



**CLEAN
ENERGY
COUNCIL**



CLEAN ENERGY AUSTRALIA

REPORT 2016

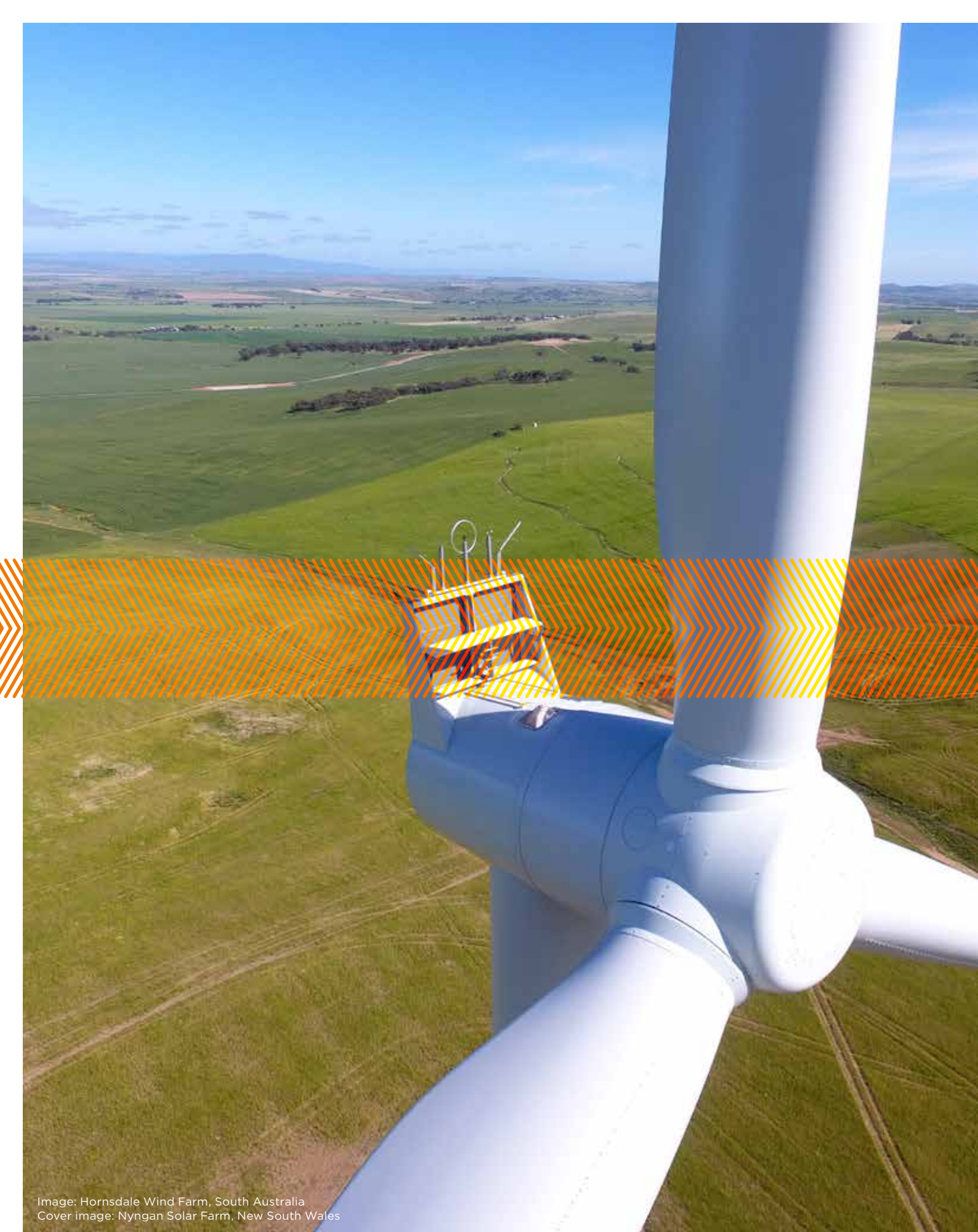


Image: Hornsdale Wind Farm, South Australia
Cover image: Nyngan Solar Farm, New South Wales



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It's boom time
for large-scale
renewable energy.

INTRODUCTION



Kane Thornton
Chief Executive,
Clean Energy Council

It's boom time for large-scale renewable energy. With only a few years remaining to meet the large-scale part of the Renewable Energy Target (RET), 2017 is set to be the biggest year for the industry since the iconic Snowy Hydro Scheme was finished more than half a century ago.

While only a handful of large-scale renewable energy projects were completed in 2016, project planning and deal-making continued in earnest throughout the year. A variety of policies introduced by state and territory governments, combined with support from the Australian Renewable Energy Agency and the Clean Energy Finance Corporation, sought to repair the damage to investment confidence which had lingered since the review of the RET by the Abbott Government in 2014 and 2015. All this is now bearing fruit.

The projects that were progressed throughout 2016 and go to construction during 2017 represent more than \$6.9 billion of investment, 3725 direct jobs and 3150 megawatts in new power generation capacity – about half of what needs to be delivered under the Large-scale Renewable Energy Target by 2020.

Rooftop and commercial solar continue to perform strongly, though at more sustainable levels than the boom years of 2011 and 2012. Between household, commercial and large-scale solar power, solar power production increased by more than a quarter (29 per cent) during the year. Significantly, many businesses are switching on to the idea

of generating their own renewable energy to manage electricity prices that continue to rise following a decade of energy and climate policy uncertainty.

The business case is helped by Bloomberg New Energy Finance analysis which confirms renewable energy is now the cheapest type of new power generation that can be built in Australia, undercutting the skyrocketing price of gas and well below new coal – and that's if it is possible to find investors willing to take a high-stakes punt on a new coal plant, which seemed unlikely at the beginning of 2017. This new normal is a substantial change from a decade ago, and it is taking policymakers time to catch up. The cost of large-scale solar in particular has plunged more than 40 per cent in just the last couple of years.

Battery storage continues to light the imaginations of many people across the energy sector. There is no doubt it will play a huge role in the future as new technologies are developed and prices continue to tumble. In the meantime, the Clean Energy Council has done a huge amount of work developing policy to unlock its potential, consulting on new standards and developing new installation guidelines and training.

All the hard work is paying off. It is a very exciting time for our industry, full of great challenge and opportunity.

A handwritten signature in black ink, appearing to read 'Kane Thornton', written in a cursive style.

EXECUTIVE SUMMARY



Renewable energy supplied 17.3% of Australia's electricity during 2016

Image: Water running to Catagunya Power Station, Tasmania

Approximately 17,500 gigawatt-hours (GWh) of renewable energy was generated in 2016 towards meeting the large-scale component of the Renewable Energy Target (RET), which is set at 33,000 GWh in 2020. This puts the industry just over halfway towards achieving it.

The last of the lingering uncertainty from the Abbott Government's review of the RET had washed out of the industry's system by the end of 2016.

As of March 2017, the projects set to go to construction during the year added up to more than 3725 direct jobs, \$6.9 billion in investment and 3150 megawatts (MW) of new generation capacity. This is approximately half of the capacity required to meet the remainder of the RET, and much of it will be delivered in a single year. The target now appears very much in the industry's sights.

Tasmania's energy crisis was resolved after the Basslink cable linking the island with the mainland was repaired in June, and strong winter rains restored its dams to healthy levels. Consequently, a resurgent hydro sector was the strongest contributor to a bounce in renewable energy generation. Overall, renewable energy supplied 17.3 per cent of Australia's electricity during 2016.

While the industry is headed into a boom in 2017, project activity the year before was subdued for large-scale renewable energy. The Moree Solar Farm – the country's second largest – started to generate power early in the year, leaving a variety of smaller solar power plants and three wind farms as the only projects to be completed. But the aggregate rise of small, medium and large-scale solar led to an increase in solar generation output of 29 per cent.

