IEA INTERNATIONAL ENERGY AGENCY

AUSTRALIAN PV INSTITUTE

IEA-PVPS

With support from

ARENA

Australian Government

Australian Renewable Energy Agency

National Survey Report of PV Power Applications in AUSTRALIA

2014

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Prepared by

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INTERNATIONAL ENERGY AGENCY
CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS (PVPS)

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Australia, 2014

The Australian PV Institute (APVI)

Australian input to the IEA PVPS is managed by the APVI. The objective of the APVI is to support the increased development and use of PV via research, analysis and information.

APVI 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 who 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 the IEA Solar Heating & Cooling Program, and
- management of Australian participation in the PVPS Program, including:
  - PV Information Exchange and Dissemination
  - PV System Performance, and
  - High Penetration PV in Electricity Grids.

More information on the APVI can be found: www.apvi.org.au

ACKNOWLEGEMENTS

Front page photo: University of Queensland 1,22 MW array. (University of Queensland, 2015)

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This report is prepared on behalf of and with considerable input from members of the Australian PV Institute and the wider Australian PV sector.

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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 member countries

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 participating countries and organisations can be found on the www.iea-pvps.org website. Australian participation is managed by the Australian PV Institute, with funding support from ARENA.

The overall programme is headed by an Executive Committee composed of representatives from each participating country or organisation. The Australian Executive Committee member is Dr Renate Egan (ACAP) and the alternate member is Dr Muriel Watt (ITP Renewables).

The management of individual tasks (research projects/activity areas) is the responsibility of Operating Agents, with participating countries providing Task Leaders and Experts. In Australia, the Australian Task 1 Leader is Warwick Johnson (SunWiz); the Task 13 Leader is Lyndon Frearson (CAT Projects); the Task 14 Leader is Iain MacGill (UNSW) and the Task 15 Leader is Greg Watt (CoB Communications). Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers, and to enhance technology co-operation. 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 2014. Information from this document will be used as input to the annual trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information. Australian information is available from www.apvi.org.au.

1 INSTALLATION DATA

The photovoltaic (PV) power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2014 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2014, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

The Australian market for PV installations experienced modest growth in 2014. In 2014, the majority of installations took advantage of incentives under the Australian Government's Renewable Energy Target (RET) mechanisms, with further drivers provided by grants and financial assistance from the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC). The market for rooftop systems on private residences declined in volume, though it remained the primary market segment. The decline in residential volume was entirely offset by growth in commercial systems less than 100 kW in size. The market grew dramatically for systems greater than 100 kW, owing largely to the installation of several utility-scale systems funded some years prior, but is not expected to be sustained at this level. Average system size has continued to grow steadily as residential system sizes increase and as a growing number of businesses invest in PV, as shown in Figure 1 and Figure 3.

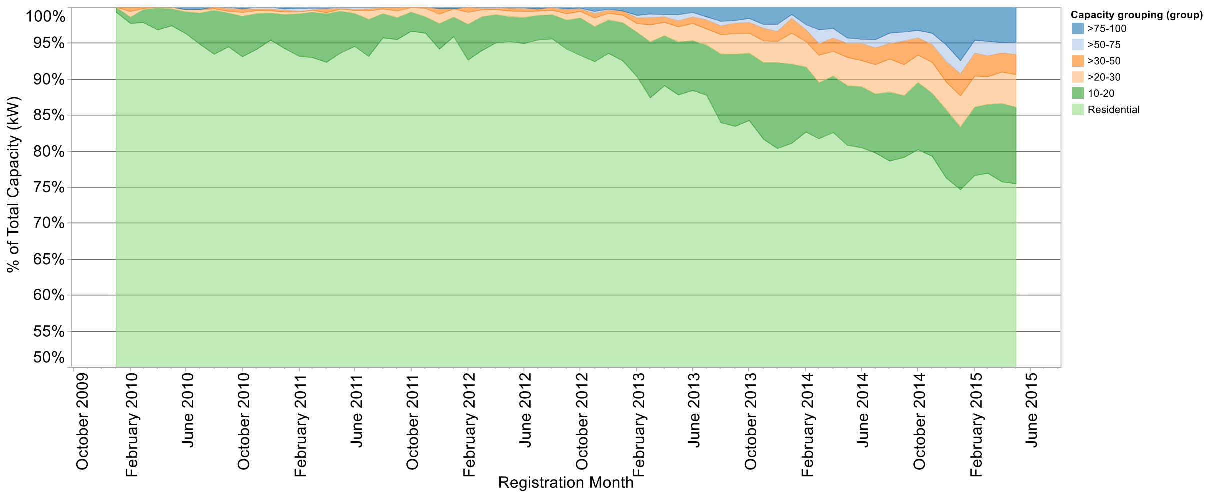

Figure 1: Growing Proportion of Commercial Capacity

Though PV has reached grid parity against retail electricity tariffs in many parts of Australia, electricity prices have stabilised, and high market penetration in the residential segment is constraining sales to this sector.

Figure 2 illustrates penetration levels approaching 40% of residential dwellings in Brisbane and surrounds – the situation is similar across Australian capital cities. For this reason, the Australian PV industry is increasingly turning its attention towards commercial installations, which represented over 20% of capacity installed in 2014. Utility-scale projects that were installed in 2014 were mostly dependent upon Government funding, though the Belectric 3 MW solar farm and a rollout of large PV systems on every IKEA building were examples of foreign investment in 2014 in projects otherwise supported only by the RET.

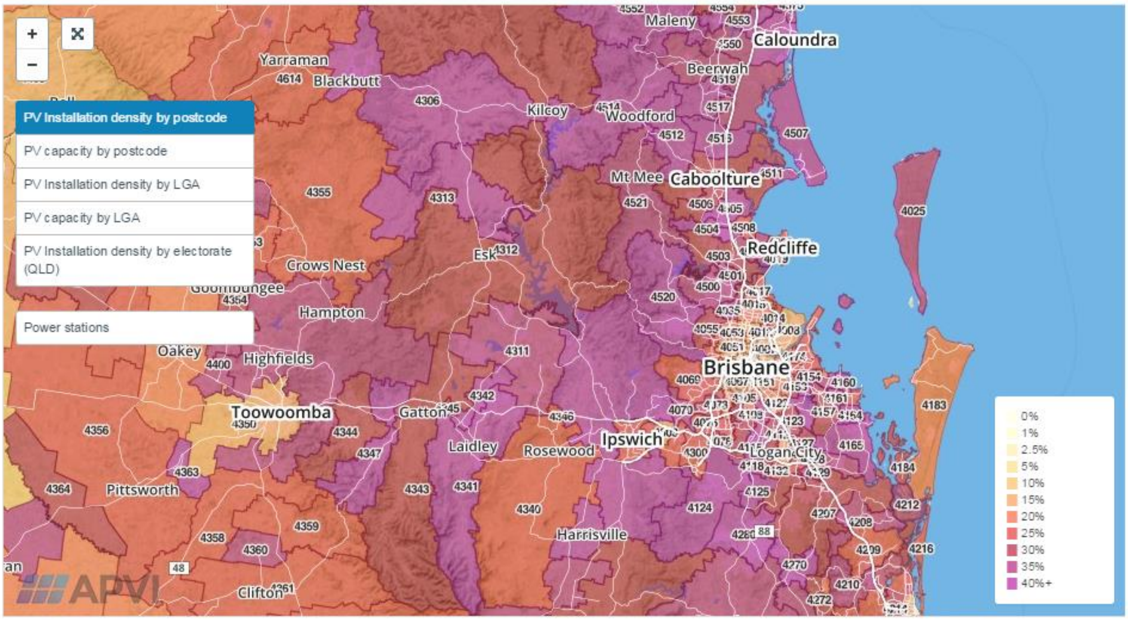

Figure 2: Penetration Levels exceeding 40% (Source: APVI)

Australia's long-standing off-grid market continues to be important, particularly in residential applications where PV displaces diesel in hybrid power systems. Off-grid industrial and agricultural applications are also an important market. These include power systems for telecommunications, signalling, cathodic protection (CP), water pumping and lighting. The roll-out of the National Broadband Network has presented new opportunities for off-grid solar. Significant markets also exist for fuel saving and peak load reduction on diesel grid systems in communities, mine sites and tourist locations. There is also a reasonably significant market for recreational PV applications for caravans, boats and off-road vehicles. Interest is also surging in grid connected systems with battery-backup, though installation volumes were immaterial in 2014.

1.2 Total photovoltaic power installed

The PV power installed in four sub-markets during 2014 is shown in Table 1 (below). PV data for the tables above are derived from the Renewable Energy Certificate (REC) Registry of the Australian Government's Clean Energy Regulator (CER) and information supplied by PV companies. 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 2014 installations, though a projection has been made of historical trends in late registration. In addition, REC data is not broken down by application, so that the separation of domestic and non-domestic markets for the off-grid categories is based on industry survey data and may not be correct within ±10%. Also, not all installed PV is registered with the CER. PV output is derived from the REC registry at a weighted average of 1.400 GWh/GW. Information on off-grid system installation is based upon an industry survey and has low accuracy.

Table 1: PV power installed during calendar year 2014

			MW installed in 2014		AC or DC
Grid-connected	BAPV	Residential	825	654	DC
		Commercial		171	DC
		Industrial		0	
	BIPV (if a specific legislation exists)	Residential	0		
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	63	63	DC
		CPV		0	
Off-grid		Residential	13	12,9	DC
		Other	4	3,2	DC
		Hybrid systems		0,5	DC
		Total	905 MW		

Information about Australia's broader electricity sector is shown in Table 2, which is derived from reports by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Energy Regulator, and the Energy Supply Association of Australia.

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

MW-GW for capacities and GWh-TWh for energy	**2014 numbers**	**2013 numbers**
Total power generation capacities (all technologies)	55,4 GW	55,4 GW
Total power generation capacities (renewables including hydropower)	12,4 GW	11 GW
Total electricity demand	227,5 TWh[1] (excl. PV)	232,5 TWh (excl. PV)
New power generation capacities installed during the year	1440 MW	1300 MW
New power generation capacities installed during the year (renewables including hydropower)	1440 MW	1300 MW
Total PV electricity production in GWh-TWh	5,6 TWh	4,5 TWh
Total PV electricity production as a % of total electricity consumption	2,5%	2,3%

[1] Consumption in the NEM reduced by 5 TWh on 2013 figures. Data on the rest of the country is not yet available

Table 3 (below) provides other summary information about the PV market. Figure 3 (below) shows the density of solar PV installations across Australia by colour codes.

