				*17*
Import of PV products				*-2595*
Value of PV business				**1249**

5 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 16 lists the main support measures (definitions at start of guidelines) for PV during 2011. Further details on these are provided on the following pages.

Table 16: Australian PV support measures in 2011

	On-going measures	**Measures that commenced during 2011**
Enhanced feed-in tariffs	Vic: net metering SA: AUD 0,16/kWh net ACT: net metering NT: net metering Qld: AUD 0,44/kWh net NSW: AUD 0,08 to 0,10/kWh net WA: AUD 0,08/kWh net	
Capital subsidies for equipment or total cost	Solar Homes & Communities: AUD 8/W ended June 2009 but still driving a backlog of installations in 2011 RRPGP: 50% ended June 2009 but continued with some installations in 2011	
Green electricity schemes	GreenPower	
PV-specific green electricity schemes		
Renewable portfolio standards (RPS)	Small-scale Renewable Energy Scheme (SRES) that includes Solar Credits: 5 times (to end June 2011) then 3 times (to end Dec 2011) multiplier for STC creation for small generation units	
PV requirement in RPS		
Investment funds for PV		
Income tax credits		
Net metering	Available to the majority of residential customers, although in NSW and WA is significantly less than retail tariff	
Net billing		
Commercial bank activities e.g. green mortgages promoting PV	Bendigo Bank: 0.5% reduction in mortgage rate for sustainable energy inclusion	
Activities of electricity utility businesses	Via GreenPower, SRES, Solar Cities, REBS	
Sustainable building requirements	NSW BASIX NABERS GreenStar ratings	

5.1 PV financing schemes

A number of installation companies offer finance or leasing options, especially for commercial systems. For many business customers, leasing makes better economic sense, since the interest payments on a lease option would be tax deductible, while the capital cost could only be depreciated over 20 years.

Table 17: Examples of PV financing schemes

Name of scheme	Description
EkoEnergy solar leasing	Finance up to AUD 35 000 available for business customers via Flexirent Capital.
Solar Choice Commercial Finance	Finance of AUD 50 000 or more for commercial systems valued at AUD 100 000 or more. Finance provided via CAFGA and typically repaid over 5 years.

5.2 Description of changes to support measures in 2011

5.2.1 The Renewable Energy Target

The Solar Credits multiplier was originally meant to be 5X to end June 2011, reducing to 4X in July 2011 for the 2011-2012 period. However, because of the large numbers of STCs created, it was reduced from 4 to 3 from July, with multipliers in subsequent years also reduced by 1. See Section 2.1 for more detail.

5.2.2 State and Territory Feed-in Tariffs

- The Victorian feed-in tariff (called the Premium Feed-in Tariff) closed and is being replaced by the Transitional Feed-in Tariff from 1 Jan 2012, which will guarantee a minimum of AUD 0,25/kWh for systems up to 5kW. Net metering (called the Standard Feed-in Tariff) is available for systems between 5 and 100kW.
- In South Australia, in addition to the Feed-in Tariff, as of 27 Jan 2012 systems will also be eligible to receive what has been called the Premium Feed-in Tariff, which is meant to represent the value of the exported electricity to the retailer. The value of the Premium Feed-in Tariff is AUD 0,071/kWh until 30 June 2012, AUD 0,098/kWh until 30 June 2013 and AUD 0,112/kWh until 30 June 2014. The value after this date is yet to be determined.
- The ACT Government is conducting a two-stage reverse auction process for large-scale PV systems. The pre-qualification stage shortlisted proponents with the best capacity and track record to deliver, and 49 proposals were received by the closing date of 10 April 2012. Prequalified proponents will then be invited to compete to deliver a total of 40MW.
- In NSW, some retailers pay either AUD 0,06/kWh or AUD 0,08/kWh for exported electricity, which is meant to represent the value of the exported electricity to the retailer; some pay nothing. On 14 March 2012 the NSW government recommended that retailers pay between AUD 0,052/kWh or AUD 0,103/kWh for exported electricity for the 2011/12 period. A new value will be recommended for 2012/13 in due course.

5.3 Indirect policy issues

5.3.1 International policies affecting the use of PV Power Systems

Increased international climate change and PV development activities continue to set the benchmark for Australian policies. In addition, Australian PV prices are impacted by the large support programs for PV internationally, as well as manufacturing activity and the Australian dollar exchange rate.