One of the signature trends of the last few years has been the plunging cost of large-scale solar power, a technology that also has shorter project lead times than wind energy – a virtue when the 2020 RET deadline is fast approaching.

The ACT Government's reverse auction scheme led to the cheapest wind power ever contracted in Australia, for \$73 a megawatt-hour (MWh) at Stage 3 of Neoen's Hornsdale Wind Farm in South Australia. AGL appears set to go one better, with electricity from the Silverton Wind Farm reported to be as low as \$65/MWh.

Official employment numbers in the renewable energy industry dropped 15 per cent to 11,150 in the 2015-16 financial year, down from more than 13,000 the year before. The numbers were even more stark when compared to the industry peak of more than 19,000 jobs in 2011-12, when rooftop



solar was booming and many wind projects were underway.

Household and commercial solar growth continued steadily, with many solar businesses now targeting the 30-100 kW section of the market. With power prices rising and the cost of solar technology continuing to fall, the business case strengthens each year. The fastest-growing sector is now commercial solar between 75-100 kW.

A state-wide blackout following a once-in-50-year storm in South Australia in September thrust energy security into the national spotlight. While political ‘battlelines’ have emerged around renewable energy, there followed an increased and long overdue focus on the reforms necessary to ensure the system can support higher levels of renewable energy in the future.

It was also a big year for innovative third-party software and systems linking the solar and storage technology of customers with the energy market. This is something that is expected to grow exponentially in the years ahead.

While research from solar consultancy SunWiz indicates only 6750 energy storage units were installed in 2016, this was up 13 times on the year before. It is expected that the uptake of battery storage will continue to increase significantly in years ahead. With energy security now a front-of-mind issue for many Australians, this is likely to drive increased sales at the household and business level as unit prices drop and power prices continue to rise.

ABOUT US

The Clean Energy Council is the peak body for the renewable energy and energy storage industry in Australia. We represent and work with hundreds of leading businesses operating in solar, wind, hydro, bioenergy, energy storage, geothermal and marine along with more than 4000 solar and battery storage installers.

We are committed to accelerating the transformation of Australia’s energy system to one that is smarter and cleaner.

The Clean Energy Council leads and supports the growth of the clean energy industry in Australia through:

- > shaping policy
- > developing standards and regulations and ensuring the integrity of the industry
- > promoting the industry
- > providing a range of valuable services to our members, customers and partners.

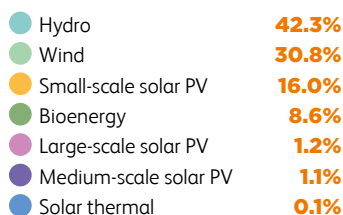
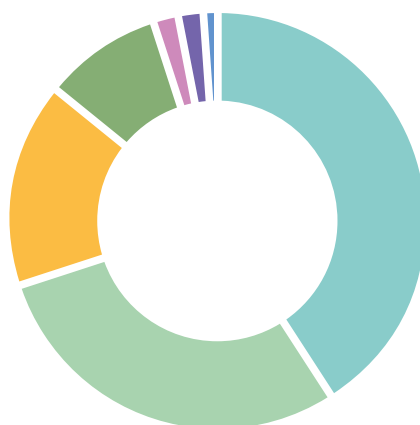
2016 SNAPSHOT

Renewable energy generation increased sharply in 2016 on the back of a resurgent hydro sector. Overall, renewable energy supplied 17.3 per cent of Australia's electricity throughout the year – enough to power the equivalent of almost 8 million average homes. It was a breakthrough year for the sector, with renewable energy providing the highest proportion of Australia's electricity of any year this century.

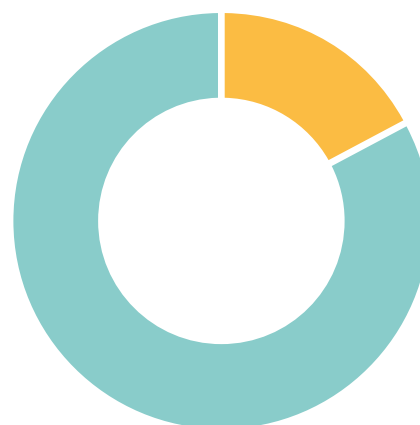
It was a significant rise on the 14.6 per cent generated by renewables the year before, and much of the improved performance for the sector was delivered by a boost in hydro generation of more than a quarter (26 per cent) compared to 2015. The difference was improved rainfall in the dam catchment regions of Tasmania and the Snowy Hydro Scheme, which returned to more typical levels following several dry seasons.

Project activity was subdued, with only three new wind farms becoming operational along with seven solar power plants. The solar plants were relatively small, with the exception of Fotowatio Renewable Ventures' (FRV)

RENEWABLE GENERATION BY TECHNOLOGY TYPE



ANNUAL ELECTRICITY GENERATION IN 2016



RENEWABLE ENERGY GENERATION¹

TECHNOLOGY	GENERATION (GWh)	PERCENTAGE OF RENEWABLE GENERATION	PERCENTAGE OF TOTAL GENERATION	EQUIVALENT NUMBER OF HOUSEHOLDS POWERED OVER COURSE OF THE YEAR
Hydro	17,747	42.3%	7.32%	3,380,371
Wind	12,903	30.8%	5.32%	2,457,723
Small-scale solar PV	6701	16.0%	2.76%	1,276,305
Bioenergy	3608	8.6%	1.49%	687,238
Medium-scale solar PV	456	1.1%	0.19%	86,766
Large-scale solar PV	502	1.2%	0.21%	95,598
Solar Thermal	27	0.1%	0.01%	5143
Geothermal	0.50	0.0%	0.00%	95
TOTAL	41,944	100%	17.29%	7,989,239

¹ Source: Clean Energy Council Renewable Energy Database, NEM Watch, *Australian Energy Statistics 2016*, REC Registry, SunWiz, AEMO, AEMC. Note: some figures have been rounded. Figures do not include auxiliary load or transmission line losses. Electricity generation equivalent in households is calculated using 5.25 MWh national average household energy consumption (from AEMC 2016).

Moree Solar Farm, the second largest in the country, and Elecnor's 25 MW Barcaldine Solar Farm. Almost all of these projects had additional support beyond the Renewable Energy Target, with two out of the three wind farms supported by the ACT Government's reverse auction program and many of the solar farms attracting support from the Australian Renewable Energy Agency (ARENA). Consequently, the contribution of wind power to overall generation rose only modestly. Solar output rose 29 per cent during the year across small, medium and large-scale projects.

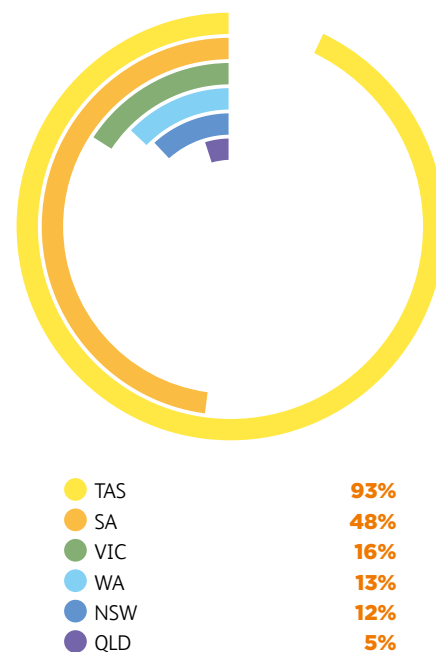
The fastest-growing sector of the solar market has been commercial systems between 75-100 kW, helping to push up the average size of solar power systems to 5.56 kW at the end of 2016. Commercial systems between 30-100 kW are particularly popular in the ACT, New South Wales, South Australia and the Northern Territory, where they make up about 30 per cent of sales.