Table 3: Other information

	2014 Numbers
Number of PV systems in operation in Australia	**1.418.000**
Capacity of decommissioned PV systems during the year in MW	**0**
Total capacity connected to the low voltage distribution grid in MW	**3.907,7 MW**
Total capacity connected to the medium voltage distribution grid in MW	**74,3 MW**
Total capacity connected to the high voltage transmission grid in MW	**0**

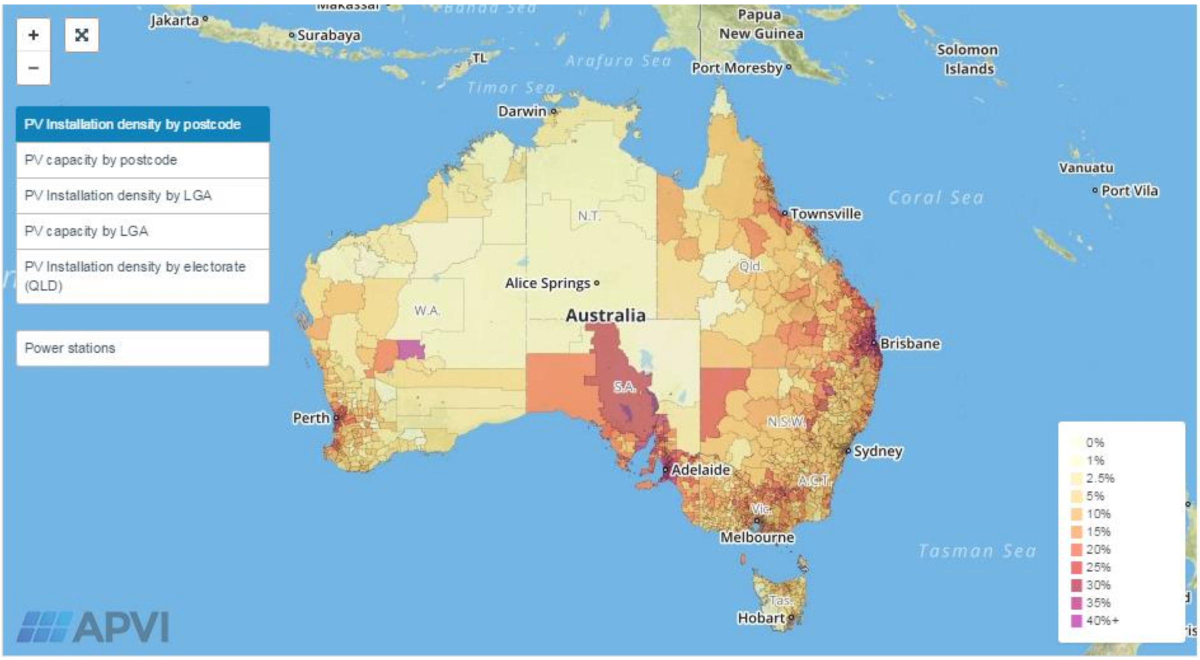

Figure 3: PV Installation Density by Local Government Area (APVI, 2015)

A summary of the cumulative installed PV Power, from 1992-2014, broken down into four sub-markets is shown in Figure 4 and Table 4.

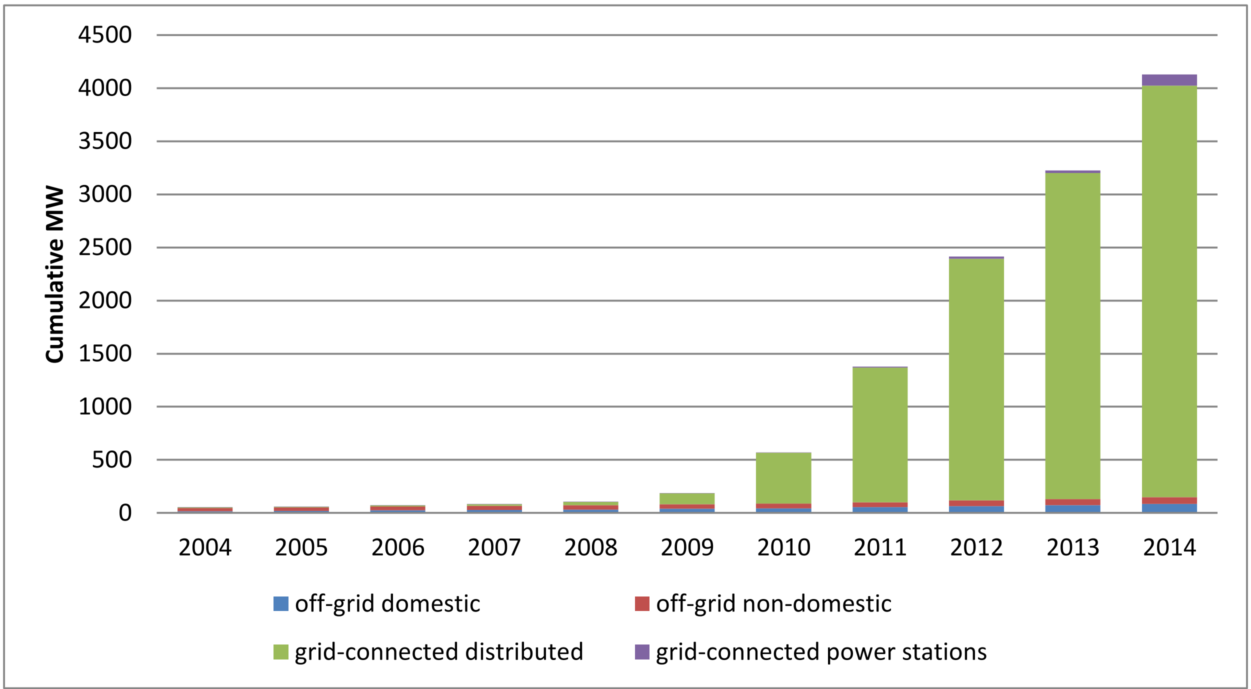

Figure 4: Australian PV Installations by Category 2004-2014

Table 4: The cumulative installed PV power in MWp in the four sub-markets

Sub-market	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
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	54,6	64,6	74	86,9
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	46,89	53,02	58	61,2
Grid-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	1267,9	2275,9	3070	3875
Grid-central				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	21,5	24	107
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**	**187,6**	**570,9**	**1376,8**	**2415,0**	**3225**	**4130**

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Prices are based upon information drawn from the APVI national survey 2014, supplemented by analysis of wholesale price lists. Although pricing is seen to have increased in 2014, this is largely due to the Australian Dollar declining in value against other major currencies. This information is plotted in Figure 5. Table 5 (below) shows the typical price of modules in Australia since 1993 in AUD.

Table 5: Typical module prices for a number of years

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Standard module price(s): Typical	9	7	8	8	7	8	8	8	8	7	7	8	8	8,5	8	8	6	3,2	2,1	1,5	0,75	0,8
Best price														7,5	7	5	3	2	1,2	0,9	0,5	0,62

2.2 System prices

A summary of typical system prices is provided in the following tables, including turnkey prices and national trends in system prices for different applications.

Table 6: Turnkey Prices of Typical Applications – local currency

Category/Size	Typical applications and brief details	Current prices per W
OFF-GRID Up to 1 kW	Water pumps, lighting, remote homes	AUD 9 - AUD 15
OFF-GRID >1 kW	Pastoral systems	AUD 7,50/W – AUD 11/W
	Telecommunications / mining power systems	AUD 22/W – AUD 60+/W
Grid-connected Rooftop up to 10 kW (residential)	Residential	AUD 1,95
Grid-connected Rooftop from 10 to 250 kW (commercial)	Commercial rooftop	AUD 1,78
Grid-connected Rooftop above 250 kW (industrial)	Larger rooftops	AUD 1,80
Grid-connected Ground-mounted above 1 MW	Solar farms	AUD 1,80

Pricing for solar power systems (installed cost before any applicable subsidies) is shown in Table 6 (above). This includes pricing for off-grid solar PV systems in a number of different applications as well as grid-connected systems categorised into different system size brackets. Table 7 (below) shows Australian trends in PV system prices for different applications.

Table 7: National trends in system prices (current) for different applications – AUD

Price/Wp	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Residential PV systems < 10 KW					11	12	12	14	14	13	10	12	12	12,5	12	12	9	6	3,9	3	2,5	1,95
Commercial and industrial																						1,78
Ground-mounted																						1,8

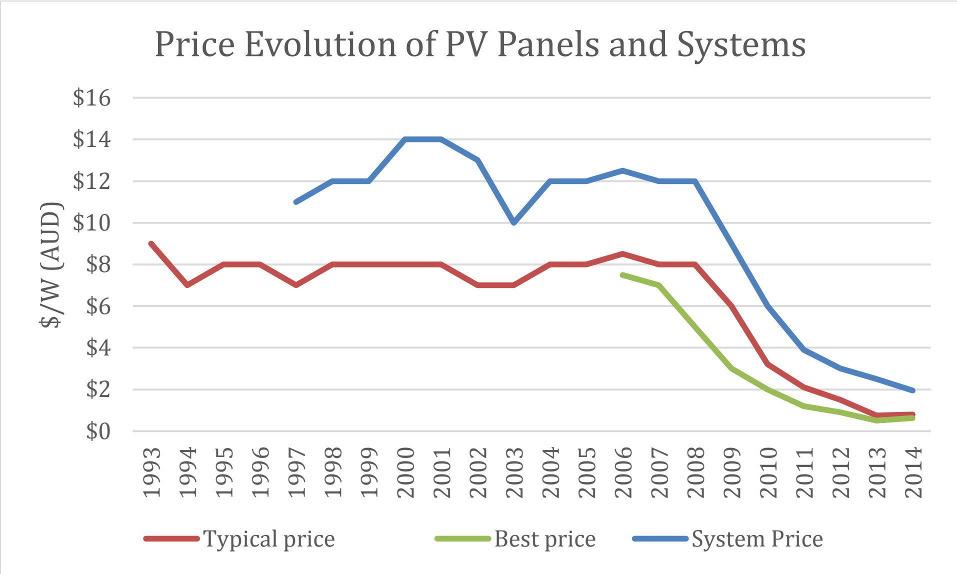

Figure 5: Price evolution of PV Panels and Systems

Figure 5 (above) shows the significant decline in PV panel and system prices in the past six years from 2008, although 2014 as compared to 2013 has stabilised somewhat.

2.3 Cost breakdown of PV installations

The cost breakdown for a typical residential PV system shown below in Table 8 (below) is based upon a small survey of participants, and represents the average of their values at a single point in time during late 2014. Consequently the breakdown presented here is different to the overall market average shown in Table 7 (above).

