IEA INTERNATIONAL ENERGY AGENCY

AUSTRALIAN PV INSTITUTE

IEA-PVPS

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National Survey Report of Photovoltaic Applications in AUSTRALIA 2017

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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INTERNATIONAL ENERGY AGENCY
CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in Australia, 2017

The Australian PV Institute

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 SHC and PVPS Programmes, including:
    - PV Information Exchange and Dissemination
    - PV System Performance
    - High Penetration PV in Electricity Grids.

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

ACKNOWLEGEMENTS

Front page photo: Kidston Solar Farm stage 1, Courtesy of Genex

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This report is prepared on behalf of and with considerable input from members of the Australian PV Institute, ARENA 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 Technology Collaboration 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.

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

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 country National Survey Report for the year 2017. 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.

1 INSTALLATION DATA

The PV power systems market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. 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 2017 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2017, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

The Australian grid-connect PV market comprises a residential market segment that is a world leader in terms of per-capita uptake, a steadily growing commercial rooftop segment, a smaller but rapidly growing industrial rooftop segment, and a burgeoning utility-scale segment. In 2017, the majority of installations took advantage of incentives under the Australian Government's Renewable Energy Target (RET) mechanisms – the Small-scale Renewable Energy Scheme (SRES) for systems up to 100kW and the Large-Scale Renewable Energy Target (LRET) for systems over 100kW. Further grants and finance assistance was provided by the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC).

Almost 1,8 million Australian homes and businesses are now powered by their own PV system – over 160 000 of which were added in 2017. On average, over 20% of households have installed a PV system, though this reaches over 50% of households in some urban areas.

Residential installed capacity was declining year-on-year from 2012 until 2016 when it stabilised at 541MW. 2017 saw a marked turnaround in the residential market, growing 44% to 779MW due to significant increases in the price of electricity that also flowed onto feed-in tariff rates. The average PV system size continues to grow steadily as residential system sizes increases and as a growing number of businesses purchase PV.

The rise in wholesale electricity prices in 2017 affected the economics of solar power across the entire range of system sizes. Like the residential market, the sub-100kW commercial market is supported by an upfront subsidy based upon array capacity. This small-commercial segment grew by 60% to reach 331MW. In percentage terms, industrial-scale electricity users saw the greatest increase in their power price – which, when combined with soaring prices for renewable energy certificates, created the right conditions for the 100-5000kW market segment to grow by 123% to 76MW. The commercial end-customers vary considerably by business type; with the agricultural, retail, health care, and engineering business segments well-represented.

The rapid escalation of the Large-scale Renewable Energy Target not only drove the Large-scale Generation Certificate (LGC) price skyward, it also drove deployment of a wave of solar farms. Many commenced construction in 2017, though only a few projects (totalling 123MW) were commissioned.

Together combined, 2017 was a record year for Australian PV installations, with 1,3 GW recorded. 2017's record volume was driven by large increases in electricity prices, continued reduction in PV system prices, an increasing awareness of the benefits of PV to businesses, and the swift ramp-up of the Renewable Energy Target (RET). At the end of 2017, the cumulative installed capacity of Australian PV installations reached 7,2GW.

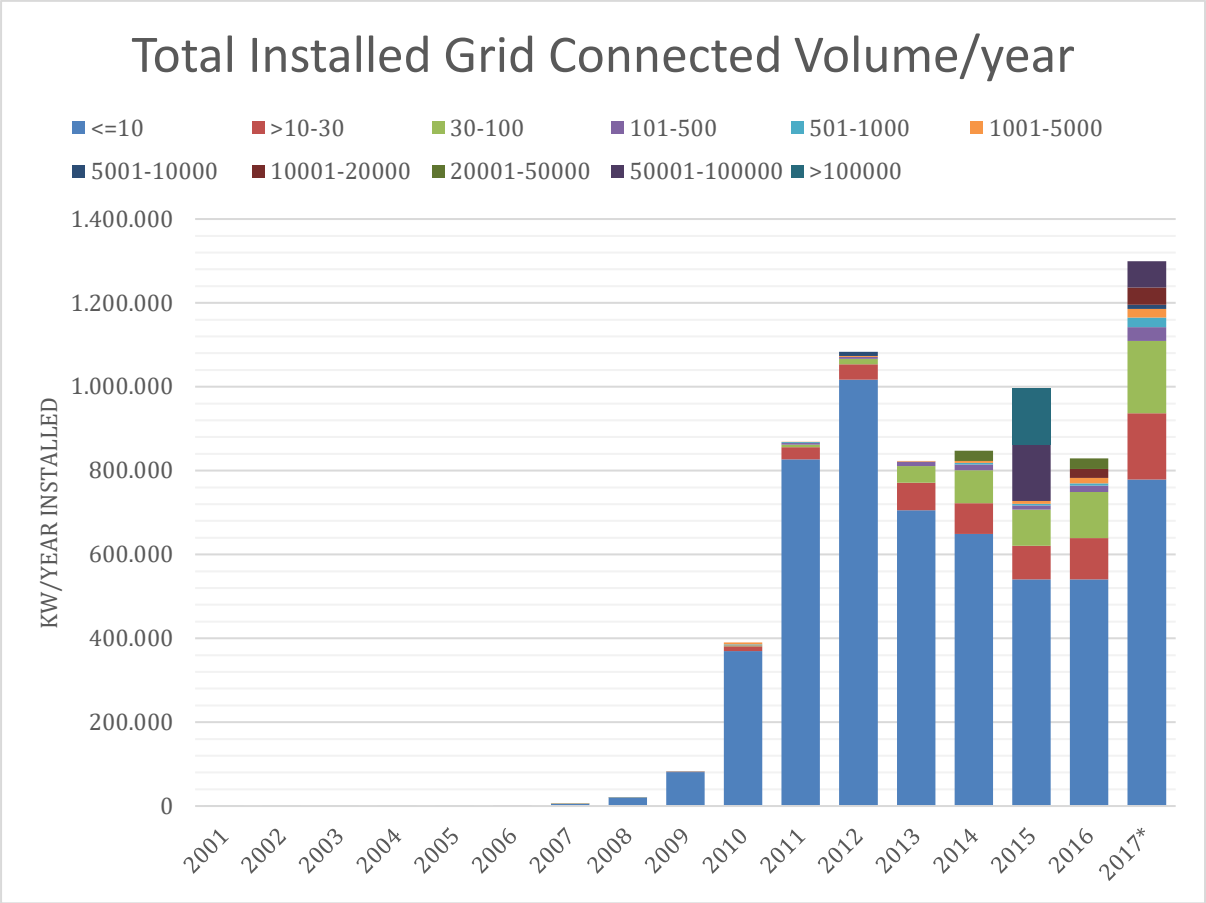


Figure 1: Australian PV had a record year in 2017

Australia's long-standing off-grid market continues to be important, particularly in residential applications where PV continues to displace 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, 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.

In 2017, Australia confirmed its place as is a leading country for batteries. Over 20 000 residential energy storage installations took place in 2017, and the world's largest Lithium-ion battery was installed in South Australia in under 100 days. This saw the market reach over 300 MWh.

By contrast to other areas of global leadership, very little building-integrated PV (BIPV) was added in 2017, and no Vehicle-integrated PV was known to occur. 'Floatovoltaics' also played a minor role, with a single 100kW installation occurring.

1.2 Total photovoltaic power installed

The PV power installed in Australia during 2017 is shown in Table 1. In reading this table the following should be noted:

- PV data for the tables above are derived from the Renewable Energy Certificate (REC) Registry of the Australian Government's Clean Energy Regulator and information supplied by PV companies, supplemented by a manually-recorded tally of projects over 100 kW.

- 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 2017 installations, though a projection has been made of historical trends in late registration.
- Installations over 100kW typically take longer to register RECs than systems 100kW and under, so the size of this market segment is based upon publicly-announced projects.
- In addition, not all installed PV is registered with the CER.
- PV output is derived from the REC registry at a weighted average of 1400 GWh/GW.
- Information on off-grid system installation is based upon historically reported projections and has low accuracy.
- The division between each category is based upon capacity rather than upon application.
- Utility-scale capacity is often reported in AC terms, and occasionally in DC terms. There was 98,8MW of AC capacity commissioned in 2017. Where the DC capacity is unknown, we have assumed a 1,25x DC:AC ratio. The utility-scale projects commissioned in 2017 included Kidston, Sunshine Coast, Mugga Lane, Lakeland 1, and Gullen Range.