Tasmania remained the leader in the use of renewable energy as a percentage of its power use, with

renewable energy supplying more than 90 per cent of the state's electricity, largely thanks to hydro. However, a damaged Basslink cable and low dam storages leading into 2016 meant the island used higher levels of gas – and also some diesel generation – to secure its energy supply than it had in the past. The higher rainfall over the winter months and the repair of the damaged Basslink cable in June helped the system to return to normal operation.

With the Northern coal-fired power station shutting down in South Australia for economic reasons, 48 per cent of the state's electricity came from renewable energy. Wind power was the leading source of energy for the first time during 2016, delivering 40 per cent of the state's electricity and just edging out gas-fired power. Given Northern did not shut down until May, it appears almost certain that renewable energy will end up delivering more than half of the state's power during 2017, meaning the state's target for renewable energy will have been met eight years ahead of schedule.

PENETRATION OF RENEWABLE ENERGY BY STATE²



PENETRATION OF RENEWABLE ENERGY BY STATE²

STATE	TOTAL GENERATION (GWh)	FOSSIL FUEL GENERATION (GWh)	TOTAL RENEWABLE GENERATION (GWh)	PENETRATION OF RENEWABLES
TAS	11,103	817	10,286	93%
SA	11,364	5856	5508	48%
VIC	55,221	46,619	8602	16%
WA	19,609	17,001	2608	13%
NSW	64,339	56,879	7460	12%
QLD	60,782	57,932	2850	5%
NATIONAL	222,418	185,104	37,314	17%

² Total generation includes National Energy Market and WEM data and small-scale solar PV. The ACT is part of the NSW region and there is no data for the small NT grid. Some of the Snowy Hydro Scheme in NSW is counted as Victorian generation by AEMO. Note: These figures are not the same as the total electricity generation, as non-scheduled and off-grid generators are not included in this data (other than domestic solar). Source: NEM Watch, SunWiz

2016 SNAPSHOT CONTINUED

> 10

Renewable energy projects completed in 2016

264.1

Megawatt capacity

> 11

Renewable energy projects under construction at the end of 2016

865.8

Megawatt capacity

Images: Ararat Wind Farm, Victoria

2016 was a breakthrough year for the sector, with renewable energy providing the highest proportion of Australia's electricity of any year this century.

RENEWABLE ENERGY PROJECTS COMPLETED IN 2016

TECHNOLOGY	STATE	OWNER	PROJECT	CAPACITY (MW)
Solar	NSW	Fotowatio Renewable Ventures (FRV)	Moree Solar Farm	56
Solar	QLD	Elecnor	Barcaldine	25
Solar	ACT	Maoneng Australia	Mugga Lane Solar Farm	13
Solar	WA	Sandfire Resources NL	De Grussa Mine	10
Solar	ACT	Impact Investment Group	Williamsdale	10
Solar	NT	UGL	Darwin Airport	5.5
Solar	QLD	Scouller Energy and Canadian Solar	Normanton Solar Farm	5
Wind	SA	Neoen and Megawatt Capital	Hornsedale Stage 1	100
Wind	VIC	Windlab	Coonooer Bridge	19.8
Wind	SA	Palisade and Northleaf Capital	Waterloo Stage 2	19.8

RENEWABLE ENERGY PROJECTS UNDER CONSTRUCTION AS OF 31 DECEMBER 2016

TECHNOLOGY	STATE	OWNER	PROJECT	CAPACITY (MW)
Hybrid	SA	EDL	Cooper Pedy	5
Landfill waste	VIC	Yarra Valley Water	Wollert*	1
Solar	QLD	Sunshine Coast Council	Sunshine Coast Solar Farm	15
Solar	QLD	Conergy - Lakeland Solar & Storage P/L	Lakeland Solar & Storage Project	10.8
Timber waste	VIC	City Circle Cement	Brooklyn*	1
Wind	VIC	RES (Renewable Energy Systems) Australia	Ararat	240
Wind	QLD	RATCH	Mt Emerald	180
Wind	NSW	Goldwind Australia	White Rock Stage 1	175
Wind	SA	Neoen and Megawatt Capital	Hornsedale Stage 3	109
Wind	SA	Neoen and Megawatt Capital	Hornsedale Stage 2	100
Wind	VIC	Pacific Hydro	Yaloak South	29

* These projects were in commissioning phase at end of 2016

INDUSTRY GEARS UP TO MEET THE RENEWABLE ENERGY TARGET

“Investment confidence has rebounded and our economy is set to reap the benefits through a massive increase in activity between now and the end of the decade.”

– Kane Thornton, Chief Executive, Clean Energy Council

30
new renewable
energy projects

At least 30 projects will be under construction during 2017, in what is shaping up to be the biggest year for the industry since the iconic Snowy Hydro Scheme was built more than half a century ago.

instrumental in bringing forward projects, particularly in solar, and driving innovation in financial models.

\$6.9B
in investment

An unprecedented program of works will deliver more than \$6.9 billion in investment, create 3725 jobs and build 3150 MW of capacity – much of it in regional Australia – as the industry gears up to meet the national Renewable Energy Target (RET).

The renewable energy projects underway in 2017 will provide direct investment and jobs – as well as indirect jobs, spending and community funding in regional areas – which will continue through to 2020 as the industry builds more projects to meet the RET.

3725
new jobs

The ambitious scope of works is largely due to the bipartisan support returned to the RET in 2015, continued falls in the cost of renewable energy and strong support from a number of state and territory governments. The Australian Renewable Energy Agency and the Clean Energy Finance Corporation have also been

Australia is realising the significant benefits of backing the renewable energy industry. For these economic benefits to continue, clear policy direction and support is required beyond 2020.

3150
megawatts
of new capacity



PROJECTS UNDER CONSTRUCTION END OF 2016 AND TO START CONSTRUCTION IN 2017 (AS OF MARCH 2017)

TECHNOLOGY	STATE	DEVELOPER	PROJECT	MW	INVESTMENT	JOBS	TURBINES
Wind	SA	Neoen/ Megawatt Capital	Hornsedale Stage 2 & 3	209	\$800m*	150	73
Wind	VIC	RES	Ararat	240	\$450m	165	75
Wind	NSW	Goldwind Australia	White Rock Stage 1	175	\$400m	300	70
Wind	QLD	RATCH	Mt Emerald	180	\$380m	150	63
Wind	VIC	Windlab	Kiata	30	\$75m	70	9
Wind	VIC	Pacific Hydro	Yaloak South	29	\$130m		
Solar	QLD	Sunshine Coast Council	Sunshine Coast Solar Farm	15	\$50m	60	
Solar	QLD	Lakeland Solar & Storage P/L (Conergy)	Lakeland Solar and Storage	10.8	\$42.5m	60	
Wind/Solar	SA	EDL	Coober Pedy	5	\$37m		2
Solar	NSW	New Gullen Range Wind Farm	Gullen Range Solar Farm	10	\$26m	70	
Wind	NSW	Powering Australian Renewables Fund	Silverton Wind Farm	200	\$460m	150	58
Solar	QLD	Fotowatio Renewable Ventures (FRV)	Lilyvale Solar Farm	100	\$400m	200	
Wind	NSW	Partners Group/ CWP Renewables	Sapphire	270	\$588m	200	75
Solar	NSW	Neoen	Three projects: Dubbo, Parkes and Griffith	110	\$230m	250	
Solar	QLD	ESCO Pacific*	Ross River Solar Farm	148	\$225m	150	
Wind	NSW	Union Fenosa	Crookwell 2	91	\$200m	80	33
Solar	SA	Snowy Hydro	Tailem Bend	100	\$200m	200	
Solar	QLD	Fotowatio Renewable Ventures (FRV)	Clare Solar Farm	100	\$190m	200	
Solar	QLD	Sun Metals P/L	Sun Metals Solar Farm	116	\$155m	250	
Wind	VIC	ACCIONA	Mt Gellibrand Stage 1	66	\$140m	100	22
Solar	QLD	Genex	Kidston Solar Farm	50	\$126m	100	
Solar	WA	APA	Emu Downs	20	\$50m	100	
Wind/Solar	QLD	Windlab	Kennedy Energy Park	40	\$120m	50	10
Solar	VIC	Overland Sun Farming	Three projects: Yatpool, Iraak, Wemen	320	\$500m	200	
Bagasse	QLD	MSF Sugar	Tableland Sugar Mill	24	\$75m	80	
Timber waste	VIC	City Circle Cement	Brooklyn#	1			
Landfill waste	VIC	Yarra Valley Water	Wollert#	1			
Solar	NSW	First Solar	Manildra Solar Farm	48.5			
Solar	SA	Lyon Group	Riverland Solar Farm	330	\$700m	270	
Wind	NSW	Infigen Energy	Bodangora Wind Farm	113.2	\$236m	120	33