Table 8: Cost breakdown for a residential PV system – Australian Dollars (AUD)

Cost category	Average (AUD/W)
Module	0,77
Inverter	0,33
Other (racking, wiring)	0,21
Installation	0,35
Customer Acquisition	0,08
Profit	0,36
Other (permitting, contracting, financing)	0,04
Subtotal Hardware	**1,31**
Subtotal Soft costs	**0,83**
Total	**2,14**

2.4 Financial parameters and programs

More finance providers and a broader range of finance options came to the market in 2014, though most residential customers in Australia still purchase their PV systems using cash or a mortgage extension, the latter typically representing the lowest finance cost available. Power Purchase Agreements (PPAs) have been introduced to Australia for both residential and commercial systems with limited success so far. The CEFC has also supported the provision of residential and commercial PPAs, and discounted equipment finance products for businesses.

Table 9 (below) gives an overview of PV financing schemes in Australia and their basic features.

Table 9: PV financing scheme

Average Cost of capital per market segment	Typical mortgage rate: 5,5%. Typical finance rate: 10%
Leasing	PV customers can lease a system for a set period, typically 5-10 years, paying no up-front cost, with repayments fixed or with a pre-determined annual escalator. Options to renew the lease or to own the system at the end of the lease period are also available.
Power Purchase Agreements	PV customers can enter into an agreement to purchase power directly via solar panels without any upfront capital expense. An external entity will pay for and own the solar power system on the customer's premises and will offer a discounted electricity rate to the customer over a fixed period (such as 25 years).

2.5 Additional information about Australia

Electricity prices vary across Australia, by electricity market, by retailer and by end use. Prices across all sectors have increased significantly over recent years, which made PV electricity cost effective against retail tariffs in most parts of the country.

General information about Australia is provided in Table 10 and more detail on electricity market operation is provided in Section 7.1.

Table 10: Information about Australia

Retail Electricity Prices for an household (range)	AUD 0,21 – 0,38 / kWh (flat tariffs)*
Retail Electricity Prices for a small commercial company (range)	AUD 0,23 – 0,35 / kWh
Retail Electricity Prices for a large commercial or industrial company (range)	AUD 0,12 – 0,22 / kWh
Population at the end of 2014 (or latest known)	23 million
Country size (km^2)	7,69 million sq. km
Average PV yield (according to the current PV development in the country) in kWh/kWp	1400 kWh/kWp per year
Name and market share of major electric utilities.	• Origin Energy (26%) • AGL (24%) • Energy Australia (19%) • Synergy (7%) • ERM Power Retail (6%) • Ergon Energy (6%) • Aurora Energy (4%) • Others (7%)

* Peak rates for time of use tariffs can be as high as AUD 0,52/kWh

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of the Australian PV market. Direct support policies have a direct influence on PV development by incentivising or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

3.1 Direct support policies

A summary table of PV support measures in Australia is shown in Table 11 (below). No new support measures commenced in 2014.

Table 11: PV support measures (summary table)

	On-going measures	Measures that commenced during 2014
Feed-in tariffs (gross / net?)	✓ (both gross and net, depending on State)	
Capital subsidies for equipment or total cost	✓	
Green electricity schemes	✓	
PV-specific green electricity schemes	✓	
Renewable portfolio standards (RPS)	✓	
PV requirement in RPS		
Investment funds for PV	✓	
Income tax credits		
Prosumers' incentives (self-consumption, net-metering, net-billing…)	✓ (Depending on State)	
Commercial bank activities e.g. green mortgages promoting PV	✓	
Activities of electricity utility businesses	✓	
Sustainable building requirements	✓	

3.2 Direct Support measures

3.2.1 The Renewable Energy Target

The RET consists of two parts – the Large-scale Renewable Energy Target (LRET), which is currently set at 41.000 GWh by 2020, and the Small-scale Renewable Energy Scheme (SRES), with no set amount. 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.

Reviews of the RET are required by legislation to be conducted every two years by the Climate Change Authority (CCA). Though the CCA's 2012 RET Review found little reason to significantly modify the RET, the new government appointed an independent review in 2014. The 2014 RET Review found that renewable energy generation was likely to exceed 20% of generation by 2020, due to reducing electricity demand, and recommended that the RET be reduced. By the end of 2014, the government was unable to secure sufficient support from the Senate to amend the RET. At the time of writing, a compromise position has been *reached that will entail no change to the SRES, a* *reduction in the LRET to 33.000 GWh, and the removal of 2-yearly reviews, though this has not yet passed the Senate.*

3.2.1.1 *Large-scale Renewable Energy Target*

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 12 (below). Note that legislation currently before parliament will reduce the final LRET to 33.000 GWh, with interim targets reduced from 2016.

Table 12: Annual Generation Targets under the LRET (as at end 2014)

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

3.2.1.2 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 up to 2016, but each year from then on will receive one year less deeming, in line with the RET completion date of 2030. Installed capacity and system size from 2009 to 2014 are shown in Figure 6 (below).

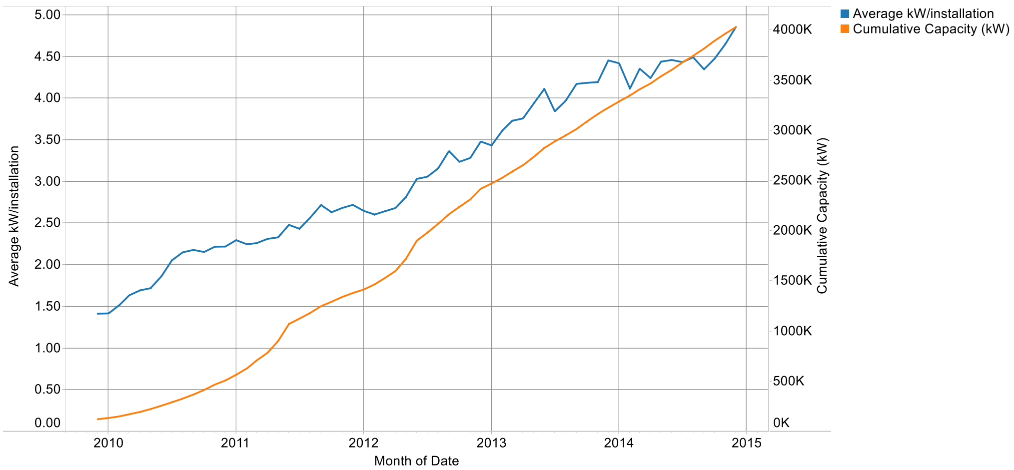

Figure 6: Cumulative installed capacity and average system size for SRES systems 2009-2014.

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.

3.2.2 The Australian Renewable Energy Agency (ARENA)

ARENA has two objectives: to improve the competitiveness of renewable energy technologies, and to increase the supply of renewable energy in Australia. It had an AUD 2,5 billion budget (of which approximately AUD 1,3 billion remained at end 2014) to:

- fund renewable energy projects
- support research and development activities, and
- support activities to capture and share knowledge.

ARENA is supportive of all renewable energy technologies and projects across the various stages of the innovation chain – from research in the laboratory to large scale technology projects. More details are provided under Section 4.1. The Australian Government has proposed abolishing ARENA, but to date has not gained sufficient support in the Senate for this.

3.2.2.1 Solar Flagships

The Solar Flagship program is now administered by ARENA. A project by AGL/First Solar was selected for a Solar Flagship grant. It will deliver projects with a total nominal capacity of 155 MW_{AC} at Nyngan (102 MW) and Broken Hill (53 MW) in New South Wales. Details are provided in .

The system frames are being manufactured by IXL in Adelaide. Construction commenced in 2014 and construction of both plants is expected to be completed by end 2015. 31 MW was installed by end 2014.

In addition to supplying the solar modules for the projects, First Solar will provide the engineering, procurement, and construction (EPC) services, as well as operations and maintenance (O&M) support for the first five years of operation.

The Australian Government will provide AUD 129,7m in funding to support project implementation, and the NSW Government will provide AUD 64,9m . Total capital expenditure for the two solar projects is expected to be approximately AUD 450m. An additional AUD 40,7m has been made available to the Universities of Queensland and NSW for education infrastructure research funding associated with the Flagship, as discussed in Section 4.4.13.

Capacity/Generation:	Nyngan	Broken Hill
MW (AC)	102	53
Annual GWh (at plant boundary)	233.4	126
AC Capacity factor (at plant boundary)	26%	27%
Construction:		
Scheduled construction start	Jan 2014	July 2014
Scheduled construction end	June 2015	Nov 2015
Peak Direct construction jobs created	300	150
Design Details:		
Site area (ha)	460	200
Solar Field area (ha)	250	140
Number of modules (approx)	1,350,000	650,000
Number of posts (approx)	150,000	75,000
Number of inverters	154	80
Number of strings	105,000	55,000
Environmental Benefits:		
Equivalent NSW homes powered @ 7 MWh/yr	33,300	17,000
Equivalent cars off the street	53,000	29,000

Figure 7: Details of the First Solar / AGL Solar Flagship Projects (First Solar, 2015)

Figure 7 (above) gives an overview of the Nyngan and Broken Hill solar flagship projects.

3.2.3 Clean Energy Finance Corporation

The CEFC is an Australian Government initiative that invests using a commercial approach to overcome market barriers and mobilise investment in renewable energy and lower emissions technologies. The current government has proposed the CEFC be abolished, but has to date been unable to gain sufficient cross-bench support for this action.

Recent CEFC-funded PV projects include innovative solar leasing projects with 3 major PV companies:

- SunEdison Australia is working with local partners to deliver PPAs and leasing programs to customers with the support of AUD 70m from the CEFC
- Tindo Solar is offering a PPA product to residential and business customers for small to medium-sized systems. The CEFC has contributed up to AUD 20m to finance this project.
- Kudos Energy is offering PPAs focused on commercial and strata sectors. The CEFC is providing up to AUD 30m to this project.

The CEFC has also committed to AUD 80m in funds for Australia's first unlisted clean energy direct infrastructure investment fund. The fund is hoped to attract new sources of investment in renewable energy including superannuation funds.

The Uterne solar power station at Alice Springs will be upgraded with the assistance of AUD 13m from the CEFC. The 3,1 MW upgrade brings the total Uterne solar plant to 4,1 MW in size making it one of the largest solar-tracking power plants in the Southern Hemisphere.

The CEFC has also provided AUD 60m senior debt finance to the 56 MW Moree solar farm, which will be completed in 2015.

3.2.4 Direct Action

The federal government's Direct Action Plan was brought into legislation after critical support was won in October 2014. Although the Direct Action Plan supports emissions reduction mechanisms, it doesn't directly support the growth of PV.

3.2.5 State and Territory Support

State Governments support a range of research, development and demonstration projects.