5.3.2 Taxation Measures

The South Australian Government introduced a Payroll Tax Rebate for the on-site labour of renewable energy projects. The Rebate commenced on 1 July 2010 and will continue to 30 June 2014. The rebate available for solar is up to AUD5 million.[1]

During 2011, legislation was passed for a scheme that will place a fixed price on greenhouse gas emissions for 3 years as of July 2012, then converts to an emissions trading scheme after that. Given that the levelised cost of PV electricity is at or approaching grid parity in many Australian jurisdictions, this will improve the economic viability of PV systems immediately.

5.4 Interest from electricity utility businesses

In the past, electricity utilities were heavily involved in PV demonstration programs through their own R&D arms. More recently, utility interest has largely been driven by government programs, such as the Solar Cities and, to a lesser extent, Smart Grids programs, as discussed below. The Electricity Networks Association has begun to examine issues of high PV penetration and is preparing guidelines and protocols for utilities.

All electricity retailers are liable under the Renewable Energy Target and some have installed their own PV systems to contribute to meeting their liability. Some utilities have also established solar businesses and sell PV systems.

5.4.1 Solar Cities

As discussed in more detail in Section 2.3, Solar Cities is a demonstration program, where each Solar City consortium trials a unique combination of energy options such as energy efficiency measures for homes and businesses, the use of solar technologies, cost reflective pricing trials to reward people who use energy wisely, and community education. The Solar Cities are Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth and Townsville. A major review of the program in 2011[2] recommended greater effort in communicating results of the various trials to facilitate wider uptake of successful strategies. To this end, a national forum is to be held in October 2012.

5.4.2 Smart Grid/Smart City Program

The Australian Government has committed up to AUD 100 million to develop the Smart Grid, Smart City demonstration project in partnership with the energy sector. This initiative will gather robust information about the costs and benefits of smart grids to inform future

[1] http://www.renewablessa.sa.gov.au/files/2009dec16_payroll_tax.pdf

[2] Wyld Group, 2011, *Mid-term Review of the Solar Cities Program*, Report for the Department of Climate Change and Energy Efficiency.

decisions by government, electricity providers, technology suppliers and consumers across Australia.

The electricity retailer EnergyAustralia is in the process of demonstrating Australia's first commercial-scale smart grid, based in Newcastle, New South Wales, under the Australian Government's National Energy Efficiency Initiative - Smart Grid, Smart City. EnergyAustralia, working with their consortium partners IBM Australia, GE Energy Australia, AGL Energy, Sydney Water, Hunter Water Australia, and Newcastle City Council, will deploy a commercial scale project that will lead to Australia-wide advances in energy management.

5.4.3 Verve Energy's Greenough River Solar Farm

Work started on construction of the 10MW AC Greenough River Solar Farm near Geraldton in the Mid-West region of Western Australia in November 2011. It is owned by Verve Energy and joint venture partner GE Energy Financial Services and is being built by First Solar using its thin film PV modules. It will be Australia's first central-grid connected utility scale solar farm and the largest solar PV installation in Australia.

5.5 Interest from communities and local governments

Many local governments around Australia have active greenhouse gas reduction and renewable energy support programs. Examples include:

- The City of Sydney plans to establish its own mini-grid, using gas tri-generation, energy efficiency and renewable energy generation to increase self-reliance.
- The small town of Tathra, in the Bega Valley Shire, has set a 50:50 by 2020 target – 50% reduction in greenhouse gases and 50% of energy from renewable sources.
- The Fraser Coast Regional Council has established a Community Solar Farm which will generate approximately 630 MWh annually - enough to power approximately 100 homes and save around 600 tonnes of carbon emissions every year.

5.6 Standards and codes

The main areas still being addressed under standards and codes relate to system safety. To address these important issues over the last 18 months there has been a major effort put into the revision of the Australian PV array installation standard and grid connection standard. This work is nearing completion, with the PV array installation document expected to be published in the second half or 2012 and the grid connection standard published late 2012 or early 2013. Careful coordination has been carried out between the PV committee and the main electrical wiring committee (which oversees AS/NZS 3000 "Wiring Rules") to make sure that all standards are carefully and consistently linked.

5.6.1 AS/NZS 5033 – Installation of PV arrays

The new draft of AS/NZS 5033 is in its final stages of development and is expected to be published in 2012.