	3150.5 MW new capacity	\$6985.5M investment	3725 new jobs	523 wind turbines
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* This investment figure represents a total value for Stages 1, 2 and 3 of the Hornsdale Wind Farm.

These projects were in commissioning phase at end of 2016 and are not included in the total new capacity figure.

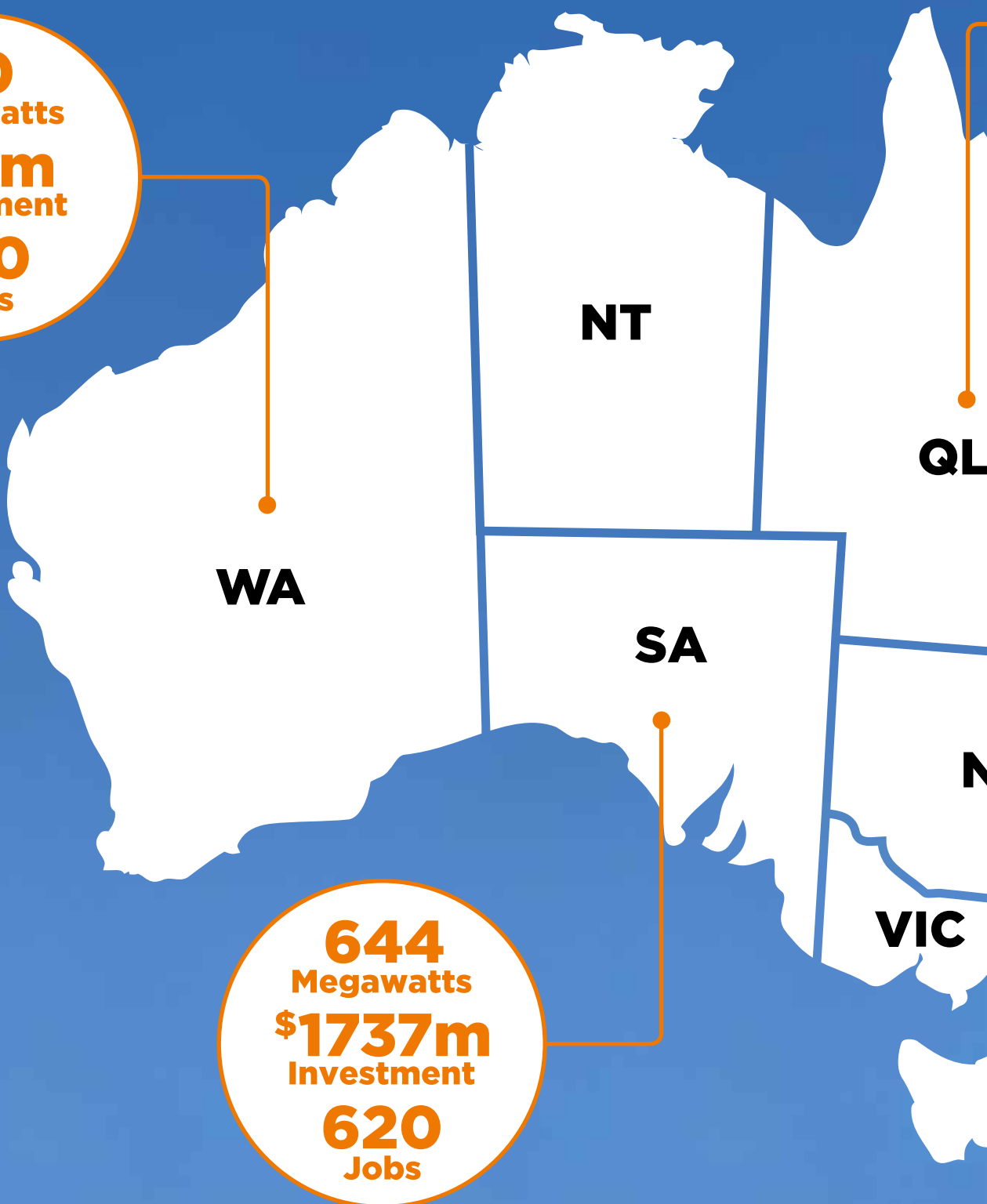
* Developer is ESCO Pacific/Palisade Asset Management