Table 1: PV power installed during calendar year 2017

AC			**MW installed in 2017**	**MW installed in 2017**	**AC or DC**
Grid-connected	BAPV	Residential	1 185 511	778 513	DC
		Commercial		331 159	DC
		Industrial		75 839	DC
	Utility-scale	Ground-mounted	123 500	123 500	DC
		Total	1 309 011		DC

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

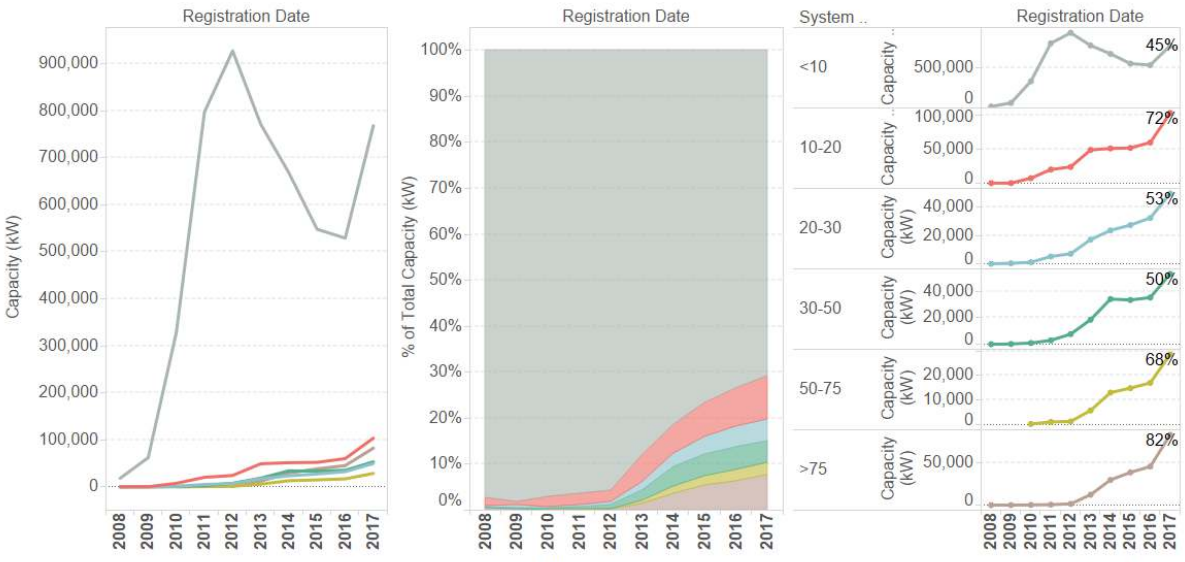
	2017 numbers	2016 numbers
Total power generation capacities (all technologies)	56,2 GW	56,0 GW
Total power generation capacities (renewables including hydropower)	17,1 GW	15,3 GW
Total electricity demand	259,4 TWh[1]	259,4 TWh
Total energy demand		6 065 PJ
New power generation capacities installed during the year (all technologies)	194MW (1790 MW Renewables, less 1630 MW decommissioned fossil fuel power stations + 34MW new fossil fuels)	410MW (1196 MW Renewables, less 786 MW decommissioned fossil fuel power stations)
New power generation capacities installed during the year (renewables including hydropower)	1 790 MW	1 196 MW
Total PV electricity production in GWh-TWh	10,2 TWh	8,4 TWh
Total PV electricity production as a % of total electricity consumption	3,9%	3,3%

Table 3: Other information

	2017 Numbers
Number of PV systems in operation in your country	1,82m (of which 1,75m are residential)
Capacity of decommissioned PV systems during the year in MW	0
Total capacity connected to the low voltage distribution grid in MW	6 600
Total capacity connected to the medium voltage distribution grid in MW	188
Total capacity connected to the high voltage transmission grid in MW	463

A summary of the cumulative installed PV Power, broken down into sub-markets is shown in Figure 2, Figure 2 and Table 4.

[1] https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2016-17-and-2017



System ..	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<10	18,284	62,269	328,801	797,513	927,203	770,930	667,663	547,873	528,990	768,066
10-20	350	415	7,597	20,356	24,283	49,216	51,442	52,153	60,143	103,550
20-30	41	351	1,119	5,174	7,095	17,118	23,663	27,373	32,425	49,734
30-50	35	203	934	2,936	7,674	18,573	34,180	33,474	35,333	53,170
50-75			304	1,152	1,324	5,811	13,089	14,891	17,050	28,641
>75	99	100	273	608	1,516	12,238	29,551	38,348	45,253	82,368

Figure 2: Sub-100kW Installation Capacity by System Size Range[2]

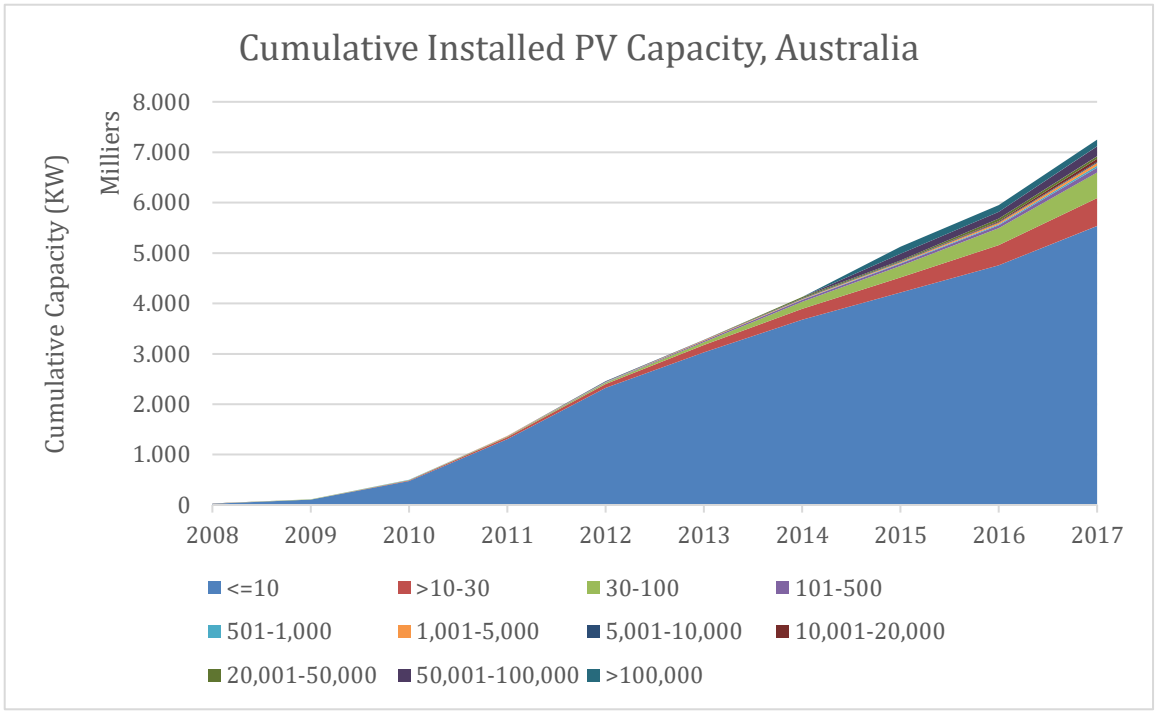


Figure 3: Cumulative Australian PV Installations by Category 2004-2017

[2] Note that data is based upon the year of registration rather than commissioning.

Table 4: Cumulative installed PV capacity by size range (MWp)

	<=10	>10-30	30-100	101-500	501-1 000	1 001-5 000	5 001-10 000	10 001-20 000	20 001-50 000	50 001-100 000	>100 000	Total
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	1	0	0	0	0	0	0	0	0	0	0	1
2004	1	0	0	0	0	0	0	0	0	0	0	1
2005	2	0	0	0	0	0	0	0	0	0	0	2
2006	3	0	0	0	0	0	0	0	0	0	0	3
2007	8	0	0	0	0	0	0	0	0	0	0	9
2008	28	1	0	1	1	0	0	0	0	0	0	30
2009	109	2	1	2	1	0	0	0	0	0	0	113
2010	478	13	3	3	2	4	0	0	0	0	0	503
2011	1 305	43	8	8	3	5	0	0	0	0	0	1 372
2012	2 322	79	21	12	3	7	10	0	0	0	0	2 455
2013	3 027	145	62	23	3	9	10	0	0	0	0	3 278
2014	3 676	218	141	36	7	14	10	0	24	0	0	4 126
2015	4 216	298	227	46	11	21	10	0	24	134	134	5 122
2016	4 757	397	336	62	17	34	10	22	49	134	134	5 951
2017	5 536	555	510	94	40	54	20	62	49	197	134	7 250

Figure 4 shows the installation volume of systems over 100kW, highlighting some noteworthy solar farms.