The ACT Large-scale Solar Auction

The 40 MW ACT Large-scale Solar Auction commenced on 27 January 2012 and closed on 16 April 2013. Three proponents were successful and awarded a 20 year Grant of Feed-in Tariff Entitlement, namely:

- FRV Royalla Solar Farm Pty Limited (shown in Figure 8 below) for a 20 MW proposal, in the Tuggeranong district of the ACT (fixed plate PV);
- OneSun Capital 10 MW Operating Pty Ltd for a 7 MW proposal to be located in the Coree district of the ACT (fixed plate PV); and
- Zhenfa Canberra Solar Farm One Pty Ltd for a 13 MW proposal to be located in the Tuggeranong district (mainly fixed plate PV but including around 0,5 MW of ground mounted tracking PV).

The FRV project has commenced and was commissioned in July 2014. Although progress was made on the OneSun and Zhenfa projects in 2014, neither has commenced construction. OnseSun faced community opposition to its preferred location, and has recently found an alternative site.

Figure 8: Royalla Solar Farm. (FRV Services Aust Pty Ltd, 2015)

The Solar Auction represented the first capacity release under the ACT *Electricity Feed-in (Large-scale Renewable Energy Generation) Act 2011*, which now provides for up to 550 MW of renewable energy generation capacity for generators located in the National Electricity Market and connected to that network. In 2014 the ACT also created a new Community Solar Feed-in-Tariff (FiT) for up to 1 MW, and has recently announced an EOI process for Next-Generation Solar.

3.2.5.1 Other State Support

The NSW Government provides funding through its Regional Clean Energy Program (RCEP) and Growing Community Energy (GCE) grants. GCE grants have supported 19 recipients with community energy initiatives including several solar PV projects.

Queensland has a Gambling Community Benefit Fund which supports not-for-profit organisations with financial support for investment, including solar PV.

South Australia's RenewablesSA initiative established a new target of 50% renewable energy production by 2025 through continuing to develop projects in South Australia and help remove barriers to investment in the renewables sector.

3.2.5.2 Feed-in-Tariffs

Though the final premium FiT concluded in 2014, historical FiTs applied in many Australian states in 2014 for systems less than 30 kW, as shown in Table 13 (below). The Australian Capital Territory also provided FiTs via the Large-scale Solar Auction as discussed above.

Table 13: Australian State and Territory Feed-in-Tariffs in 2014

State	Start Date	Size Limits	Rate AUD c/ kWh	Scheme end	Type	Eligibility
Victoria						
Premium FiT (closed 1 Jan 2012)	1 Nov 2009	5 kW	60	2024	Net	Residential, community, small business
Transitional (closed 30 Sept 2012)	1 Jan 2012	5 kW	25	31 Dec 2016	Net	Residential, community, small business
Standard (closed 30 Sept 2012)	1 Jan 2012	100 kW	Retail rate	31 Dec 2016	Net metering	Residential, community, small business
New Standard	1 Jan 2013	100 kW	8 (updated each year)	1 Jan 2015	Net	Residential, community, small business
Comments	Customers lose their FiT and revert to the New Standard FiT if they change their system size or move house. It is compulsory for retailers to offer at least the New Standard FiT rate.					
South Australia						
Groups 1, 2 & 3 (closed 30 Sept 2011)	1 July 2008	10 kVA 1Ø 30 kVA 3Ø	44	30 June 2028	Net	A facility that consumes less than 160 MWh/yr
Group 4 (closed 30 Sept 2013)	1 Oct 2011	10 kVA 1Ø 30 kVA 3Ø	16	30 Sept 2016	Net	A facility that consumes less than 160 MWh/yr
Group 5	1 Oct 2013	10 kVA 1Ø 30 kVA 3Ø	5,3 (updated each year)	Open ended	Net	A facility that consumes less than 160 MWh/yr

Comments	Groups 1, 2 & 3 differ according to the amount of electricity the FiT applies to and when the system was logged with the network operator. The Group 5 FiT is called the 'minimum retailer payment' and customers may receive it in addition to their Group 1-4 FiT. It was originally set at AUD 0,071/kWh for 2011-12, AUD 0,098/kWh for 2012-13, and AUD 0,112/kWh for 2013-14, however was left at AUD 0,098/kWh for July to Dec 2013 and was reduced to AUD 0,076/kWh from Jan 2014 and AUD 0,053/kWh from 2015. Group 1-4 customers may convert to Group 5 if they change their system size or move house. They will be required to convert to Group 5 if they install storage.					
ACT						
Gross FiT (closed 31 May 2011)	1 March 2009	30 kW	50,05 (<10 kW), 40,04 (10-30 kW), after 1 July 2010 45,7 (<30 kW)	20 years after connection	Gross	Residential, business
Gross FiT (closed 13 July 2011) Net metering (closed 30 June 2013) Solar Buyback Scheme	1 April 2011 14 July 2011 1 July 2013	30-200 kW 30 kW 30 kW	34,27 Retail tariff 7,5	20 years after connection 30 June 2020 Open ended	Gross Net metering Net	Residential, business Residential, business Residential, business
Comments	Although the Gross FiT (30 kW) was closed on 31 May 2011, <30 kW systems were made eligible for the Gross FiT (30-200 kW) from 12 July 2011 to 13 July 2011 to allow these systems to access the cap originally set aside for systems 30 kW to 200 kW.					
Northern Territory						
Alice Springs Solar City FiT (closed 31 May 2013) Net metering	May 2008 1 June 2013	2 kW 30 kVA	Ranged 45,76 to 60,40 from 2008/09 to June 2013 Retail tariff	30 June 2013 Open ended	Gross Net metering	Alice Springs residential, business NT wide
Comments	The Alice Springs PV systems were provided as a package, with the largest being 2 kW. The FiT consisted of the retail peak rate (increased over time) plus AUD 0,2265/kWh.					
Queensland						
Solar Bonus Scheme (closed 10 July 2012) New SBS	1 July 2008 11 July 2012	10 kVA 1Ø 30 kVA 3Ø 5 kW	44 around 6	1 July 2028 Open ended	Net Net	Consumers with less than 100 MWh/yr Consumers with less than 100 MWh/yr
Comments	The SBS net amount was not be mandated for SE Qld after 1 July 2014. Customers may default to the new SBS FiT if they change their system size or move house.					
New South Wales						
Solar Bonus Scheme 60 (closed 27 Oct 2010)	1 Jan 2010	10 kW	60	31 Dec 2016	Gross	Residential

SBS 20 (closed 28 April 2011) Current SBS	28 Oct 2010 28 April 2011	10 kW 10 kW	20 around 6	Until 31 Dec 2016 Open ended	Gross or Net Net	Residential Residential
Comment	Customers may default to the 20 FiT if they change their system size or move house. It is not compulsory for retailers to offer the 'current SBS'					
Western Australia						
Residential FiT scheme (closed 1 Aug 2011) Renewable Energy Buy-back Scheme (REBS)	1 July 2010 2005	5 kW (city) 10 kW 1Ø 30 kW 3Ø (country) Up to 5 kW	40 to 30 June 2011 20 from 1 July 2011 dropped to 7,135 from 9,5 on 1 September 2014	10 years after installation Open ended	Net Net	Residential Residential, Commercial (Horizon Power)
Comments	The amount of the REBS FiT depends on the local cost of generation, the retail tariff and whether residential or commercial					

3.2.6 *Prosumers' development measures*

Self-consumption of electricity is allowed in all jurisdictions in Australia. Currently no additional taxes or grid-support costs must be paid by owners of residential PV systems (apart from costs directly associated with connection and metering of the PV system), although there is significant lobbying from utilities for additional charges to be levied on PV system owners.

3.2.7 *BIPV development measures*

None.

3.2.8 *Rural electrification measures*

None

3.2.9 *Other measures including decentralized storage and demand response measures*

There are no direct support mechanisms for storage and demand response. However, Australia is likely to be one of the first international markets in which storage is financially attractive, owing to the sizable difference between solar generation that is self-consumed and that which is export to the grid.

3.2.10 *Support measures phased out in 2014*

None.

3.2.11 *New support measures implemented in 2014*

Direct Action was implemented in 2014, though does not directly support PV

3.2.12 *Measures currently discussed but not implemented yet*

None.

3.2.13 Financing and cost of support measures

The RET is a cross- subsidy incentive (paid for by electricity consumers). Emissions Intensive Trade Exposed (EITE) industries are exempt from paying RET costs. Government mandated feed-in tariffs are mostly funded via indirect cross-subsidies through payments from electricity retailers or occasionally state governments.

Payments from electricity retailers are funded by customers and typically represent avoided cost in purchasing power elsewhere.

3.3 Indirect policy issues

3.3.1 International policies affecting the use of PV Power Systems

Anti-dumping in Europe and the US has made Australia more interesting for Chinese exports. Consequently Australian panel prices are some of cheapest in world. In 2014, an anti-dumping claim launched by Australian manufacturer Tindo was investigated by the Anti-Dumping Commissioner. In mid-2015 the Commission found “that PV modules or panels exported to Australia from China during the investigation period were dumped. The volume of dumped goods, and the dumping margins, were not negligible.” Dumping margins in the range of 2,1-8,7% were calculated. However, the Commission found “that injury or hindrance to the establishment of an Australian industry caused by dumped exports is negligible”. The case is yet to be finalised.

3.3.2 The introduction of any favourable environmental regulations

None.

3.3.3 Policies relating to externalities of conventional energy

None.

3.3.4 Taxes on pollution (e.g. carbon tax)

In 2014 the Australian carbon price was abolished. The effects of this effectively reduced wholesale electricity prices. This produced a dampening effect upon retail electricity prices, which would otherwise have risen due to coal and gas generation cost increases. The overall impact of the carbon price repeal has been to worsen the financial appeal of solar.

3.3.5 National policies and programmes to promote the use of PV in foreign non-IEA countries

Australia will extend an AUD 4,9m grant for the construction and installation of solar power systems on nine islands in Tonga. Australia is participating in the project through the Australian Agency for International Development (AUSAID) together with the Asian Development Bank (ADB) which will also provide an AUD 2,18m grant for the project.

Kiribati and the World Bank signed an agreement for an AUD 4m solar energy project for the small Pacific nation. Mostly funded by Australia, the project will provide 15 percent of Kiribati’s electricity.

4 HIGHLIGHTS OF R&D

Australia has a long history of publicly funded support for R&D, market stimulation and demonstration programs. Current activities are led by ARENA and the Australian Research Council (ARC). Research is carried out largely in Australian Universities and Institutes, plus a small number of private companies that carry out research into product development and design as well as research and analysis of the role of PV in the energy market.