**JOBS AND
INVESTMENT
IN RENEWABLE
ENERGY
BY STATE**

LARGE-SCALE RENEWABLE ENERGY PROJECTS UNDER CONSTRUCTION OR STARTING IN 2017*

20
Megawatts
\$50m
Investment
100
Jobs



WA

NT

QLD

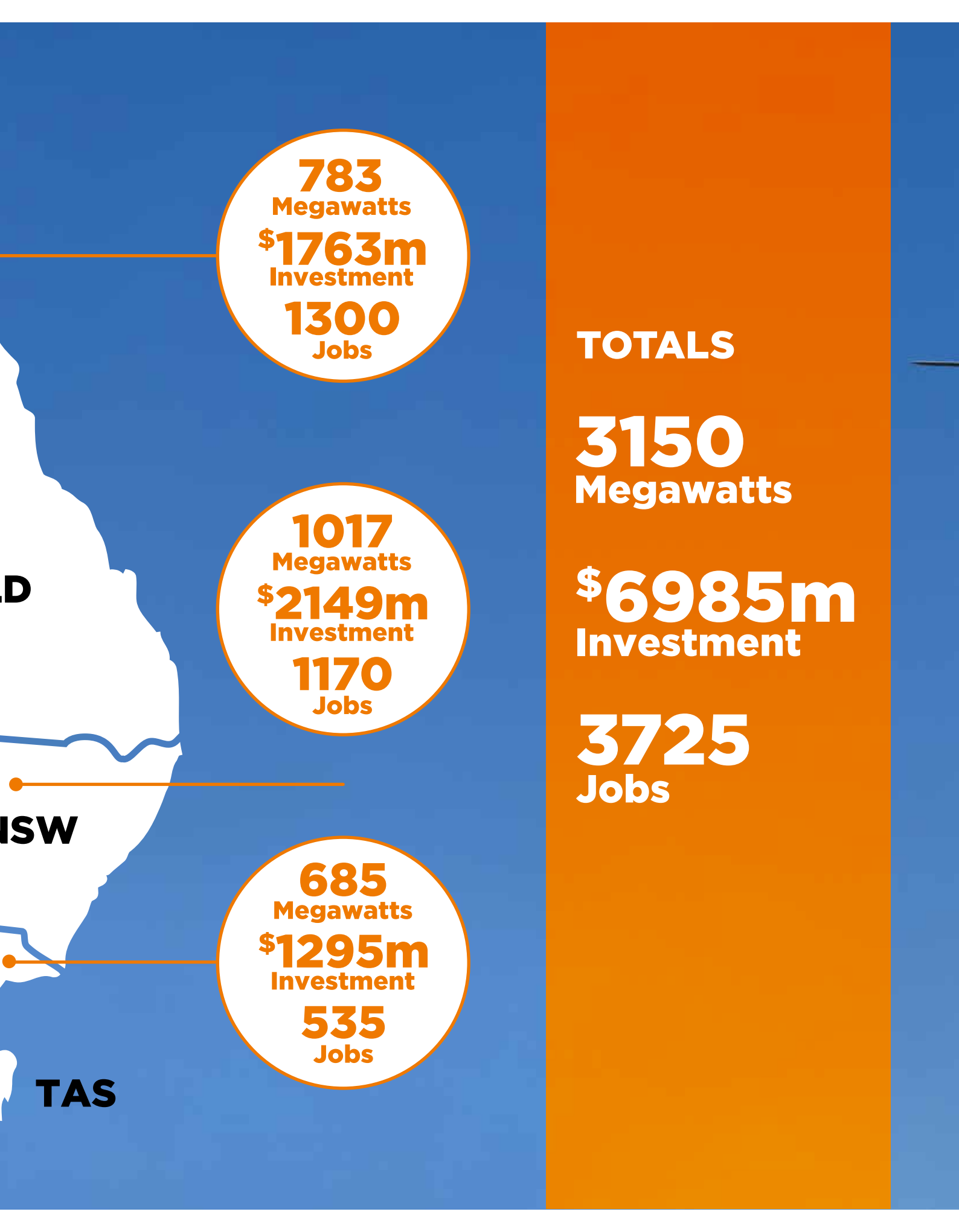
SA

VIC

644
Megawatts
\$1737m
Investment
620
Jobs

* As at March 2017

Image: Hornsdale Wind Farm, South Australia



783
Megawatts
\$1763m
Investment
1300
Jobs

1017
Megawatts
\$2149m
Investment
1170
Jobs

685
Megawatts
\$1295m
Investment
535
Jobs

TOTALS

3150
Megawatts

\$6985m
Investment

3725
Jobs



INDUSTRY OUTLOOK 2017 - 2020

THE RENEWABLE ENERGY TARGET

The national Renewable Energy Target (RET) is an industry development policy designed to accelerate new renewable energy projects across Australia, generating jobs and investment from the resulting economic activity.

Despite the remarkable fall in the price of wind and solar power over the last decade, new renewable energy in the Australian market must compete against existing coal and gas generators, the majority of which were wholly built by state governments many decades ago. The RET addresses a market failure which tilted the playing field heavily in favour of the incumbents.

The RET is split into two parts: the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). The SRES is uncapped and provides a modest incentive for households to install renewable energy systems such as solar power or solar hot water.

The LRET level is capped at 33,000 GWh of renewable energy generation by 2020, following a legislative change in 2015.

PROGRESS TOWARDS THE RENEWABLE ENERGY TARGET

The majority of the Large-scale Renewable Energy Target (LRET) will be met by a combination of wind and solar plants. When bipartisan support was returned to the policy in 2015, most analysts assumed that wind power would make up most of the target, as it was the cheapest large-scale technology at the time.

However, a variety of state and federal government programs has helped deliver substantial cost reductions in large-scale solar technology. The other advantage of solar projects is that they can be built rapidly. This is an important factor as the deadline for the end of the policy is now looming, favouring those technologies which can be financed and constructed quickly before 2020.

During 2016, about 17,500 GWh of renewable energy was generated under the LRET, putting the industry just over halfway towards meeting the target of 33,000 GWh.

More than 900 MW of renewable energy projects were actively under construction at the beginning of 2017, but the number of projects which have secured finance and indicated they are planning to go to construction during the year is much greater.

As of March 2017, these projects added up to more than \$6.9 billion in investment, more than 3725 direct jobs and 3150 MW of new power generation capacity.

The 14,500 GWh of additional generation required to meet the LRET translates to between 5000 and 6000 MW of new wind and solar capacity. Approximately half of this required capacity is expected to be under construction during 2017, most of which will be delivered within a calendar year.

Combined with a strong wind and solar project pipeline and with more project announcements expected in 2017, the industry is confident that the policy will be successfully delivered, provided the policy settings remain unchanged.

ENERGY GENERATION VERSUS 2020 TARGET



- 3 W Johnston, SunWiz, *Believe the hype: Australia's battery market is set for eye-watering growth*, 20 February 2017. Available online: <http://www.sunwiz.com.au/index.php/2012-06-26-00-47-40/73-newsletter/420-battery-market-hotter-than-previously-thought.html>
- 4 REN21, *Fact Sheet: Renewables 2016 Global Status Report Highlights*, 2016. Available online: <https://ren21drive.app.box.com/s/ncjlnevu67e9xc9tyzl85z8jx4s0vdkk/1/8121641589/67842273061/1>
- 5 E. Gosden, The Telegraph, *Global renewable power capacity overtakes coal as 500,000 solar panels installed every day*, October 2016. Available online: <http://www.telegraph.co.uk/business/2016/10/25/global-renewable-power-capacity-overtakes-coal-as-500000-solar-p/>
- 6 J.Hill, Clean Technica, *New coal built most expensive energy option for Australia, according to BNEF*, February 2017. Available online: <https://cleantechnica.com/2017/02/07/new-coal-build-expensive-energy-option-australia-bnef/>

“We are witnessing a transformation of global power markets led by renewables”

- Fatih Birol, Executive Director, International Energy Agency

OUTLOOK FOR SMALL-SCALE RENEWABLE ENERGY

Many solar businesses operating in Australia are now targeting the commercial solar market, and strong growth is expected in systems between 30 – 100 kW as the business case improves year on year.

With strong consumer interest in energy storage and prices dropping quickly, energy storage is set for a big future. This seems to be a question of when rather than if, and energy storage manufacturers have already begun to cut margins to compete with market leaders such as Tesla.

SunWiz is tipping a tripling of energy storage in 2017 compared to the year before.³ Although this is coming off a low base, trials of virtual power plants, microgrids in remote areas and off-grid property developments suggest that many businesses, individuals and governments are considering new and innovative ways to harness the technology.

As familiarity and scale push down costs further, batteries will become an increasingly common complement to solar power systems, helping households and businesses to store renewable energy to be used at their convenience. In the short term, the end of the NSW feed-in tariff for solar power makes the case for storage more attractive, as does the higher power prices paid by residents in South Australia.

PLUMMETING COSTS DRIVE RISE OF RENEWABLES

In 2015, the world added more renewable energy power generation capacity than coal, natural gas and oil combined.⁴ The most compelling part of the story was the fall in the cost of renewable energy technology such as solar and wind, to an extent which the International Energy Agency described as “unthinkable just five years ago”.⁵

According to Bloomberg New Energy Finance (BNEF), renewable energy is now the cheapest form of new energy generation that can be built in Australia, a turn-around in conventional wisdom about electricity which local policymakers are struggling to absorb. The cheapest renewable energy projects are now below the cost of gas – which continues to struggle with securing affordable fuel supplies – while far out-stripping new coal in cost competitiveness.