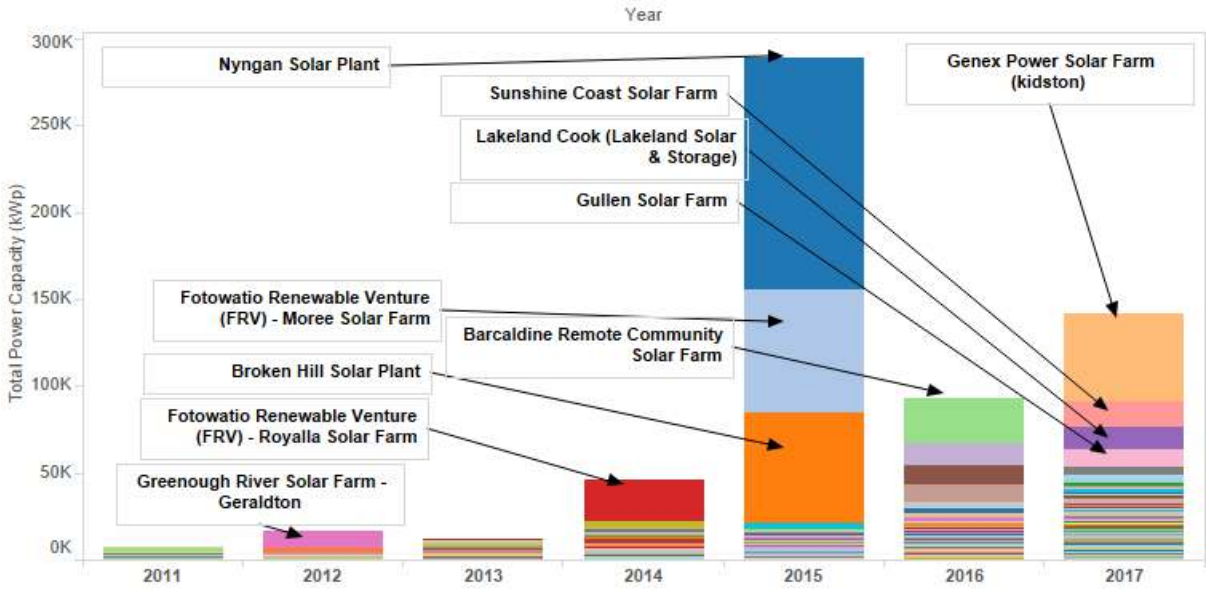


Figure 4: Systems over 100kW by Commissioning Date, illustrating Noteworthy Solar Farms

1.3 Key enablers of PV development

Table 5 presents some data on associated enablers of PV deployment in the Australian market

Table 5: Information on key enablers

	Annual Volume (Units)	Total Volume (Units)	Source
Decentralized storage systems	20 789	28 039	SunWiz
Electric cars (and light weight)	1 123	6 180	Electric Vehicle Council, WhichCar[3]

[3] https://www.whichcar.com.au/car-news/how-australia-compares-globally-for-electric-vehicle-sales

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Prices shown in Table 6 and illustrated in Figure 5 are listed in AUD, exclude GST and are based upon analysis of wholesale PV price lists.

Table 6: Typical module prices for a number of years, AUD

Year	Typical price	Lowest price	Highest Price
1993	9		
1994	7		
1995	8		
1996	8		
1997	7		
1998	8		
1999	8		
2000	8		
2001	8		
2002	7		
2003	7		
2004	8		
2005	8		
2006	8,5	7,5	
2007	8	7	
2008	8	5	
2009	6	3	
2010	3,2	2	
2011	2,1	1,2	
2012	1,5	0,9	
2013	0,75	0,5	
2014	0,8	0,62	
2015	0,8	0,62	
2016	0,78	0,57	
2017	0,67	0,53	1,35

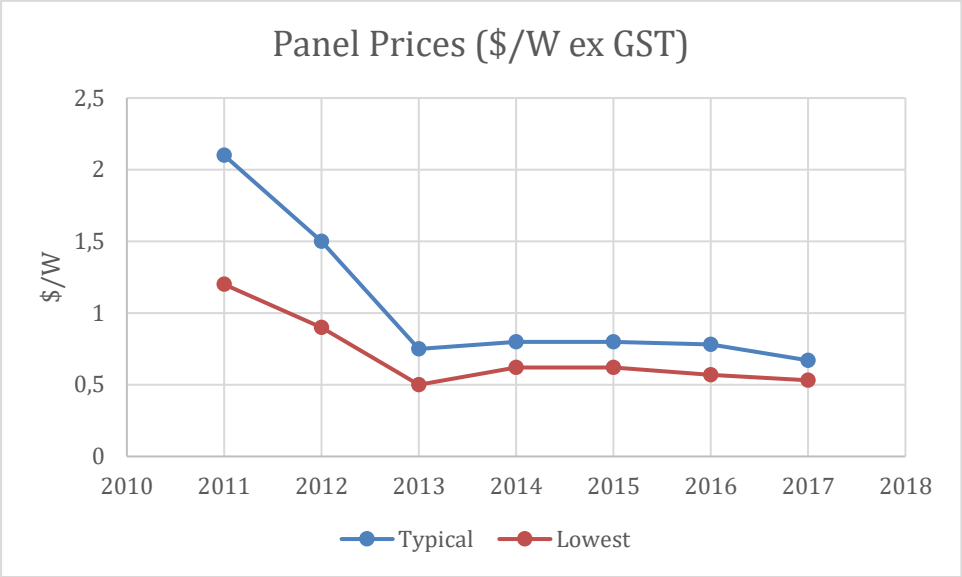


Figure 5: Recent panel prices

2.2 System prices

A summary of typical fully-installed system prices is provided in the following tables and chart. The prices are exclusive of incentives which reduce the price to consumers by a further 60-70c/Wp, depending on insolation. Residential and commercial prices are based upon a dataset provided by PV lead generator Solar Choice. Ground-mounted prices are based upon the publicised price of the Kidston, Sunshine Coast, and Mugga Lane solar farms; two of which were projects that took many years to realise and therefore had higher costs than the cost of solar farms currently being deployed for an average at or below $1,85/W[4].

Table 7: Turnkey Prices of Typical Applications – local currency

Category/Size	Typical applications and brief details	Current prices per W
Grid-connected Rooftop up to 5-10 kW (residential BAPV)	Residential	$2,22
Grid-connected Rooftop from 10 to 250 kW (commercial BAPV)	Commercial rooftop	$2,01
Grid-connected Ground-mounted above 10 MW	Solar Farms	$2,24

[4] https://arena.gov.au/assets/2016/01/ARENA-Large-scale-Solar-PV-Competitive-Round_EOI-Data-Output_March-2016.pdf

Table 8: National trends in system prices (current) for different applications – local currency

Price/Wp	Residential PV systems < 5-10 KW	Commercial and industrial BAPV	Ground-mounted > 10 MW
1997	11		
1998	12		
1999	12		
2000	14		
2001	14		
2002	13		
2003	10		
2004	12		
2005	12		
2006	12,5		
2007	12		
2008	12		
2009	9		
2010	6		
2011	3,9		
2012	3		
2013	3,1		
2014	2,77	2,68	2,7
2015	2,45	2,07	2,18
2016	2,42	2,08	2,76
2017	2,22	2,01	2,24

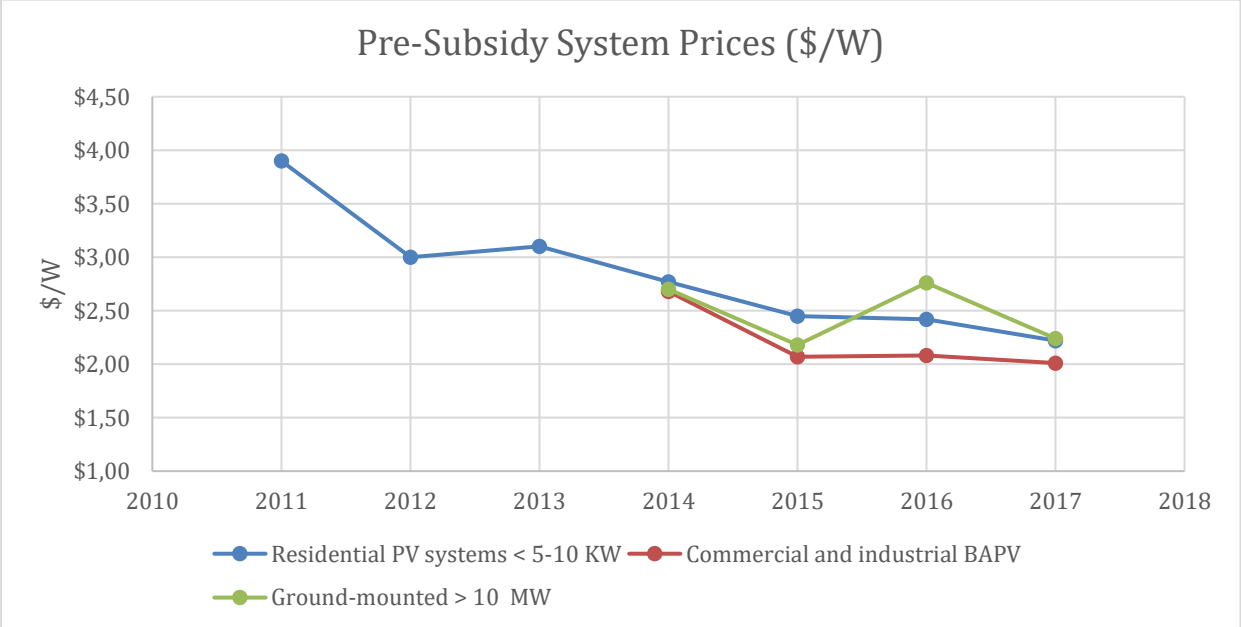


Figure 6: Recent system price trajectory

2.3 Financial Parameters and specific financing programs

More finance providers and a broader range of finance options continued to come to the market in 2017, 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) increased in prevalence in 2017. Although PPAs sales were dominated by electricity retailers, providers of PPAs as a service to solar retailers started to have some success.