4.1 The Australian Renewable Energy Agency

ARENA is the main R&D support measure in Australia specific to renewables. ARENA had an initial AUD 2,5 billion budget and two objectives: to improve the competitiveness of renewable energy technologies, and to increase the supply of renewable energy in Australia. It achieves this by:

- funding renewable energy projects
- supporting research and development activities, and
- supporting activities to capture and share knowledge.

In 2014, ARENA provided AUD 21,5m to 12 solar research and development projects.

4.2 The Australian Research Council

The ARC is a statutory agency within the Australian Government. Its mission is to deliver policy and programs that advance Australian research and innovation globally and benefit the community. The ARC provides advice to the Government on research matters, manages the National Competitive Grants Program (NCGP), and administers Excellence in Research for Australia (ERA).
Through the NCGP - a significant component of Australia's overall investment in research and development - the ARC supports the highest-quality fundamental and applied research and research training through national competition across all disciplines, with the exception of clinical medicine and dentistry.

ERA assesses research quality within Australia's higher education institutions and gives government, industry, business and the wider community assurance of the excellence of research conducted. It also provides a national stocktake, by research discipline areas, of research strength against international benchmarks.

In 2014 AUD 2,6m was provided for PV related R&D.

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

The Australian budgets for solar research and field testing are shown in Table 14 (below)

Table 14: Public budgets in AUD million for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	24,12	79,2
State/regional	0	32,5
Total	135,82	

4.4 Details of Research

Almost every university in Australia undertakes some level of PV research, be it science, engineering or socio-economic. A selection of key research is described below.

4.4.1 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://sun.anu.edu.au) at ANU was founded in 1991, and is one of the largest and longest established solar energy research groups in Australia.

Activities in CSES span the range from basic R&D through to technology commercialisation with a focus on silicon. The research is supported by a sophisticated research laboratory and an extensive PV testing and characterisation facility. Current grants and contracts total AUD 20m. Funding support comes from the Australian Research Council, ARENA, the Defence Department, industrial companies and several other sources. In 2014 work continued on the following projects:

- >24% efficient Interdigitated Back Contact solar cells
- Next Generation Sliver Solar Cells
- Roof-top solar micro concentrators
- Plasmonics for solar cells
- Flexible portable micro modules
- Improving conventional silicon solar cells
- Defect detection and quenching

ANU offers a popular Renewable Energy Major as part of its undergraduate engineering degree, as well as a corresponding master's degree. PV is an integral part of the Master of Energy Change program offered by the ANU Energy Change Institute (http://energy.anu.edu.au).

4.4.2 Australian PV Institute

The Australian PV Institute (APVI) is a member based association of companies, agencies, individuals and academics with an interest in solar energy research, technology, manufacturing, systems, policies, programs and projects with an objective to s*upport the increased development and use of PV via research, analysis and information*

The APVI conducts research into the Australian PV Market and is intended to be apolitical and of use not only to our members but also to the general community through a focus on data analysis, independent and balanced information, and collaborative research, both nationally and internationally. In addition to Australian activities, the APVI provides the structure through which Australia participates in two International Energy Agency (IEA) programs – PVPS (Photovoltaic Power Systems) and SHC (Solar Heating & Cooling).

2014 highlights include the Live Solar Map including a number of tools for mapping of PV penetration by postcode and local government area, for market analysis and for identifying key areas with high solar potential as well as an animation demonstrating the uptake in solar. A snapshot of the graphics appears below in Figure 9.

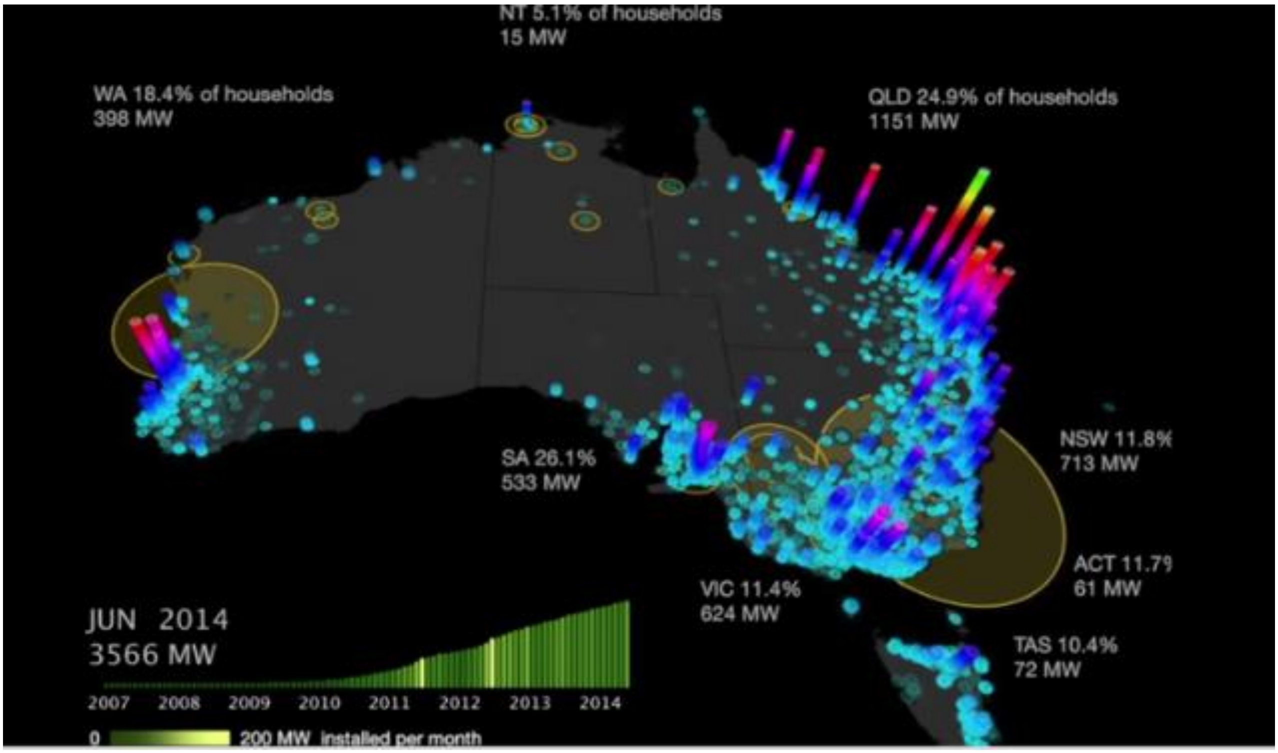

Figure 9: APVI Solar Mapping Tools – Animation. (APVI, 2015)

4.4.3 Charles Darwin University

PV research at The Centre for Renewable Energy (CRE - http://cre.cdu.edu.au), within Charles Darwin University, focuses on three main areas: remote area hybrid PV systems, network integration and PV module performance under the unique cyclonic tropical locale of the Northern Territory.

Remote area hybrid PV systems

- Integration of PVs into existing diesel power systems in remote communities.
- The economics and performance of storage devices in remote areas.
- Development of smart algorithms using artificial intelligence techniques for system optimization.

Network integration

- The use of intelligent techniques to prevent overvoltage for residential rooftop PVs.
- The economics and effects of implementing demand-side management for residential systems.

PV module performance

- Performance testing of various PV technologies (CIGS, CdTe, c-Si, etc.) under the Northern Territory climate.
- The impact of environmental effects such as soiling, temperatures, fauna, rainfall, etc. on different PV technologies.
- Development of forecasting models for system optimization.

The CRE has five full-time staff, three adjuncts and three post-graduate students working on renewable energy technologies, energy efficiency and policy research. Funding support comes from the Northern Territory Government, ARENA, Department of Industry and Science, Defence Housing Australia, Industry Partners and other sources.

4.4.4 CSIRO PV Performance Laboratory

2014 saw the completion of CSIRO's PV Performance facilities at Newcastle, including awarding of the IEC/ISO 17025 competency standard for the cell measurement laboratory. The new PV Performance Laboratory includes NATA accredited testing of solar cells, plus calibrated flash testing of modules, and an advanced outdoor facility for characterising a solar module's response to a host of environmental variables. In addition to providing commercial measurement services, the facilities are supporting CSIRO's PV research. In 2014 this research was primarily in two areas, Perovskite solar cells and PV output modelling. The output modelling research focussed on the accuracy of current-voltage translation equations and the impact of solar spectrum, both of which will improve the way we deal with the intermittent nature of the output from large PV systems for electricity generation in Australia.

Figure 6: CSIRO's PV Performance Laboratory consists of NATA accredited cell testing, advanced outdoor testing and calibrated module flash testing. (CSIRO, 2015)

4.4.5 Dyesol Ltd

Dyesol Limited (ASX: DYE) is a renewable energy supplier and leader in Perovskite Solar Cell (PSC) technology. The Company's vision is to create a viable low cost source of electricity with the potential to disrupt the global energy supply chain and energy balance.

Dyesol manufactures and supplies PSC materials and is dedicated to the successful commercialisation of PSC photovoltaics. A team of highly skilled scientists and engineers focus on:

1. Developing (and continuously advancing) a suite of thoroughly tested PSC chemicals, components and equipment used in the manufacture of PSC cells, modules and panels to researchers and industrialists,
2. Providing turn-key and custom fabrication facilities for research, development and production of PSC photovoltaic devices, and
3. Providing specialist training, consulting and engineering solutions for the application of PSC photovoltaic technology.

4.4.6 Global Roam Pty Ltd

GLOBAL-ROAM Pty Ltd is a company that has, for more than 15 years, sought to make the energy market more understandable to a diverse range of clients to enable them to make better decisions. Beginning in 2014, GLOBAL-ROAM worked with APVI and RenewEconomy in the development of the "Generation by Fuel Type" research tool. This is another means for providing a clear display of the current generation mix sustaining electricity demand in Australia's National Electricity Market. This widget is a sub-set of the data available in the broader NEM-Watch application, which also now features solar data from the APVI. This analysis (www.NEM-Watch.info) is widely used across the industry, and is also featured online in social media in places such as: RenewEconomy and Climate Spectator.