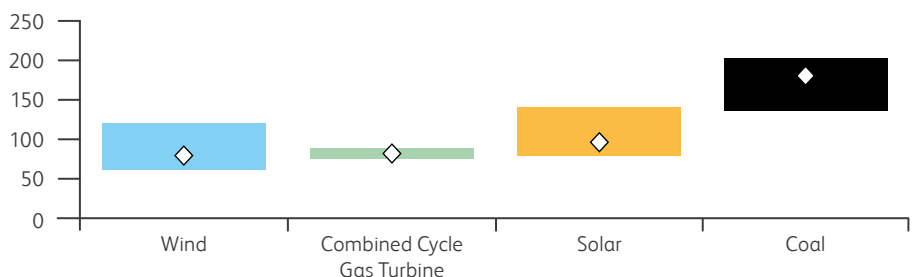
BNEF’s latest data puts the Levelised Cost of Energy (LCOE) of new wind generation at A\$61-118/MWh, combined-cycle gas generation at A\$74-90/MWh, solar generation at

A\$78-140/MWh and ultra-supercritical coal fired generation at A\$134-203/MWh.⁶

BNEF estimated that a new coal-fired power station using carbon capture and storage – a critical element of any new coal generation if Australia is to meet its carbon reduction targets – had an LCOE of approximately A\$352/MWh.⁷ And this is dependent on whether the technology is able to work on a commercial scale or whether it is able to attract finance, neither of which are certain.

Comparatively, the ACT Government’s reverse auctions for wind power contracted stage 3 of the Hornsdale Wind Farm at a record low of \$73/MWh. It has been reported that AGL will deliver the Silverton Wind Farm in NSW for as low as \$65/MWh⁸. And the latest large-scale solar funding round from the Australian Renewable Energy Agency (ARENA) awarded \$92 million to 12 large-scale solar projects, and is expected to leverage \$10 for every dollar of public money invested by ARENA.⁹

2017 LEVELISED COST OF ENERGY FOR NEW BUILD TECHNOLOGIES IN AUSTRALIA (AUD/MWH)¹⁰



7 S.Vorrath, RenewEconomy, “Clean coal” most expensive new power supply, says BNEF (and not all that clean), February 2017. Available online: <http://reneweconomy.com.au/clean-coal-most-expensive-new-power-supply-says-bnef-and-not-all-that-clean-74531/>

8 J.Gifford, RenewEconomy, AGL’s new 200 MW Silverton wind farm to cost just \$65/MWh, January 2017. Available online: <http://reneweconomy.com.au/agls-new-200mw-silverton-wind-farm-to-cost-just-65mwh-94146/>

9 G.Parkinson, RenewEconomy, ARENA announces large scale solar grant winners, 480 MW in total, September 2016. Available online: <http://reneweconomy.com.au/arena-announces-large-scale-solar-grant-winners-480mw-in-total-97091/>

10 Bloomberg New Energy Finance



Image: Hornsdale Wind Farm, South Australia

\$10B
investment in
large-scale
renewable energy
by 2020

STATE RENEWABLE ENERGY POLICIES

Many state governments have recognised the job and investment opportunities available under the Renewable Energy Target (RET). Given much of the expected \$10 billion of investment and thousands of jobs generated from renewable projects will go into regional areas, the attraction is obvious for governments seeking economic opportunities outside the major cities.

The RET remains a key factor underpinning many state and territory policies, though some policies focus on the period after 2020 when the national RET has been met.

The increased ambition of state and territory governments has helped the industry in several ways. First, it has made an important contribution in returning stability to a market which was badly shaken following an extended review of the RET under the Abbott Government.

State governments have also acted to fill the void of robust national energy and climate policy beyond 2020.



AUSTRALIAN CAPITAL TERRITORY



100%

of energy in the ACT
from renewable sources
by 2020

640

megawatts of capacity
added in the ACT
through reverse auctions

The ACT Government is working towards achieving the most ambitious renewable energy target in the country: 100 per cent by 2020.

Its plan to deliver this involved four reverse auctions for new renewable energy projects, adding up to 640 megawatts (MW) of new generation capacity. The process involved project proponents bidding to build wind and solar farms at the lowest possible cost, thereby delivering maximum value for every dollar of government funding.

The ACT Government held a 40 MW reverse auction for large-scale solar projects in 2012 and 2013, followed by three 200 MW wind power reverse auctions in 2014, 2015 and 2016. The successful projects selected through this process receive long-term feed-in tariffs under a 'contracts for difference' arrangement.

The winners of the ACT's third and final wind power auction were announced in 2016:

- > Stage 3 of Neoen's Hornsdale wind farm in South Australia, with 109 MW of capacity contracted at \$73/MWh
- > Union Fenosa Wind Australia's Crookwell 2 wind farm in New South Wales, with 91 MW of capacity contracted at \$86.60/MWh

The wind farms will provide low-cost renewable energy to Canberra as well as helping to finance the roll-out of 36 MW of distributed energy storage in more than 5000 ACT homes and businesses under the ACT Government's Next Generation Storage program.

40%
of energy in VIC
from renewable
sources by 2025

50%
of energy in QLD
from renewable
sources by 2030

VICTORIA

In mid-2016, the Victorian Government announced renewable energy generation targets of 25 per cent by 2020 and 40 per cent by 2025. These targets will be supported by a competitive reverse auction scheme which aims to bring on 1500 MW of new renewable energy generation by 2020, and will help to achieve the national RET. The expanded target translates to 5400 MW by 2025, and the government estimates it will create up to 11,000 construction jobs and \$9 billion in investment over the life of the scheme.

Consultation took place throughout the second half of 2016 and the Victorian Government aims to legislate the scheme in 2017.

The Victorian Government has also been extremely active in exploring the value of solar power to the electricity system through the state Essential Services Commission. It announced in early 2017 that the minimum feed-in tariff paid to solar households would more than double. There are also further plans to introduce special higher rates for solar households, to be paid during periods of high power demand when their electricity is worth a premium to the network.

In February 2017 the government called for expressions of interest to build a 20 MW storage array.

QUEENSLAND

Queensland has set a target of generating 50 per cent of its power from renewable energy by 2030. It is one of the most ambitious targets in the country, given Queensland has a large population and is coming off a very low base for renewable energy – just 5 per cent of the state's electricity came from renewables in 2016.

A special Renewable Energy Expert Panel has developed a series of pathways to achieve the goal, and its report was being considered by the state government at the time of writing.

Queensland currently leads the nation in the number of household solar power installations. It has set a target of one million rooftops with solar power by 2020, which would more than double current levels.

The state stands to benefit from the pipeline of renewable energy projects starting construction in 2017, which were given additional assistance through the Queensland Government's Solar 150 program. The Townsville area stands to do particularly well, with 750 new jobs generated by five large-scale solar projects which will commence in the region this year.


WESTERN AUSTRALIA

With the Coalition Government swept from power by Labor's Mark McGowan in March, change is in the air for Western Australia during 2017. Former Premier Colin Barnett's government had begun to embrace different forms of renewable energy during its time in office, and the new government is already showing early signs of continuing this trend.

Given the sparsely-populated nature of the state, solar power and microgrids with battery storage make more sense for many remote locations than large power plants with long transmission lines which are costly to maintain.

The state-owned power corporations – Synergy, Horizon Power and Western Power (the planned privatisation of which has been halted by the new government) – are all actively pursuing collaborative opportunities with the private sector to develop new technologies.

The Labor Government is not pursuing a formal state renewable energy target, but new Premier McGowan promised \$60 million for energy projects in the coal town of Collie during the election campaign – \$30 million for a new biomass plant and another \$30 million for a solar farm. He also wants to see Albany completely powered by renewable energy and has pledged \$19.5 million for a wave power project in the region.



50%
of energy in SA
from renewable
sources by 2025

SOUTH AUSTRALIA

The South Australian Government has a target for renewable energy of 50 per cent by 2025, noting it offers no commercial incentive for renewable energy beyond that provided by the national RET. More than \$6.6 billion has been invested in South Australia to date. Approximately 40 per cent of this has gone into regional areas – a windfall of \$2.4 billion. The state has committed to an investment target of \$10 billion in low carbon generation by 2025.