Table 9 shows some information on typical costs of financing a PV system.

Table 9: PV financing scheme

Average rate of loans – residential installations	5,5% (mortgage finance); 16% (unsecured consumer finance)
Average rate of loans – commercial installations	10% (commercial finance)
Average cost of capital – industrial and ground-mounted installations	5% to 7% (average forward interest rate over 5 years)

2.4 Specific investments programs

Table 10 presents a summary of information on various classes of investment programs.

Table 10: Specific investment programs

Third Party Ownership (no investment)	Third Party Ownership exists in Australia primarily through Power Purchase Agreements, which have had limited success to date with the primary exception of one electricity retailer
Renting	There is no material market for solar power rentals in Australia, owing to the costs of grid connection and relocation. However, this segment has gained the attention of ARENA and other business incubators
Leasing	Leasing is well established as a financing mechanism in the Australian market
Financing through utilities	Electricity retailers now offer on-bill financing and PPAs
Investment in PV plants against free electricity	Most residential solar purchases are paid directly by homeowners
Crowdfunding (investment in PV plants)	A solar-focused electricity retailer was crowdfunded in early 2018
Community solar	Community investment in solar power occurs in small numbers in Australia
Other (please specify)	10%-20% of the residential market obtains consumer finance to purchase their PV system.

2.5 Additional Country information

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 has made PV electricity cost effective against retail tariffs in most parts of the country.

General information about Australian electricity is provided in Table 11.

Table 11: Country information

Retail Electricity Prices for a household (range)	AUD 0,19 – 0,39 /kWh (flat tariffs)[5]
Retail Electricity Prices for a commercial company (range)	AUD 0,23 – 0,42 / kWh
Retail Electricity Prices for an industrial company (range)	AUD 0,20 – 0,30 / kWh
Population at the end of 2017 (or latest known)	24,7 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	1 400 kWh/kWp per year
Name and market share of major electric utilities	Origin Energy (~25%) AGL (~17%) ERM (~12%) Energy Australia (~11%) Synergy (~5%) Stanwell (~7%) Ergon Energy (~5%) Lumo / Red Energy (~4%) Others (~13%)

[5] http://www.aemc.gov.au/getattachment/be91ba47-45df-48ee-9dde-e67d68d2e4d4/2016-Electricity-Price-Trends-Report.aspx

3 POLICY FRAMEWORK

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

Table 12 summarises the various international support mechanisms for PV and their applicability to Australia in 2017.

Table 12: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2017 - residential	On-going measures Commercial + industrial	Measures that commenced during 2017 – commercial + industrial	On-going measures Ground-mounted, including floating	Measures that commenced during 2017 – ground mounted, including floating
Feed-in tariffs	Yes	No	No	No	No	No
Feed-in premium (above market price)	No	No	No	No	No	No
Capital subsidies	STCs[6], some state and local government subsidies	No	STCs, some local government subsidies	No	Large Scale Solar Grant Funding for some projects	No
Green certificates	STCs	No	STCs or LGCs	No	LGCs	No
Renewable portfolio standards (RPS) with/without PV requirements	STCs	No	STCs or LGCs	No	LGCs	No
Income tax credits	No	No	No	No	No	No
Self-consumption	Yes	No	Yes	No	N/A	N/A
Net-metering	Yes (30 minutes)	No	Yes (30 minutes)	No	N/A	N/A

[6] Small-scale Technology Certificates

	On-going measures residential	Measures that commenced during 2017 - residential	On-going measures Commercial + industrial	Measures that commenced during 2017 – commercial + industrial	On-going measures Ground-mounted, including floating	Measures that commenced during 2017 – ground mounted, including floating
Net-billing	No	No	No	No	N/A	N/A
Collective self-consumption and virtual net-metering	No	No	No	No	N/A	N/A
Commercial bank activities e.g. green mortgages promoting PV	Yes (through CEFC)	Yes	Yes (through CEFC)	Yes	Yes (through CEFC)	Yes
Activities of electricity utility businesses	Yes	No	Yes	No	Yes	Yes
Sustainable building requirements	No	No	Yes	No	N/A	N/A
BIPV incentives	No	No	No	No	N/A	N/A
Reverse Auctions	No	No	No	No	Yes	Yes
Government PPAs	No	No	No	No	Yes	Yes
Corporate PPAs	No	No	No	No	Yes	Yes

3.1 Direct support policies for PV installations

In addition to the schemes mentioned below, the Commonwealth Government's $5 million Solar Communities Program provides funding for community groups in selected regions across Australia to install rooftop solar photovoltaic, solar hot water and solar-connected battery systems at their facility.

3.1.1 The Renewable Energy Target

The Renewable Energy Target (RET) consists of two parts – the Large-scale Renewable Energy Target (LRET), of 33 000 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. The RET is funded by cross-subsidy leveraged upon all electricity consumption except for certain classes of industrial electricity consumers.

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, which are shown in

Table 13: Annual Generation Targets under the Large-scale Renewable Energy Target

Year	Target (GWh)
2011	10 400
2012	16 763
2013	19 088
2014	16 950
2015	18 850
2016	21 431
2017	26 031
2018	28 637
2019	31 244
2020	33 850
2021-2030	33 000

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 2015, 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 2017 are shown in Figure 7.

Figure 7: Cumulative capacity and average system size for SRES systems 2009-2017.

The Clean Energy Regulator has established a voluntary 'clearing house' as a central point for the transfer of STCs at AUD 40,00, 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.

3.1.2 The Australian Renewable Energy Agency (ARENA), Clean Energy Finance Corporation (CEFC), and Clean Energy Innovation Fund (CEIF)

The Australian Renewable Energy Agency (ARENA), Clean Energy Finance Corporation (CEFC), and Clean Energy Innovation Fund (CEIF) continued to operate throughout 2017.

ARENA has two objectives: to improve the competitiveness of renewable energy technologies, and to increase the supply of renewable energy in Australia. 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.

In addition to ARENA's support for R&D activities, the following ARENA solar deployment and integration projects commenced in 2017:

1. Kidston Hydro-Solar: Project Development activities for stage two
2. Solar Farms that are now operating or under development: Manildra, Kidston, Parkes, Darling Downs, Whitsunday, White Rock, and Longreach
3. ECLIPS Container Rollout Solar System (CROSS) Development support for the ECLIPS), factory-assembled relocatable PV solar ground array
4. High Penetration Industrial Rooftop Solar: Demonstration of solar on industrial rooftops can integrate into the electricity network without requiring export limiting devices
5. Increasing Visibility of Distribution Networks to Maximise PV Penetration Levels
6. Solar irrigation of sugarcane study
7. Peak Demand Reduction using Solar and Storage on overloaded distribution substations study
8. Creation of a prototype Decentralised Energy Exchange – an online marketplace that rooftop solar and battery storage system owners are paid for allowing electricity network businesses to access their system to strengthen the grid.

The **Clean Energy Finance Corporation** (CEFC) is a Commonwealth Government initiative that invests using a commercial approach to overcome market barriers and mobilise investment in renewable energy and lower emissions technologies. CEFC finance underpins commercial finance offerings for solar uptake from major financing organizations including Macquarie Leasing, ANZ, NAB, Westpac, and the Commonwealth Bank. The CEFC also helped Ratesetter establish a peer-to-peer green lending platform.

In 2017, the CEFC continued its $250 million Large-Scale Solar financing program that provides debt finance to solar PV projects of 10MW or more. The offer of fixed-rate longer-dated senior debt is aimed at sponsors seeking loans of $15 million or more. Figure 8 illustrates the funding commitments made to May 2017, in partnership with ARENA.

PROJECT	CEFC DEBT FINANCE COMMITMENT ($ MILLION)	MW (AC)	ARENA FUNDING
Parkes Solar Farm, NSW	150	55	$18 million
Griffith Solar Farm, NSW		30	
Dubbo Solar Hub, NSW		25	
Whitsunday Solar Farm, Qld	77	57.5	$9.5 million
Hamilton Solar Farm, Qld		57.5	N/A
Gannawarra Solar Farm, Victoria		50	N/A
Kidston Solar Project Phase One, Qld	54	50	$8.9 million
Longreach Solar Farm, Qld	12	15	$3.5 million
Oakey Solar Farm, Qld	19.5	25	
Collinsville Solar Farm, Qld	60	42.5	$9.5 million
Totals	**$372.5**	**407.5**	

Figure 8: CEFC Large-Scale Solar Program

Other CEFC investments in 2017 include:

- Kennedy Energy Park, Queensland
- Bannerton Solar Park, Victoria
- Daydream Solar Farm and Hayman Solar Farm, Queensland
- Ross River Solar Farm, Queensland

The CEFC has also contributed to Impact Investment's IIG Solar Income Fund, Lighthouse Solar Fund, Palaisade Renewable Energy Fund,

The **Clean Energy Innovation Fund** is a $200 million program supporting the growth of innovative clean energy technologies and businesses. Solar-related investments include Redback Technologies smart inverter, battery recycling from Relectrify, energy monitoring from Wattwatchers, and energy management technology from GreenSync. In addition the CEIF funding supports Australia's first Clean Energy Seed Fund.