The revision includes:

- Scope expanded >30kW and up to 1000V
- Reinforcing of AS/NZS3000 cable protection and support requirements
- Earthing – if LV …All frames required to be earthed
- Requirement for earth leakage detection and insulation resistance monitoring as required by IEC 62109-2 for grid-connected inverter based systems.

- Requirement for alarms when earth faults detected.
- New calculations for overcurrent protection based on Max O/C protection rating of modules
- Voltage ratings based on lowest temperature at site.
- Connectors
- PV dc isolator clarification
- Signs
- Other minor corrections

5.6.2 AS 4777 – Grid connection of energy systems via inverters

AS/NZS4777.1 and 2 are expected to be released for public comment in the second half of 2012 after very extensive revision.

AS/NZS 4777-1 Revision

The revision of AS/NZS4777.1 includes:

- Expanded Scope for larger systems
- Improved guidelines and requirements for multiple inverter installations such as retirement villages.
- Requirements for balancing systems across phases.
- RCDs on inverter circuits
- Segregation of ac and dc wiring
- DC isolation & wiring restraint particularly near inverter.
- Alignment with amended AS/NZS3000
- Updated labelling and signage requirements.
- Recommendations of very low Voltage drop from inverter- point of connection.

AS/NZS 4777-2&3 Revision to combined document AS/NZS 4777.2

Parts 2 and 3 will be combined to simplify product testing and to make sure inverters meet both requirements. Other issues include:

- Important utility safety and quality of supply issues which are arising out of higher penetration levels of PV in the electricity network
- Revision of voltage and frequency settings to line up with regulators requirements.
- Two averaging times and trip settings
- Recommended default settings for Australia and NZ
- Possible revised anti-islanding requirements.

6 HIGHLIGHTS AND PROSPECTS

2012 will see the introduction of a carbon price into the Australian electricity sector, but also a reduction in specific support for PV. At the same time, increasing electricity prices will bring grid parity to most residential PV customers, and many commercial ones. The issues for the PV sector will therefore move to long term regulatory frameworks, including the right to connect and appropriate tariffs for power fed back into the grid.

6.1 Industry concerns and priorities

A survey of the Australian PV industry found that the main issues for 2011 were:

- Rapidly declining module prices
- Low quality modules and other components
- The rapid drop in STC (Renewable Energy Certificate) prices, as well as their volatility and unpredictability
- The complexity of STC trading processes
- The accelerated decrease in the Solar Credit multiplier
- The end of Feed-in Tariffs in many States
- A lack of support for the commercial sector
- The end of RRPGP for off-grid systems.

In addition to measures to address the above issues, where possible, the key needs for the industry in the future were thought to be:

- The need for restrictions to be placed on anti-competitive actions of electricity retailers and gentailers
- More emphasis and support for energy storage to enable higher PV penetrations
- Encouragement of people on fringe of grids that faced costly network upgrades to convert to off-grid systems
- Engagement with utilities to better integrate PV into networks
- The development of a separate market for Distributed Energy Services.

7 ANNEX A: COUNTRY INFORMATION

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

1) retail electricity prices vary across the country and between retailers and also have different fixed supply charges and step rates. Typical flat tariffs range from AUD 0,13 to 0,23 per kWh for households, with higher summer tariffs in some jurisdictions and off-peak hot water tariffs or around AUD 0,04 – 0,12 per kWh also available.

Time of use tariffs also vary, but for residential customers, can be as high as 0,40/kWh between 2pm and 8pm on weekdays.

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 and peak power 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) typical household electricity consumption ~ 8 000 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 – an increasing number of residential consumers in Australia, including most households with PV systems, have interval meters. They are being introduced progressively, accompanied by Time-of-Use tariffs.

4) average household income – AUD 44 200 per year

5) typical mortgage interest rate in 2011 – 7.5%

6) voltage – 240 volts

7) The electricity sector has separate retail, distribution, transmission and generation businesses. Some States have privatised sections of their electricity industry. The Australian Energy Market Commission (AEMC) is 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 in 2011: AUD 1,2 to 1,6 per litre in capital cities, retail prices in rural and remote areas are higher. Price includes the Diesel Fuel Excise of AUD 0,38143 and a 10% GST which some consumers are eligible for rebates on.

9) typical values of kWh / kW for PV systems in Australia: 1200 to 1800 kWh/kW per year depending on location.