Based on data from the Australian Energy Market Operator (AEMO) and solar data, 48 per cent of South Australia's power came from renewable energy in 2016.¹¹ Following the closure of the Northern coal-fired power station – the state's last coal generator – for economic reasons in May 2016, the level of renewable energy in South Australia is likely to crest 50 per cent during the 2016-17 financial year. This means the state target for renewable energy will have been achieved at least eight years earlier than scheduled.

With coal gone, the state's gas-fired power plants now set the price for the rest of the market. Issues with sourcing affordable gas supplies have caused this price to spike sharply. Many large energy customers have faced substantially higher prices as a result, leading to tensions which played out through the media.

In September 2016, a once-in-50-year storm knocked down more than 20 major electricity pylons and three of the state's four major transmission lines. The cascading chain of events led to a state-wide blackout when the interconnector linking it with Victoria overloaded.

The extended state-wide blackout was seized on by some politicians to criticise both the South Australian Government for a lack of planning and renewable energy as a key cause of the blackout. The Federal Government was advised at the time by AEMO that the incident was not the fault of renewable energy.¹²

NEW SOUTH WALES

In early 2016, the New South Wales Government tendered for renewable energy developers and pricing models as part of the Sydney Metro North West rail link. Expressions of interest were sought for the supply of about 137 GWh per annum of electricity from a renewable energy project in the state.

Later in the year, NSW released a new strategic plan for the state's Climate Change Fund, which includes the potential to run some reverse auctions similar to the ACT and Victorian schemes. The government is still working through the details.

TASMANIA

Tasmania has a long history as a renewable energy leader, due to the system of hydro power plants that have provided most of its electricity for the last century. More than 90 per cent of the island's electricity is supplied by renewable energy.

Historic low rainfalls and an extended outage of the Basslink cable connecting Tasmania to the National Electricity Market via Bass Strait created major issues in 2016, with diesel generators brought in to ensure security of supply and several major energy users asked to wind back their energy use during this period. However, the Basslink cable was fully repaired in June and strong rainfall in hydro catchments during winter eased the pressure on the electricity system.

Dr John Tamblyn is leading a joint Commonwealth and Tasmanian Government study into the feasibility of a second Basslink electricity interconnector. The Australian Renewable Energy Agency will lead a feasibility study into the upgrade and expansion of the Tasmanian hydro network, including the possibility of up to 2500 MW of pumped hydro storage. Meanwhile a number of proposals for new wind farms continue to be assessed and developed.

¹¹ NEM Watch, SunWiz

¹² The Australia Institute, *Freedom of Information requests for advice about SA blackout*, February 2017

EMPLOYMENT

The latest figures from the Australian Bureau of Statistics clearly illustrate the impact of the extended review of the Renewable Energy Target (RET) under the Abbott Government.



Image: Solar installer, South Australia



JOBS IN THE RENEWABLE ENERGY INDUSTRY

2014-15
13,000+

2015-16
11,150

**15%
DECLINE**

Overall the industry directly employed 11,150 people in the 2015-16 financial year, down 15 per cent from more than 13,000 the financial year before. The latest figures are also a long way down on the industry high point this decade of more than 19,000 in 2011-12.

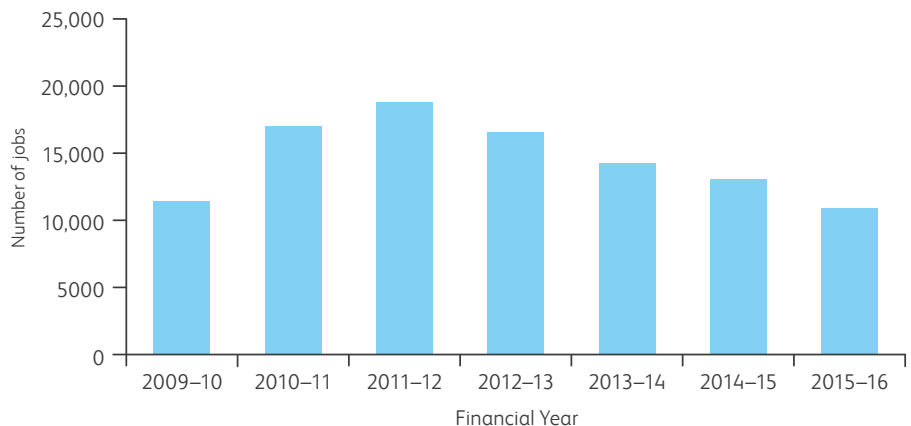
New South Wales remains the largest employer in the renewable energy sector. Employment fell by just over a quarter (26 per cent) in the state, with falls also seen in Victoria, Queensland and South Australia.

As would be expected from the policy uncertainty affecting the large-scale RET, wind power was the hardest hit. Wind employment figures dropped by

about 50 per cent, adding to a decline of 30 per cent the year before. The utility solar sector also contracted by a similar proportion, but from a much smaller base.

The good news for the industry is that 2017 will be the biggest construction year for large-scale renewable energy for at least half a century. The economic activity created by new wind and solar projects under the RET will create major job opportunities out to the end of the decade. As of March 2017, the projects expected to start construction during the year were expected to create 3725 new jobs in renewable energy.

TOTAL JOBS BY YEAR



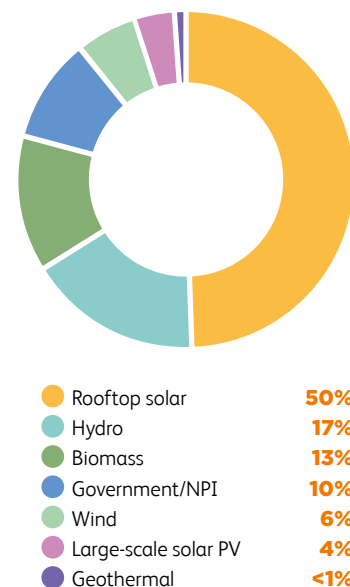
The economic activity created by new wind and solar projects under the RET will create major job opportunities out to the end of the decade.

ANNUAL DIRECT FTE EMPLOYMENT IN RENEWABLE ENERGY ACTIVITIES BY RENEWABLE ENERGY TYPE

ENERGY TYPE	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Rooftop solar PV (a)	7,010	11,960	14,300	11,060	7,950	6,780	5,570
Large-scale solar PV	10	10	50	140	380	890	490
Wind	1,090	1,620	1,110	1,440	1,720	1,220	620
Hydro	1,370	1,390	1,420	1,700	1,750	1,760	1,840
Biomass	1,360	1,360	1,370	1,370	1,520	1,480	1,430
Geothermal	100	80	70	60	60	40	40
Govt/NPI ¹³	750	810	900	1,100	1,120	1,130	1,160
TOTAL	11,690	17,230	19,220	16,870	14,500	13,300	11,150

(a) includes solar hot water systems

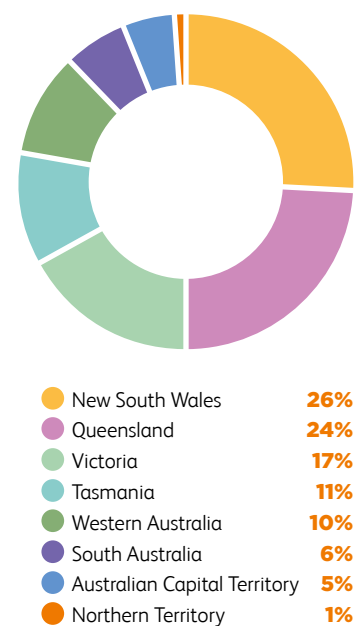
2015-16



DIRECT FTE EMPLOYMENT IN RENEWABLE ENERGY ACTIVITIES BY STATE/TERRITORY

STATE	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
NSW	3,270	4,340	3,790	3,280	3,250	3,940	2,920
VIC	1,720	2,850	3,430	2,920	2,720	2,430	1,900
QLD	2,750	4,120	5,570	5,010	3,850	3,240	2,710
SA	1,400	2,290	2,360	1,870	1,390	870	710
WA	1,070	2,080	2,230	1,600	1,100	1,050	1,060
TAS	960	940	1,200	1,540	1,470	1,150	1,190
NT	70	60	70	70	90	100	110
ACT	450	550	570	580	630	520	550
TOTAL	11,690	17,230	19,220	16,870	14,500	13,300	11,150