3.1.3 Direct Action

Although the Direct Action Plan supports emissions reduction mechanisms, its budget has almost been exhausted without directly supporting any solar project.

3.1.4 State and Territory Support

3.1.4.1 Direct Subsidies

The NT Government's Home Improvement Scheme offers a $2000 subsidy for the installation of rooftop solar systems. It was the only direct subsidy offered by a state or territory for a PV system in 2017.

3.1.4.2 Feed-in Tariff

The final premium-feed in tariff accessible to new installations concluded in 2014. Many historical premium feed-in tariffs concluded at the end of 2016 (see Table 14), with hundreds of thousands of households in New South Wales, Victoria, and South Australia, transitioning from feed-in tariffs of up to 60c/kWh rates as low as 6-12c/kWh (see Table 15).

This means most Australian solar customers now receive feed-in tariffs whose value is little more than the wholesale electricity price; in some states a minimum value is stipulated by the government but in other states the value is left to electricity retailers to decide. In Victoria, the value of avoided greenhouse gas emissions is included in the mandatory minimum feed-in tariff.

There are still large numbers of Australians receiving historic feed-in tariffs, as illustrated in Table 16. The next tranche of customers to transition off premium feed-in tariffs will be those in Tasmania (January 2019), then WA and the ACT (from 2020).

Table 14: Feed-in Tariffs that ended in 2016

State	Name	Start Date	Eligibility cut-off date	Size Limits	Rate AUDc/ kWh	Scheme end	Type
VIC	Transitional	1 Jan 2012	30 Sept 2012	5 kW	25	31 Dec 2016	Net
VIC	Standard	1 Jan 2012	30 Sept 2012	100 kW	Retail rate	31 Dec 2016	Net
SA	Group 4	1 Oct 2011	30 Sept 2013	10 kVA 1Ø 30 kVA 3Ø	16	30 Sep 2016	Net
NSW	Solar Bonus Scheme (SBS) SBS 60	1 Jan 2010	27 Oct 2010	10 kW	60	31 Dec 2016	Gross
NSW	SBS 20	28 Oct 2010	28 April 2011	10 kW	20	31 Dec 2016	Gross or Net

Table 15: Net Feed-in Tariffs available in 2017 to customers not on historical premium FiTs

State	Rate Type	Rate AUDc/ kWh	Size Limits	Terms
VIC	Mandatory Minimum	>= 11,3c	100 kW	Includes benefits of avoided air pollution
SA	Market	11-18c		Prior to 2017, the SA government set a minimum value, but in 2017 decided not to set a minimum value
ACT	Market	9c	30 kW	
NT	Mandated	25,67	30 kVA	Higher for commercial customers
QLD	Market	7-12c		Voluntary rate in South-East Queensland
QLD	Mandated	10,1c	30 kW	Mandated rate in regional Queensland
NSW	Market	9-15c	10 kW	
WA	Mandated	7,125c	5kW	SWIS (urban) areas.
WA	Mandated	7,14-51c		Horizon Power (regional) townships, rate varies by town
TAS	Mandated	8,93	10kW	

Table 16: Historical premium Feed-in Tariffs in 2017 while existing customers maintain eligibility

State	Name	Start Date	Eligibility cut-off date	Size Limits	Rate AUDc/ kWh	Scheme end	Type
VIC	Premium FiT	1 Nov 2009	1 Jan 2012	5 kW	60	2024	Net
TAS	1:1 Feed-in Tariff		30 Aug 2013		28	1 Jan 2019	Net
SA	Groups 1, 2 & 3	1 July 2008	30 Sep 2011	10 kVA 1Ø 30 kVA 3Ø	44	30 June 2028	Net
ACT	Gross FiT (residential)	1 March 2009	31 May 2011	30 kW	50 (<10kW), 40 (10-30kW), after 1 July 2010 45,7 (<30kW)	20 years after connection	Gross
ACT	Gross FiT (Commercial	1 April 2011	13 July 2011	30-200 kW	34,27	20 years after connection	Gross
ACT	Net metering (closed 30 June 2013)	14 July 2011	30 June 2013	30 kW	Retail tariff	30 June 2020	Net metering
QLD	Solar Bonus Scheme	1 July 2008	10 July 2012	10 kVA 1Ø 30 kVA 3Ø	44	1 July 2028	Net
WA	Residential FiT scheme	1 July 2010	1 Aug 2011	5 kW (city) 10 kW 1Ø 30 kW 3Ø (country)	40 to 30 June 2011 20 from 1 July 2011	10 years after installation	Net

3.1.4.3 Tenders, auctions & similar schemes

Solar tenders have come from a mix of state governments, local governments, electricity retailers, and the Australian Renewable Energy Agency (ARENA). Each has its own process with varying funding mechanisms, the most common being PPAs for energy generation or Renewable Energy Certificates or both.

State Governments:

- The Australian Capital Territory (ACT) ran a reverse auction for solar power in 2012 that resulted in the build of three solar farms totaling 40MW. In 2016 it ran a further 200MW auction for renewables that was won by two wind farms. Proceeds from this auction also support an ongoing subsidy for home energy storage systems.
- In 2017, the Queensland Government ran an Expression of Interest for 400 MW of renewable energy and 100 MW of energy storage. 79 businesses submitted 115 project proposals totaling 15 000 megawatts, with nearly 6 000 MW of energy storage and 9 000 MW of renewable energy.
- In addition, the Queensland Government supported via a Contract for Difference six large-scale projects totaling 300 MW that were part of ARENA's large-scale solar funding round.
- In late 2017, the New South Wales government contracted the LGCs from the 24 MW Dubbo Solar Hub. The government is also committed to sourcing 100% of its energy (137 GWh; 60 MW) from renewable energy for its Sydney Metro Northwest rail project.
- In 2017 the Victorian government legislated the Victorian Renewable Energy Target (VRET) of 25% by 2020 and 40% by 2025. The VRET will be supported by the Victorian Renewable Energy Auction Scheme (VREAS) – and in 2017 its first reverse auction called for bids of up to 550 MW of large-scale (technology-neutral) renewable energy plus 100 MW of large-scale solar. The Victorian Government Renewable Certificate Purchasing Initiative supported two Victorian Solar Projects totaling 138 MW: Bannerton Solar Park and Numurkah Solar Farm, which meet the electricity requirements of Melbourne's network of trams.

State Governments also support a range of research, development and demonstration projects, many of which are mentioned in this section (Section 3) of the report.

In addition to state government tenders, corporations are running tenders for supply of electricity, known as Corporate PPAs. For example:

- Tenders have been announced by electricity utilities such as Ergon, Alinta, Synergy and Snowy Hydro contracting to purchase their Renewable Energy Certificate requirements.
- In 2017, the University of New South Wales signed a PPA of 124 GWh/year with Maoneng for part of a 200 MW solar farm. Wind farms have been more successful in winning corporate PPAs - from the Melbourne Renewable Energy Buying Group, Adelaide Brighton cement, Telstra/Coca Cola Amatil/ANZ in 2017.
- 2018 should see further corporate PPA activity for solar farms, with the launch of 'solar firming' financial instruments.

3.1.5 Local Government Support

In 2017, local governments played a continued part in supporting the deployment of solar power systems. Local governments installed PV on their own premises, offered Environmental Upgrade Agreements, and supported community bulk-buy initiatives. Local governments also took the following actions

- The Sunshine Coast Regional Council installed a 15 MW solar farm
- The City of Adelaide offered a 20% subsidy from the system cost for a PV system installed within its boundaries

3.2 Indirect support Policies

3.2.1 Self-consumption measures

Table 17 presents a standardised summary of how various forms self-consumption measures apply in Australia.

Table 17: Self-Consumption Schemes

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill
	3	Charges to finance Transmission & Distribution grids	Tariff structure changes in some states
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Feed-in Tariff
	5	Maximum timeframe for compensation of fluxes	30 minutes
	6	Geographical compensation	On site only
Other characteristics	7	Regulatory scheme duration	Unlimited but FiT are revised annually
	8	Third party ownership accepted	Yes (e.g. Solar Leasing)
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Yes (injection control / ramp-rate control / no DC-injection)
	10	Regulations on enablers of self-consumption (storage, DSM…)	None
	11	PV system size limitations	None

	12	Electricity system limitations	None (except additional grid codes)
	13	Additional features	None

3.2.2 Collective self-consumption, community solar and similar measures

Current network operation regulations act as a barrier to collective self-consumption or virtual net-metering in Australia and are only really practical within 'embedded networks'. There are a few trials of PV-driven microgrids operating across the country, particularly in new housing developments and in power supplies for remote communities.