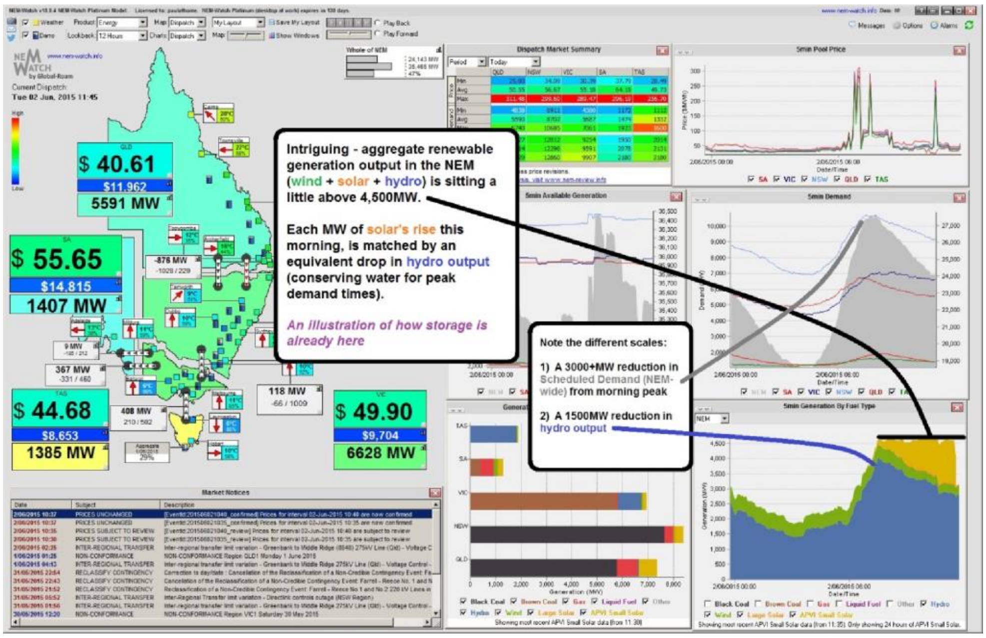

Figure 7. Solar Generation contributing to the National Electricity Market (NEM). (Global Roam Pty Ltd, 2015)

Into the future, GLOBAL-ROAM plans to also include historical the APVI small-scale solar output into our NEM-Review (www.NEM-Review.info) historical analysis software package. This will enable a broad range of people to perform their own analysis relating to the changing pattern in the generation mix over time.

4.4.7 Monash University

Monash University is a world leading research organisation in next-generation solar cells that harness the potential of printing methods. The team attracted about AUD 2m in 2014 from the Australian Research Council, ARENA and the Victorian Government. It has published in leading international journals, such as Nature Material, Nature Photonics and Nature Chemistry, with 66 manuscripts in 2014 alone. The university's target is to work with industrial partners to develop relevant and ground-breaking research towards cost-competitive solar cell technologies.

A research team of four academics and more than 40 postgraduates and research fellows in the Renewable Energy Lab at Monash University focuses their research on solution based photovoltaic technologies. These include dye sensitised solar cells, organic solar cells and more recently perovskite solar cells. As a key partner of the Victorian Consortium of Organic Solar Cells (VICOSC), the Monash team developed a ten metre long screen printing line for continuous printing of dye sensitised solar cells (DSC) on glass and plastic substrates, up to 300x300 mm in size (Figure 10).

Figure 10: Screen printing line for printing dye sensitised solar cells. (Monash University, 2015)

A major effort in 2014 was on the development of perovskite solar cells. The team investigated the problems in forming perovskite thin films and developed two novel coating techniques that de-coupled the nucleation and grain growth during the spin coating process, resulting in high quality perovskite films. Planar perovskite solar cells of 17% efficiency were achieved.

Research into organic photovoltaics focuses on understanding the device physics and morphology of high performance devices. A particular strength is the use of advanced synchrotron techniques to characterise thin-film microstructure, with the Australian Synchrotron located adjacent to the university's campus. Polymer based solar cells with efficiency of greater than 9% have been achieved, and the microstructural characteristics of such devices defined. Low-temperature characterisation of cell behaviour is also being carried out with an optical cryostat capable of going down to liquid helium temperatures.

4.4.8 Murdoch University

PV activities at Murdoch University (MU) are coordinated through the School of Engineering and Information Technology (SEIT) and cover a range of PV research and educational activities.

A group of MU researchers is contributing to a joint research project on "Climate Based Photovoltaic System Performance & Reliability" coordinated by the Australian PV Institute with the U.S. National Renewable Energy Laboratories (NREL), University of NSW, the Centre for Appropriate Technology in Alice Springs, and the Clean Energy Council. This project contributes to the International Energy Agency Photovoltaic Power Systems Task 13: Performance and Reliability of PV Systems and the International PV Module Quality Assurance Task Force.

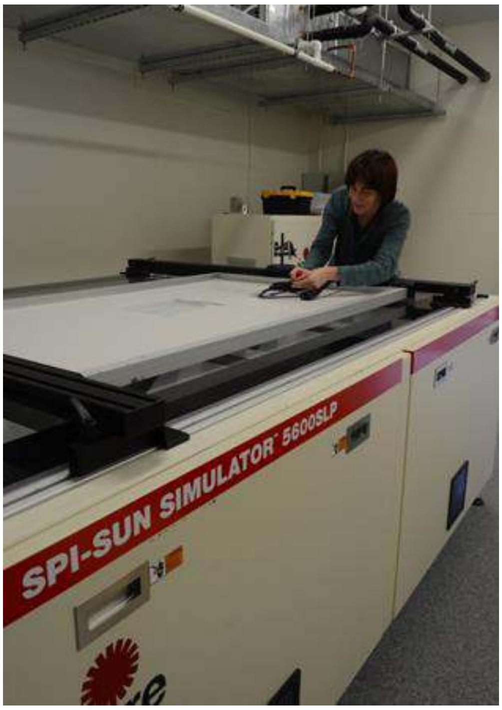

Figure 11 Spire SPI-Sun Simulator 5600SLP at Murdoch University. (Murdoch Univ. 2015)

Figure 9: Kieran Peters, Murdoch University final year Renewable Energy Engineering student, with a Photovoltaic Array Troubleshooting and Educational Facility built as a final year thesis project. (Murdoch Univ. 2015)

Advances in 2014 include:

i) the development of the PV Module and System Fault Reporting Portal (www.surveymonkey.com/s/pvwebportal)
ii) to the characterization and assessment of PV module conditions in the field, and
iii) case studies in Indonesia and Western Australia concerned with the effect of dust on the performance of PV modules.

Murdoch has completed the installation and commissioning of a new solar simulator from Spire. The newly commissioned solar simulator is a Spire SPI-Sun Simulator 5600SLP, solar panel IV measurement system. This system has Class A+ spectral/spatial/temporal performance with a measurement repeatability of ≤ 0,15% and can accept a wide range of modules sizes. This new system allows the provision of testing services to local industry as well as providing students at Murdoch University practical experience with top of the range industry equipment.

The School's thin film PV devices group is looking at ways of incorporating silicon nanowires into thin film devices to improve their efficiency and stability. Research in this area continued on the design and optimisation of nanocrystalline silicon solar cells. A variety of suitable catalysts were used to grow the silicon nano wires (SiNWs) in situ and several different designs were tested to determine the best approach.

Another key research area within the School is interdisciplinary research on low emission technologies: assessing their appropriateness, cost and environmental impacts as well as analysing the influence of policies and processes on uptake of low emission technologies including PV applications.

4.4.9 Queensland University of Technology (QUT)

PV Research at QUT spans the full range of activities from fundamental materials and cell development through to integration of photovoltaics in the electricity system, including issues of network power flows and optimisation of battery storage and development of battery storage algorithms. The research is conducted through the Future Energy Systems and Clean Technology Program of the Institute for Future Environments. Research on solar thermal electricity generation is also being conducted as part of the Australian Solar Thermal Research Initiative consortium.

The research focuses in three main areas: materials and devices; systems; and network integration (including storage).

4.4.10 Solar Systems Pty Ltd

Solar Systems is developing a unique "Dense Array" concentrating dish PV technology in Victoria using multi-junction cells operating at ~40% conversion efficiency. Two facilities have been built in recent years - a 40 dish, 1,5 MW CPV demonstration facility in Mildura which received funding support from the Victorian and Australian governments, and a 28 dish, 0,8 MW power generation facility operating in Nofa, Saudi Arabia.

Figure 12: 1,5 MW Solar Systems CPV system, Mildura, Victoria. (Solar Systems Pty Ltd, 2015)

Solar Systems is focussed on taking this technology to market in high DNI solar regions with a strategic investor or acquirer.

4.4.11 University of Melbourne

The University of Melbourne, as lead partner in the Victorian Organic Solar Cell Consortium (VICOSC) has developed a world leading printing capability in the two key emerging technologies, bulk heterojunction solar cells (BHJ) and dye sensitised solar cells (DSC) technologies. The consortium is aiming to bring the organic photovoltaic technologies to a level where they can be commercialised, with product development leading to cost competitive products and finally to printed modules rivalling traditional silicon solar cells. The international development goal post for high efficiency solar cells has been set at 10% PCE for a single junction device.

The University of Melbourne is actively examining new materials classes and device architectures through a fundamental understanding of structure-function and synthesis of organic materials. For example, the University is developing Luminescent Solar Concentrators (LSC) using a new class of aggregation-induced emitters. The aim is to develop highly efficient LSC materials for use on the large glassed areas available in modern buildings where light is channelled and amplified for collection by high efficiency solar cells at the windows' edge.

4.4.12 University of New South Wales (UNSW Australia)

The main UNSW Australia research and educational activities are coordinated through of the School of Photovoltaics and Renewable Energy Engineering. The School hosts 29 academic staff, 60 research and support staff and 140 PhD students.

The Australian Research Council (ARC) Photovoltaics Centre of Excellence commenced at UNSW Australia in 2003. The Centre is now dependent upon industry-related funding for research with near-term outcomes and upon more academically orientated ARC, ARENA and international schemes for its long-term research.

The Centre maintains its world-leadership in "first generation" devices, with international records for the highest-performing silicon cells in most major categories. Centre research addresses the dual challenges of reducing cost and further improving efficiency. The rapid growth of the industry is generating widespread interest in ongoing innovations of the Centre's first generation technology with several distinct technologies now in large-scale production with an estimated 10% of the current manufacturing capacity using the UNSW PERC concepts.

Centre researchers have pioneered work in second generation photovoltaics with activities in thin silicon layers on glass, organic solar cell research, as well as CZTS (copper-zinc-tin-sulphide) solar cell technology.

The Centre's interest in advanced "third-generation" thin-film solar cells targets significant increases in energy-conversion efficiency. The Centre's experimental 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.

Significant research is also undertaken in the areas of PV and renewable energy systems and policy. During 2014, research has included high PV penetration in electricity grids, development of a live PV Map for Australia, PV performance analysis, integration of PV and storage, PV/thermal systems, solar forecasting, PV policy and distributed energy market design.

The School of Photovoltaics and Renewable Energy Engineering is unique in its offering of a Bachelor of Engineering (Photovoltaics and Solar Energy) program. This program has been running for over ten years and has been enormously successful, attracting some of the best and brightest students entering the University and providing the human resources to fuel the recent growth of the industry. Complementing this is the Centre's second undergraduate program, leading to a Bachelor of Engineering (Renewable Energy), with 2015 being its tenth year of operation.