Community solar investment occurs in small numbers in Australia:

- In 2015 an ARENA project funded the development of a National Community Energy Strategy.
- The recently re-developed Sydney International Convention Centre hosts a 520kW PV system that is investor-owned through Sydney Renewable Power Company.
- Embark is a non-profit organisation focused on accelerating the uptake of community renewable energy projects by providing practical capacity-building tools and seed and investment funding. It lists 70 active groups pursuing renewable energy projects.
- The Citizens Own Renewable Energy Network Australia has funded 23 small projects and attracted over $300 000 of financial contributions from the donors.
- Some of the groups working to develop community solar projects received support from the NSW government's Growing Community Energy grants[7].
- In May 2017, a competitive process run by the Victorian government invited eligible organisations to apply to become a Pilot Community Power Hub host. The Hubs enable community groups to access renewable energy expertise and services for renewable energy projects. The three successful applicants are Ballarat Renewable Energy and Zero Emissions (BREAZE); Bendigo Sustainability Group (BSG); and Gippsland Climate Change Network for the Ballarat, Bendigo and Latrobe Valley Hubs respectively.

Community-driven project creation appears to have slowed in recent years, though some private companies like SolarCloud appear to be filling the gap.

3.3 Other measures

3.3.1 Climate change Commitments

The commonwealth government intends to implement a National Energy Guarantee. The Guarantee is made up of two parts that together will require energy retailers and some large users across the National Electricity market to deliver reliable and lower emissions energy generation each year.

1. A reliability guarantee will be set to deliver the right level of dispatchable energy—from ready-to-use sources such as coal, gas, pumped hydro and batteries—needed in each state.
2. An emissions guarantee will be set to contribute to Australia's international commitments. The level of the guarantee will be determined by the Commonwealth.

At this stage the government intends the emissions guarantee will reduce Australia's emissions from the electricity sector by 26-28% below 2005 levels by 2030. This target is in line with

[7] http://www.environment.nsw.gov.au/communities/community-energy-grants.htm

Australia's COP21 commitments, if the electricity sector is to contribute its exact share to the nation's emissions reduction commitments.

At this stage, the exact mechanism for achieving the emissions reduction is unspecified. Therefore the extent that the NEG will drive PV uptake is unclear, though some analysts suggest that the government's current target will deliver additional renewable energy beyond business-as-usual.

3.3.2 BIPV development measures

None

3.3.3 Utility-scale measures including floating and agricultural PV

ARENA and CEFC funding supported the deployment of utility-scale PV, as detailed in Section 3.1.2. The Renewable Energy Target also provided support, as described in Section 3.1.1.

3.3.4 Rural electrification measures

None

3.3.5 Support for electricity storage and demand response measures

Over 20 000 home energy storage systems were deployed in 2017, most of which did not receive any subsidy. The subsidy schemes in place in 2017 include:

- The ACT Government offers a subsidy for residential storage systems, as part of a $25 million 'Next Generation Energy Storage Program', which will provide batteries to over 5000 homes and businesses by 2020. This fund is cross-subsidised by the ACT government's large-scale renewable auction.
- The NT government program mentioned in Section 3.1.4.1 can also be used towards residential batteries.
- The SA government funded the world's largest Lithium-ion battery, the Hornsdale Power Reserve (also known as the Telsa Big Battery), a 100MW/129MWh battery that was installed within 100 days.
- A subsidy was also made available to SA households that wished to participate in AGL's virtual power plant, which saw its first installations take place in 2017.

In 2017, the Victorian government and Queensland government each initiated tenders for large-scale energy storage. A growing number of microgrid and Virtual Power Plant trials were announced in 2017 and early 2018.

3.3.6 Support for electric vehicles

None

3.3.7 Indirect policy issues

Continued political differences around climate change and carbon pricing have impacted the renewable energy sector and made long term investments higher cost than they may otherwise have been. This has also led to antagonism towards renewables, which are routinely blamed for price rises and supply disruptions, even when these have been shown to have other causes.

3.4 Financing and cost of support measures

Table 18 shows the source of finance for solar-related government programs.

Table 18: Common financing methods

Financing type	Programs	Finance Source
Cross subsidy	RET (LGCs and STCs), most Feed-in Tariffs	Levy on electricity bills
Subsidised Loan	CEFC-backed projects, and CECF-backed financial instruments from banks and some PV retailers	Government borrowing at lower interest rates than commercially available
Direct Subsidy	ARENA-funded projects, NT Government Home Improvement Scheme	Typically from government budget
Contract for Difference	ACT Solar Auction, Queensland Government support for ARENA projects	Typically from government budget, offset by reduced electricity expenditure
Purchase Agreement for LGCs and/or Power	Sydney Metro Northwest Rail Project, Victorian Trams, Queensland Government	Typically from government budget, offset by reduced electricity expenditure

4 INDUSTRY

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

For many years, Tindo Solar has been the sole manufacturer of solar panels in Australia. In early 2017, Tindo solar was bought by SA PV retailer 'Cool or Cosy', though the panels continue to be branded Tindo Solar. Tindo supplies DC 270W poly panels using minghwei cells, and 295W PERC mono panels, and flash tests its panels in Australia. Tindo's business model is to both sell panels wholesale and retail PV systems (now via Cool or Cosy).

Tindo Solar manufactured 20MW of panels in 2016, but no information on 2017 production was available. Total PV cell and module manufacture together with production capacity information is summarised in Table 19 below.

Table 19: Production and production capacity information for 2017

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Tindo Solar			20		60
TOTALS			20		60

4.2 Manufacturers and suppliers of other components

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

4.2.1 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. Redback Technolgies is an Australian intelligent hybrid PV-storage inverter manufacturer. MIL Systems is an Australian power systems engineering company that produces a residential grid-connect inverter.

4.2.2 Storage batteries

Australian company RedFlow manufactures Zinc Bromine batteries. Its ZBM product delivers up to 3 kW of continuous power (5kW peak) and up to 8 kWh of energy. Redflow has launched a product to serve the residential market.

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

There are a large number of foreign manufactured battery companies supplying to the Australian market.

4.2.3 Battery charge controllers and DC switchgear

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

- Magellan Power have 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. Also produce solagrid audible alarm safety device in case of faults.
- Solar Analytics – provide a home energy monitoring solution with a focus on solar, with over 22 000 sales to by mid 2018.
- Wattwatchers have developed low-cost, ultra-compact, multi-circuit meters with built in wireless communications with thousands of sales to end of 2017
- CatchPower, SwitchdIn, Greensync, Reposit are developing internet-of-energy solutions including to optimise solar and battery interactions with the grid.

4.2.4 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 155MW Solar Flagship systems in NSW and for the UQ Gatton Solar Plant. It previously manufactured the supports for the 10MW First Solar Greenough River solar farm in WA.

5B is a Sydney based renewable energy technology business that has created a completely pre-fabricated and rapidly deployable solar array solution - enabling faster, lower cost and more flexible solar projects. 5B's technology is completely home grown having been born in a Sydney backyard, prototyped in a dusty sand quarry nearby, polished in a R&D workshop in Marrickville and now under commercial production in 5B's 30MW p.a. production facility in Alexandria, Sydney

4.2.5 BIPV

Tractile Solar combines PV cells with Thermal Hot Water. Tractile listed on the Australian Stock Exchange in 2015.

5 PV IN THE ECONOMY

This chapter provides information on the benefits of PV for the economy.

5.1 Solar Value Chain

The Australian solar supply chain is currently typically structured as follows:

- Wholesalers import from overseas manufacturers, and sell to PV Retailers.
- PV retailers buy products from wholesalers and arrange for installation using accredited installers that may be contractor or employees.
- Installers collect equipment from retailers (or from wholesaler's bonded warehouses) and transport it to site to then install.

There are exceptions, which include:

- Some PV retailers are large enough to buy direct from the overseas manufacturer. Some of these retailers also wholesale product to other retailers.
- Some PV installers are also micro-retailers.

5.1.1 Manufacturer

5.1.1.1 Panels

- Typically, Chinese manufactured PV modules are installed in Australia. Figure 9 shows that Australia imports over 70% of its solar panels from China.
- Historically Australia was a purchaser of lower-quality panels. More recently, solar industry preferences have shifted towards Tier 1 panels, as these became more affordable and accessible. Negative experiences with lower-quality product, tightening regulations, higher barriers to entry/accreditation, and Electrical Regulatory Authorities Council (ERAC)[8] listing also have driven lower-quality panels out of the market. This evolution is shown in Figure 10.