One highlight of 2014 was the achievement by University of NSW (supported by ARENA) of a world record 40,1% efficiency for solar using a solar PV 'Power Cube'.

4.4.13 University of Queensland

Research at the Centre for Organic Photonics and Electronics (COPE) led by Professors Paul Burn and Paul Meredith focuses on developing new materials and architectures to improve the efficiency of organic semiconductor based solar cells and thin film perovskite solar cells. This involves the creation of new active light absorbing materials, modification and understanding of organohalide perovskite materials and architectures, the development of hole and electron transporting materials, transparent conducting electrodes and work function modifiers. COPE also has extensive expertise in the basic electro-optics and transport physics of excitonic and non-excitonic solar cells – this includes developing new experimental methods, theory, simulations and advanced photo-physics and spectroscopy. COPE is a partner in the ARENA funded Strategic Research Initiative (SRI): Australia-US Institute for Advanced Photovoltaics. Within the SRI, the Centre focuses on applying its core expertise in electro-optics and charge transport physics in organic semiconductors and organohalide perovskitesand the creation of new molecules for advanced photon harvesting concepts.

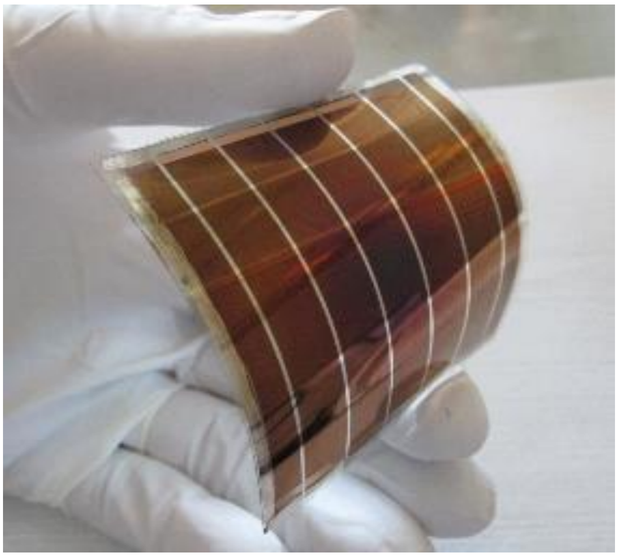

Figure 13: Plastic Solar Cell 5X5 cm^2. (University of Queensland, 2015)

Professor Lianzhou Wang of the Nanomaterials Centre at the University of Queensland is leading a research team investigating new types of solid-state solar cells (SSCs) using perovskite sensitisers and solid electrolytes. Wang's team are investigating less toxic perovskite sensitisers and more stable inorganic hole transporting materials, and optimising the perovskite-based SSCs to improve their efficiency, reproducibility, and stability.

The Power & Energy Systems Group (School of ITEE) led by Professor Tapan Saha 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.

The Energy Economics and Management Group (EEMG) headed by Professor John Foster 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 with the Global Change Institute (GCI) at UQ and played a key role in the development of the very successful UQ Solar research portfolio.

The Global Change Institute (GCI) 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. The Clean Energy Program is led by Professor Paul Meredith and Program Manager, Craig Froome. In particular, the GCI manages the research program of the UQ MW Array Project and the Education Investment Fund Research Infrastructure Project attached to the AGL Solar PV Utility Project.

Figure 14: Gatton Solar Research Facility, an AGL Solar PV Plant Education Investment Fund Research Infrastructure Project. (APVI, 2015)

The Gatton Solar Research Facility is funded by the Australian Government's Education Infrastructure Fund (EIF). The University of Queensland is the lead research organisation and will partner with the University of New South Wales in an AUD 40,7m EIF research infrastructure program that will support the development of the utility-scale solar industry in Australia. The program shares learnings with the projects that First Solar is constructing for AGL Energy at Nyngan and Broken Hill that have a combined capacity of 155 MW (AC).

The Gatton Solar Research Facility is located at UQ's Gatton Campus and is one hour west of Brisbane. It was completed and opened in March 2015 and contains 3.275 MW of fixed, single axis tracking and dual axis tracking First Solar CdTe PV panels. In third quarter of 2015, a large 760 kWh lithium ion battery will be installed at the site, completing the infrastructure package. The Gatton Solar Research Facility is Australia's only commercial-industrial scale PV research facility and is one of the most sophisticated anywhere in the world. This facility brings the total PV plant owned and operated by UQ to > 5 MW.

4.4.14 University of Wollongong

The Sustainable Buildings Research Centre (SBRC) is a multidisciplinary facility that brings together a wide range of researchers to address the challenges of making our buildings sustainable and effective places in which to live and work. The SBRC building includes development of a building integrated “plug-and-play” microgrid containing 160 kWp of solar photovoltaics (refer to picture below). More information can be found at http://sbrc.uow.edu.au.

Figure 15: Sustainable Building Research Centre Solar PV System. (Uni Wollongong, 2015)

Facilities at the SBRC also include the Illawarra Flame House, the winning entry to the 2013 Solar Decathlon China competition, which is currently being used for research into the control and optimisation of building integrated photovoltaic thermal systems. The house incorporates a grid-connected solar photovoltaic system, evacuated tube solar hot water system, and thermal storage utilising phase change material.

More information can be found at http://www.illawarraflame.com.au/.

Other solar photovoltaics related research areas include: enabling tools and technologies for commercial scale solar and solar precincts; net zero energy buildings using solar photovoltaics; and energy management for demand responsive homes.

Current staffing levels of personnel working on solar related projects include three academics, one research engineer, and several higher degree research students. Key research partners in the solar photovoltaics area include Energy Matters (SunEdison) and BlueScope Steel.

5 INDUSTRY

5.1 Production of photovoltaic cells and modules (including TF and CPV)

Tindo Solar manufactures solar panels at Technology Park in Adelaide, South Australia. The Tindo Karra panel is certified with Q-cells and STX, with STX providing a better temperature coefficient. Tindo supplies both traditional DC panels and AC panels, the latter with a factory fitted Solarbridge micro inverter. Both panels produce 250 Watt output +/- 2% and are flash tested in Australia. Tindo's business model is to both sell panels wholesale and retail PV systems.

Tindo Solar did not provide information on its manufacturing levels in 2014. STC registration activity shows that Tindo installed 2,5 MW of panels in 2014, meaning its manufacturing volume is certainly higher than this.

Total PV cell and module manufacture together with production capacity information is summarised in Table 15 (below).

Table 15: Production and production capacity information for 2014

Cell/Module manufacturer (or total national production)	**Technology** (sc-Si, mc-Si, a-Si, CdTe)	**Total Production (MW)**		**<u>Maximum</u> production capacity (MW/yr)**	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Tindo Solar			>2,5		60
TOTALS			**>2,5**		**60**

5.2 Manufacturers and suppliers of other components

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

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

Australian companies Latronics and Selectronics design and manufacture inverters for use in both grid and off-grid applications. Magellan Power is an Australian based manufacturer of power electronics including PV inverters designed for both residential and commercial applications.

5.2.2 Storage batteries

Australian company RedFlow manufactures Zinc Bromine batteries. Its ZBM product delivers up to 3 kW of continuous power (5 kW peak) and up to 8 kWh of energy.

A CSIRO invention called the UltraBattery combines a lead-acid battery and a super capacitor to provide a fast-charging, long-life battery. The battery is being made commercially by storage company Ecoult.

A Magellan Power's 400 kWh lithium polymer battery storage system is in operation at a NSW utility.

Batteries manufactured by foreign companies are also readily available in Australia. LG have lithium iron phosphate battery technologies which can be scaled up to 18 kWh (2 kWh each). Samsung have come out with an all-in-one Energy Storage System which can hold 3,6 kWh in a compact, slim-line housing weight 95 kg. Aquion Energy is entering the Australian market with sodium based battery technologies which could promise to be a better fit for utility-scale commercial PV projects than Lithium ion.

A range of research programs are underway to develop new types of batteries for utility-scale and residential energy applications.

5.2.3 Battery charge controllers and DC switchgear

A range of specialised fuses, switches and charge controllers are made locally. A few examples of charge controllers and switchgear implementations in Australia include:

- Magellan Power has a range of renewable energy battery, control and switching technologies.
- Solari Energy – solaGRID Energy Storage System (ESS) a stand-alone energy storage system suitable for any sized solar energy installation. The company also produce a solaGRID audible alarm safety device in case of faults.

5.2.4 Supporting structures

A range of mounting and tracking systems are made in Australia to suit local conditions. IXL have manufactured the support structures for the First Solar / AGL 155 MW Solar Flagship systems in NSW and for the UQ Gatton Solar Plant. It previously manufactured the supports for the 10 MW First Solar Greenough River solar farm in WA.

5.2.5 BIPV

Bluescope Steel has manufactured thin-film solar panels that are integrated into Colorbond steel sheet roofing. This building-integrated photovoltaic-thermal (BIPV-T) system is employed for the production of electricity and thermal energy, while an innovative thermal duct system warms and cools air to supplement air conditioning in the home.

Tractile Solar combines PV cells with Thermal Hot Water into a Solar Energy Roof Tile. Tractile will list on the Australian Stock Exchange in 2015.

6 PV IN THE ECONOMY

6.1 Labour places

Estimates of direct employment, where the positions are predominantly related to PV, are given in Table 16. Indirect employment would potentially double these numbers[2].

Table 16: Estimated PV-related labour places in 2014

Research and development (not including companies)	400
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	20
Distributors of PV products	200
System and installation companies	10.500
Electricity utility businesses and government	500
Other	3.000
Total	14.620

6.2 Business value

As Australia predominantly relies upon imported PV products, most of the value added in Australia relates to the sales and installation of PV systems. The total value of PV business for 2014 was 742 million AUD, down from 896 million in 2013.

Table 17: Value of PV business in Australia, 2014

Sub-market	**Capacity installed *in 2014* (MW)**	**Price per W (AUD)** *(from Table 7)*	**Value (AUD million)**	**Totals (AUD million)**
Off-grid domestic	*12,9*	*8*	*103*	
Off-grid non-domestic	**4,98**	**8**	*40*	
Grid-connected distributed	**805**	**1,9**	*1.530*	
Grid-connected centralized	**83**	**1,8**	*194*	
				1.867
Import of PV products				*1.125*

[2] REC Agents Association, Solar Business Services and Greenbank, 2014, Impact of abolishing the RET on jobs in the Australia solar industry, available here.