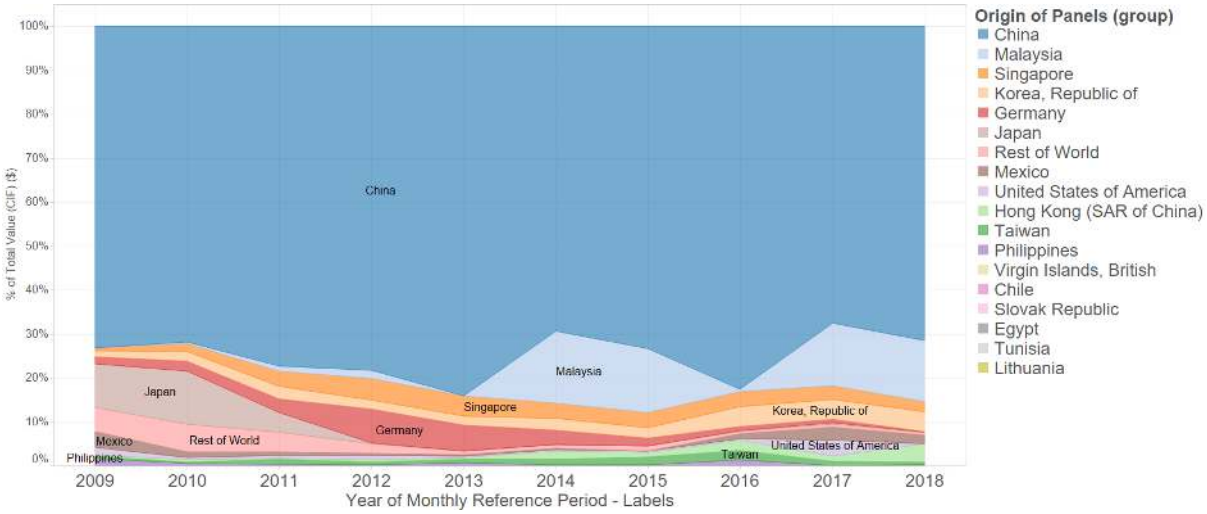


Figure 9: Australia imports over 70% of its solar panels from China. Source: ABS

[8] http://www.erac.gov.au/index.php?option=com_content&view=article&id=106&Itemid=556

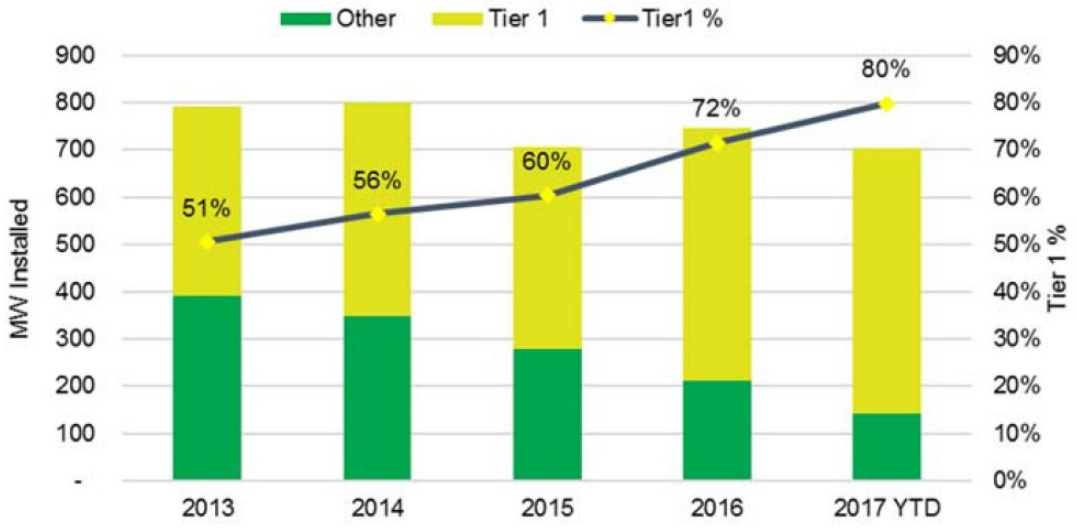


Figure 10: Australian installed panels have improved in average quality over the years (Source: Green Energy Markets)[9]

5.1.1.2 Inverters

- In the early part of the decade, the pressure to reduce system prices led to an influx of cheap Chinese inverters. This has changed over the past three years, following negative experience with product reliability, reduced price differential to higher-quality product, and higher barriers to entry (accreditation listing price and Australian Standards).
- The inverters sold into the Australian market are now predominantly of Chinese or European origin. The exceptions are micro-inverters / power-optimisers from the USA and Israel.

5.1.1.3 Racking

- Practically all racking is imported from China, with the exception of local manufacturers IXL.

5.1.2 Wholesaler

- The role of the wholesaler is to buy product from manufacturer, import it, sell it to PV retailers, and handle the logistics of making it available to installers.
- Wholesalers are therefore responsible for importing, currency hedging, warehousing, and logistics.
- Wholesalers are typically the nominated importer (and therefore have responsibility and liabilities under Australian Consumer Law and electrical legal responsibilities[10]).

5.1.3 Solar Retailer

- The role of the solar retailer is to sell the PV system to end-customer, buy product from the wholesaler, secure approval for network connection, arrange for installation, and handle STC paperwork.

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[9] Green Energy Markets, "Small-scale technology certificates Data modelling for 2018 to 2020. Draft Report to the Clean Energy Regulator", January 2018. http://greenmarkets.com.au/images/uploads/GEM%20Reports/Industry%20Reports/Modelling_report_by_Green_Energy_Markets_-_January_2017.pdf

[10] http://www.erac.gov.au/index.php?option=com_content&view=article&id=106&Itemid=556

- PV retailers often outsource installation to contract installers, though it's not uncommon for them to employ in-house accredited installers.
- The retailer is responsible for collecting the paperwork from the installer that is needed for STC creation.

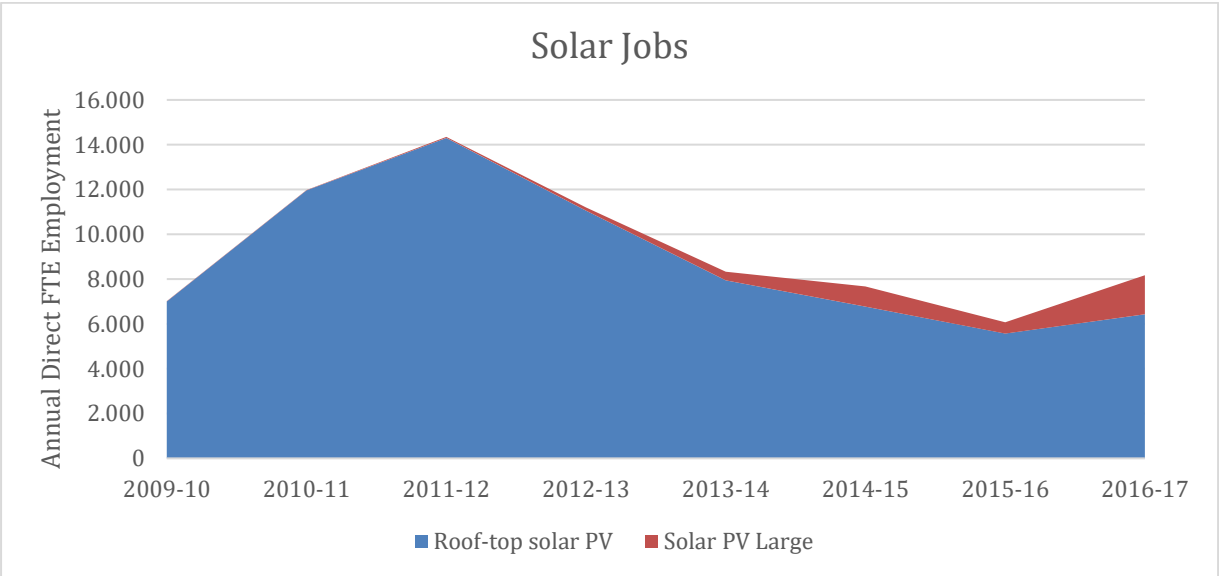
5.1.4 Installer

- Responsible for physical installation and commissioning of the system, and signing off on critical paperwork for electrical connection and STCs.
- May also sell solar systems on the side.
- Installation teams will be made up of at least one CEC-accredited installer (electrician) plus other electricians and labourers.
- The CEC-accredited installer signing off on the job is liable to ensure the system design and installation meet Australian Standards and CEC guidelines.

5.2 Labour places

The rebound in rooftop PV volumes and the growth in solar farm deployment was associated with corresponding increases in employment in 2017. According to the Australian Bureau of Statistics, there were 6430 direct full-time equivalent jobs in Rooftop PV and Solar Hot Water in 2016-17, plus 1740 in large-scale solar. However, indirect employment would include jobs related to R&D and jobs within government and electricity utilities, potentially double these numbers[11]. Casting further doubt upon the accuracy of the ABS data, the Clean Energy Council data shows a record number (4941) accredited PV installers existed at the end of 2017.

Table 20: Estimated PV-related labour places over 2009-2017



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

5.3 Business value

Table 21 summarises the total value of the Australian solar industry in 2017. It should be noted that these figures exclude the progressive tally of solar farms that were under construction (i.e. not yet commissioned) at the end of 2017.

Table 21: Value of PV business (AUD)

Sub-market	Capacity installed *in 2017* (MW)	Price per W	Value	Totals
Grid-connected distributed	1 186	$2,20	2 632	
Grid-connected centralized	114	$2,24	255	
				2 887
Export of PV products				0[12]
Import of PV products				1 264
Value of PV business				1 623

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[12] Assumed to be immaterial

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 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 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 5000 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.

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.

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.

6.2 Interest from electricity utility businesses

The businesses that make up the electricity industry have collectively recognised the inevitability of solar power rolling out across Australia, and most have opted to play a constructive role.

Though it only comprises 3,9% of overall electricity generation, solar uptake is impacting the energy market operation technically and financially. Financially, PV is reducing the amount of energy transported and sold, and reducing the wholesale electricity price during the daytime. Technical issues most commonly relate to impacts upon local voltages, and network operators have been given the ability to constrain the amount of PV that is connected to their networks, and impose these constraints upon individual applicants unless applicants used inverters with operation modes under the network operators' influence.

6.2.1 Electricity Network operators

Though the energy market operator has largely prevented the solar industry from attempts by electricity network operators to discriminate against solar customers with solar-specific tariffs that would financially penalise solar households, most network operators still impose delays and conditions to network connection approval that increase the soft costs of solar deployment. Despite that, some network operators have spun-off solar retailing companies of their own, managed at arm's length through ring-fencing provisions.

Australian energy regulators, while becoming mindful of the need to change regulatory frameworks in 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 part access to this market is not available. Regardless, momentum is swinging towards a more neutral playing field that balances the needs of both incumbents and the newcoming distributed energy market participants.

The Energy Networks Association is actively considering a future with high-penetration PV, working with CSIRO to produce an Electricity Network Transformation Roadmap.

6.2.2 Electricity Generators and Retailers

Electricity generators and retailers are commonly the same company in many parts of Australia, and are therefore collectively referred to as 'gentailers'. These businesses are currently participating in the rollout of solar farms by contracting PPAs from solar farms, in order to meet their RET liability. The three largest electricity retailers also have their own solar retailing divisions; indeed Origin Energy ranked amongst the top solar retailers by volume with a 3,2% share of the sub-100kW market.

6.3 Interest from municipalities and local governments

There is high and increasing interest in PV implementation from local governments and community organisations around Australia. These groups typically are less well-resourced than utility or large government organisations, and must operate within the electricity market described above, but are backed by a high level of community support for local generation and employment creation. 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.

Specific examples of local government solar PV support initiatives include:

- The City of Adelaide provides 50% of the cost of batteries up to a value of $5000, plus up to a further $5000 for 20% of the price of a PV system[13].
- Commercial businesses operating in the City of Melbourne can access finance to install solar panels using the innovative environmental upgrade agreement (EUA) funding model. The fund's investment program provides loans of up to $2 million for 10 years' maximum repayment period.
- The Melbourne Renewable Energy Project is a consortium of local government, educational institutions, and private companies that successfully purchased 110 GWh worth of energy from new large scale renewable energy facilities.
- The Sunshine Coast Council completed construction of a 15MW solar farm in 2017, Australia's first Local Government-owned solar farm.

Other examples of programs used by local governments include:

- Solar Bulk Buy Programs – Gives households and businesses in these municipalities access to bulk purchase discount deals. Many local government bulk-buy programmes exist.
- 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.
- Tenders for PV system installations on council buildings across the nation.

[13] http://www.adelaidecitycouncil.com/your-council/funding/sustainable-city-incentives-scheme/

- 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.

See Section 3.1.5 for more details.

6.4 Interest from state and territory governments

In recent years, facing costs of feed-in tariffs, PV had fallen out of favour amongst many conservative state governments. Many state governments own the distribution network and generation assets; both are facing declining sales volume, due to reduced demand from manufacturing, increased energy efficiency as well as high PV uptake. In 2017, state governments continued to progress measures that would support the deployment of renewable energy, by accelerating the development approval of some solar farms, tendering for renewable energy for their facilities, creating state-based targets for renewable energy uptake, and launching tenders for grid-scale batteries. See Section 3.1.4 for more details.

7 HIGHLIGHTS AND PROSPECTS

2017 was a record year for Australian PV installations, with 1,3GW recorded. 2017's record volume was driven by large increases in electricity prices, continued reduction in PV system prices, an increasing awareness of the benefits of PV to businesses, and the swift ramp-up of the Renewable Energy Target (RET).

Australia boasts the highest per-capita number of PV systems internationally, with 20% of households hosting one of 1,8 million PV systems – over 160 000 of which were added in 2017. Residential penetration levels average over 20% of households and reach over 50% in some urban areas. At the end of 2017, the cumulative installed capacity of Australian PV installations was 7,25GW, accounting for 13% of national electricity generation capacity and 3,9% of electrical energy generation. Panel prices continued to decline, and system prices reached record lows.

Hundreds of thousands of customers had their feed-in tariff revert to unsubsidised level at the beginning of 2017, which created an opportunity for early adopters of PV to expand their system size and/or add batteries. At the beginning of the year the Victorian government took a nation-leading position in incorporating the value of carbon emissions into it's feed-in tariff. Some small subsidies applicable to solar power systems and/or storage commenced in limited areas in 2017.

The broader national energy market became front-page news throughout 2017, following supply constraints in some states over summer that were exacerbated by the retirement of some major coal-fired power stations and the low availability of gas – both of which combined to a doubling in wholesale electricity prices. The government adopted 49 of 50 recommendations from Australia's Chief Scientist into how to address the energy 'trilemma' of affordability, reliability, and low-emissions, but stopped short of adopting a Clean Energy Target in favour of proposing a National Energy Guarantee.

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 for incumbents. 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. Having weathered years of attacks by of incumbent generators and network operators, PV has returned to favour and many electricity retailers and network operators have themselves expanded their sales of PV systems and are also looking to incorporate battery storage.

Over 20 000 home energy storage systems were deployed in 2017, most of which did not receive any subsidy. The Australian storage market if viewed favourably by overseas battery/inverter manufacturers due to its high electricity prices, low feed-in tariffs, excellent solar resource, and large uptake of residential PV. The world's largest Lithium-ion battery (100MW/129MWh) was installed in South Australia in under 100 days.

Further growth in the Australian market is expected in 2018, with over 1,3 GW of solar farms currently under construction, and 35GW at various stages of development. By the end of 2017 it was clear that there were sufficient projects in advanced stages of development to meet the RET, creating a steep investment drop-off beyond 2020. However, with incumbent businesses in the network, generation, and retail space progressively embracing renewable energy as an inevitability, momentum is building for the coming decade.

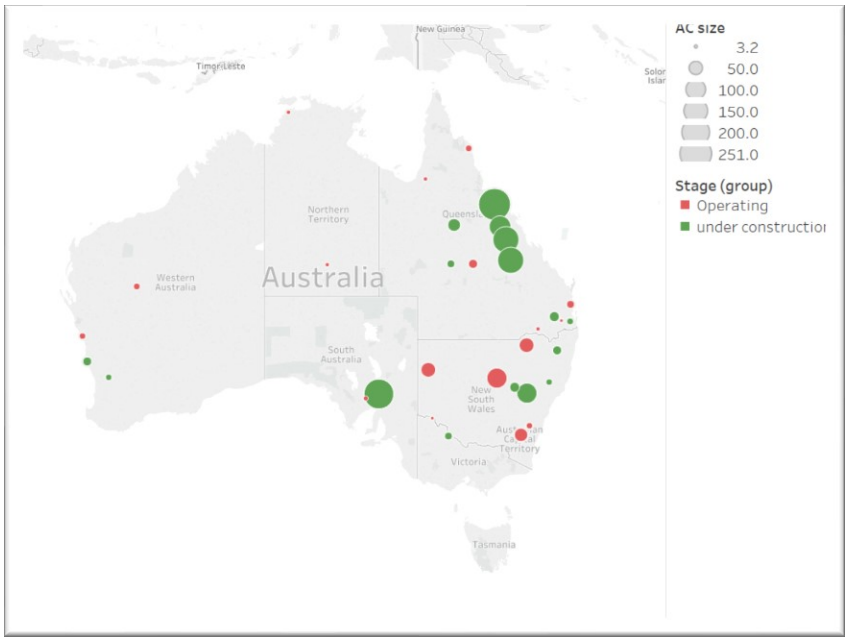

Figure 11. Map of Australian solar farms operating and under construction at the end of 2017

2018 looks certain to be another record year for Australian PV. Notwithstanding that a record volume of utility scale PV will be deployed, the economic fundamentals for residential and commercial PV are outstanding. Australia's high electricity prices and inexpensive PV systems means payback can commonly be achieved in 3-5 years, a situation that looks set to continue in 2018. Momentum is building for further acceleration of commercial PV deployment, and corporate interest in solar PPAs is emerging. However, the RET will soon be met, leaving over 20 GW of PV projects searching for an alternative pathway towards commercialisation. Though a policy gap may occur, there is acceptance amonst incumbent electricity businesses and regulators that renewable energy is the least cost source of new-build electricity, and will soon outcompete Australia's existing generation fleet that are progressively needing refurbishment.