Value of PV business	***742***

The business value above does not include the value of PV related education, research, consulting, media, electricity sector savings or environmental benefits.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

In most areas of the country on main grids the electricity system is split into generation, transmission, distribution and retail sectors. Smaller grids are typically vertically integrated. There is a mix of public and private ownership across all jurisdictions and sectors.

The NEM is a wholesale commodity exchange for electricity across the five interconnected states. The market works as a “pool”, or spot market, where power supply and demand is matched in real time through a centrally coordinated dispatch process. Generators offer to supply the market with specified amounts of electricity at specified prices for set time periods, and can re-submit the offered amounts at any time. From all the bids offered, the Australian Energy Market Operator (AEMO) decides which generators will be deployed to produce electricity, with the cheapest generator put into operation first. A dispatch price is determined every five minutes, and six dispatch prices are averaged every half-hour to determine the “spot price” for each NEM region. AEMO uses the spot price as its basis for settling the financial transactions for all electricity traded in the NEM. Network, retail and environmental charges are added to the energy price in calculating retail tariffs, as shown previously in Table 13 (above).

The NEM spans Australia’s eastern and south-eastern coasts and comprises five interconnected states that also act as price regions: Queensland, New South Wales (including the Australian Capital Territory), South Australia, Victoria, and Tasmania, a distance of around 5.000 kilometres. There are over 100 registered participants in the NEM, both State government owned and private, including market generators, transmission network service providers, distribution network service providers, and market customers.

Western Australia and the Northern Territory are not connected to the NEM. Western Australia operates two separate networks, the South West Interconnected System (SWIS) and the North West Interconnected System. A range of smaller grids also operate in remote areas of the State. The SWIS operates via a short term energy market and a reserve capacity market. Capacity and energy are traded separately. The Northern Territory operates a number of grids, both large and small to service population centres and regional townships.

7.2 Interest from electricity utility businesses

The electricity sector in most parts of Australia is organised and regulated to support centralised power generation, distribution and retailing. Most PV installed in Australia to date has been connected to the distribution network, and is supplying loads directly. This circumvents the incumbent electricity sector and is therefore causing significant problems, not necessarily technical, although these may occur as penetration levels rise, but certainly to the income stream of all established generators, networks and retailers. Daytime peak loads are significantly reduced due to PV generation, which has largely displaced gas peaking plant and hanged the network load profiles, while overall load has also reduced, partly due to PV, but also due to recent high electricity price rises and increased uptake of energy efficiency measures. Other distributed energy options likely to become more common over the next decade include storage, electric vehicles, and energy management systems. All of these will change the ownership structure of energy assets, as well as the usage patterns and, because PV is leading the way, it is bearing the brunt of the initial negative response.

Australian energy regulators, while becoming mindful of the need to change regulatory frameworks in the light of these developments, are currently themselves restricted by their own governance arrangements and reporting structures. Nevertheless, it is clear that new regulatory frameworks are needed to cater for rapidly increasing distributed energy options. For instance, network businesses are currently prevented from implementing distributed energy options themselves, even if these may provide more cost effective solutions than grid upgrades or extensions, while third party access to this market is not available.

While some network operators are experimenting with integration of storage, a greater negative impact is coming from changes to tariff structures that adversely affect the financial attractiveness of PV, or even directly penalise PV.

While environmental goals, including greenhouse gas reduction, drove initial policy support for PV, with utilities required to accept PV connections as well as contribute to the RET, the Australian Government plans to reduce or remove current incentives. State governments, which own a significant portion of electricity assets, as well as private owners, are keen to maintain value and/or income. Hence the current response to high PV uptake levels is to place restrictions on connections and change connection procedures and tariff structures so as to make PV less attractive.

Despite antipathy towards PV from most incumbent electricity generators and distribution network operators, each of the major electricity retailers sells solar power systems, many offering innovative practices such as on-bill financing, PPAs, and energy storage.

7.3 Interest from municipalities and local governments

While the Australian Government and state governments are generally trying to curb PV uptake rates, there is high and increasing interest in PV implementation from local governments and community organisations around Australia. Although these groups typically have little money, and must operate within the electricity market described above, the high level of community support for local generation and employment creation is likely to be a key factor in creating the political will to make the required changes to regulatory frameworks. Many local governments install PV on their own buildings, operate bulk-buy initiatives, and are beginning to set their own renewable energy goals and support community-owned solar installations.

Examples of local government solar PV support initiatives include:

- The Yarra Energy Foundation – helps businesses understand the potential savings available from solar power and had 24 businesses in the pipeline as at June 2014
- Solar Bulk Buy Programs – Gives households and businesses in these municipalities access to bulk purchase discount deals. Many local government bulk-buy programmes exist
- councils remain one of the biggest buyers of commercial PV in Australia
- City of Sydney has installed more than 1,6 MW of solar PV systems which includes around 1,3 MW commissioned in 2014
- City of Melbourne has a rebate for commercial PV that range from AUD 2.000 and AUD 4.000 and have a minimum system size of 10 kW
- many local governments have initiated Environmental Upgrade Agreements to assist in reducing the carbon intensity of energy use. This can include solar PV and is implemented by lower than market, fixed interest rate loans over a longer than usual loan term, and

- community solar programs have gained much popularity in recent years with the formation of many community bulk-buy solar programs and various initiatives to encourage solar PV investments.

8 STANDARDS AND CODES

PV system safety remains a top priority in Australia. A new revision of AS/NZS5033: "Installation of PV arrays" was published in 2014. The new revision takes account of power optimisers and DC to DC converters used at a module level and clarifies conditions for micro-inverter and multiple input MPPT inverters. This standard limits residential system voltages to 600 V_{DC}.

A major revision of AS/NZS 4777 – Grid connection of energy systems via inverters is still being completed, with publication pushed back to 2015 or 2016. The revision addresses many issues raised by electricity utilities particularly in the area of power quality and inverter default voltage and frequency settings. This new document will help more uniform acceptance of PV systems connected to the utility grid. This standard looks to the future where local power and volt-amperes-reactive (var) control will assist with voltage regulation and where communication options are explored for utility control and where more fault ride-through is provided. AS/NZS 4777 also addresses the issues related to multiple inverter installations, covering issues of phase balancing and protection tripping of multiple inverters. Network operators have begun to insist upon non-unity power factors and export limitations in areas with high penetration PV.

A major safety issue is the implementation of testing of inverters to IEC 62109-1 and 2 and the need for revision of that IEC standard to address known issues. The Australian committee is involved with IEC working groups to assist in this process. Inverters that do not comply with IEC 62109 will no longer be eligible for Small-Scale Technology Certificate (STC) creation from mid-2015.

Further work is required to ensure the safe operation of DC isolators, which are the leading cause of sub-standard systems. There were multiple recalls of DC isolators in 2014, and substandard installation processes of rooftop isolators is leading to water ingress which creates the potential for arcing.

PV-Battery-Grid connected systems are developing rapidly in Australia with the use of lithium ion and lead acid batteries. These systems have potential benefits for the future uptake of PV but there are many issues still to be addressed. There are complex safety implications arising because of the interconnection of PV, the grid and batteries with and without inverter isolation. Other issues of charge control and fire safety of lithium batteries are also important for the future. The industry is working on guidelines initially that will flow through to standards in the future.

9 HIGHLIGHTS AND PROSPECTS

The Australian PV market grew slightly in 2014, with installation levels increasing from around 800 MWp in 2013 to reach almost 900 MWp. Overall growth occurred primarily due to two utility-scale installations, with contraction in the residential market being offset by growth in the commercial sector. Installed capacity is now over 4 GWp accounting for 7,2% of electricity capacity and 2,4% of electricity generation. Incentives for PV, including feed-in tariffs, have been removed by state governments and reduced by the Australian government. Module prices increased slightly to AUD 0,8/Wp, largely due to changes in AUD exchange rates, whereas installed prices for small residential systems reduced slightly to just below AUD 2,00/Wp.

Over 1,4 million Australian homes now have a PV system. Residential penetration levels average 17% and are over 50% in some areas. Installation restrictions are being imposed by electricity network operators in some areas to cope with potential issues arising from high penetration levels. The major issue arising, however, is economic, not technical. With revenue for electricity networks and retailers dependent largely on kWh sales, PV uptake has contributed to revenue reductions. Large central generators have also been impacted by the overall reductions in energy sales, to which PV has contributed, but is not the only factor, with several plant closures. This has made PV a target for the established electricity sector, as well as state governments which depend on electricity sector dividends. Various proposals have been put forward to reduce the attractiveness of PV, including imposition of levies, prohibition of net metering, restrictions on system sizes and changing the relative proportion of fixed and variable components in electricity tariffs.

2014 saw some strong development in the utility-scale market. The installation of some large-scale PV systems was finally started as a result of the awarded funds coming from the Solar Flagships program. 31 MW of the 102 MW Nyngan solar farm was completed in NSW. A 3 MW project in Gatton, QLD was also completed as part of a related research program. The 24 MW Royalla (ACT) solar farm was also completed in 2014. The private sector has also entered the utility-scale market with Belectric having installed a 3 MW solar farm in 2014.

PV remains a viable option for homeowners. The residential market is likely to decline slightly again in 2015, offset by continued growth in commercial PV. 2015 will see further grid-connected utility-scale projects deployed and solar farms powering remote mine sites. This is likely to change once the government's Solar Flagship program is exhausted. The Australian government's Direct Action Program, although not specifically directed at supporting PV projects, was set into motion in 2014 and will begin supporting emissions-reduction projects in 2015.

Meanwhile the interest in on-site storage technologies has continued to increase and is expected to gain more momentum as products become more cost-effective. The solar plus storage market is already developing which may cause more friction with incumbent electricity sector businesses since it could see a further reduction in demand and some grid defection. It could, however, also offer a means of tackling the intermittency which challenges PV integration at high penetration levels.

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°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 DC (direct current) of the modules into AC (Alternating 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 or 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 community 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 that are not connected to the utility grid. Usually a means to store electricity is also 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. 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. For example, 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 or rate based incentives. 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 AUD

PV support measures:

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 that may be higher or lower 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
Compensation schemes (self-consumption, net-metering, net-billing…)	These schemes allow consumers to reduce their electricity bill thanks to PV production valuation. The schemes must be detailed in order to better understand if we are facing self-consumption schemes (electricity consumed in real-time is not

	accounted and not invoiced) or net-billing schemes (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). The compensation for both the electricity self-consumed and injected into the grid should be detailed. Net-metering schemes are specific since they allow PV customers to incur a zero charge when their electricity consumption is exactly balanced by their PV generation, while being charged the applicable retail tariff when their consumption exceeds generation and receiving some remuneration for excess electricity exported to the grid
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

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