2015-16



¹³ Note on definition of Government/Non-Profit Institutions (NPIs): The scope of this publication includes activities undertaken by employees of government agencies and NPIs to support the operation of renewable energy systems, for example, administration, legal, policy or advocacy. Therefore, employment in regulatory bodies such as the Clean Energy Regulator is in scope. Some government agencies and NPIs provide support that is critical to the go-ahead of many renewable energy projects and the employees of these units are also considered to be renewable energy employees. Examples of the latter include the Clean Energy Finance Corporation (CEFC) and Australian Renewable Energy Agency (ARENA). Employees engaged in renewable energy advocacy are also included, for example, employees of various renewable energy peak bodies.

INVESTMENT

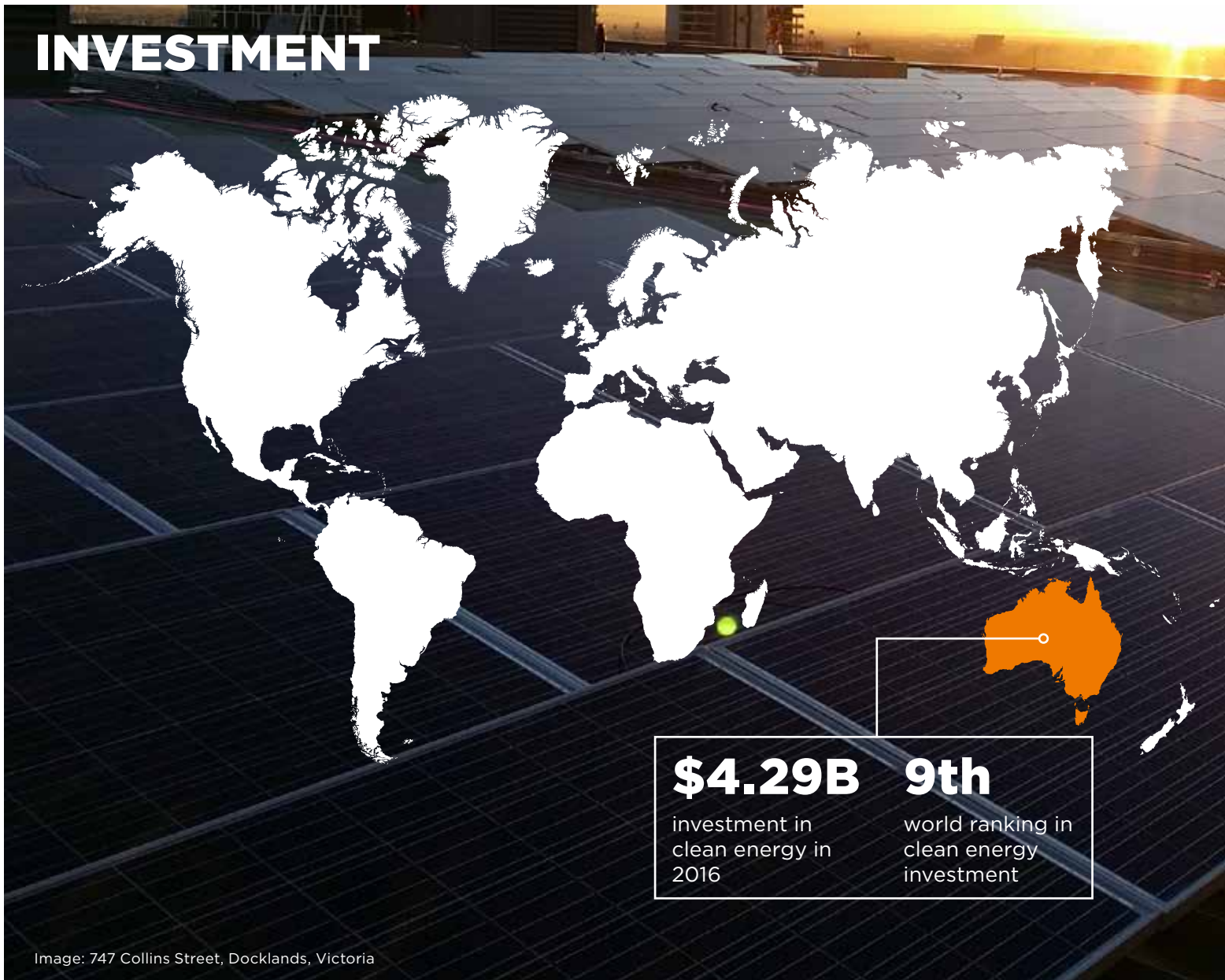


Image: 747 Collins Street, Docklands, Victoria

Australian investment in clean energy totalled more than \$4.29 billion in 2016, according to Bloomberg New Energy Finance (BNEF) data released in January.

The overall figures were on par with 2015, but saw a rise in investment in large-scale projects and a drop in rooftop solar investment – although BNEF attributes this to the falling cost of technology rather than a slide in demand.

Large-scale wind and solar project financing grew in 2016 compared to the year before, with the ACT Government’s reverse auction process resulting in investment of \$1.11 billion. This was in addition to the \$1.45 billion invested towards meeting the Large-scale Renewable Energy Target.

Globally, new investment in clean energy fell to US\$287.5 billion in 2016, 18 per cent lower than the record investment of US\$348.5 billion in 2015.¹⁴

The lower investment figure in 2016 was partially attributed to the rapidly falling cost of renewable energy technology, including solar panels and wind turbines. As in previous years, more can be installed for less. The amount of capacity connected to grids around the world grew by 19 per cent.

But the figures also reflected a slight cool-down in China and Japan, which

14 J Ryan, Bloomberg News, *Clean energy drops most on record as China slows growth*, 12 January 2017. Available online: <https://www.bloomberg.com/news/articles/2017-01-12/clean-energy-spending-drops-most-on-record-as-china-slows-growth>



US\$287.5B

total worldwide investment
in renewable energy
in 2016

18%

reduction in investment
from 2015

19%

increase in the amount
of capacity connected to
grids worldwide

went from record-breaking investment figures in recent years to some consolidation of the capacity that has been added.

Combining the rooftop and large-scale sectors, Australia's clean energy investment ranked ninth globally in 2016.

CASE STUDY

ENCOURAGING BETTER GENDER BALANCE IN THE RENEWABLE ENERGY SECTOR



“Research consistently shows that gender diversity on boards delivers a range of better business outcomes and reduces the significant pay gap that exists between men and women.”

– Deborah Oberon, AllGrid Energy

As part of an industry initiative to encourage more female leadership in the renewable energy sector, the Clean Energy Council introduced the Developing Women Directors scholarship.

The scholarship was designed to help increase female representation at leadership and board level through a scholarship to the Australian Institute of Company Directors.

The inaugural scholarship was awarded to Deborah Oberon of AllGrid Energy on International Women's Day 2016, for her work in and dedication to the industry.

AllGrid Energy is an indigenous-owned storage and solar technology provider based in Queensland. The company is designing small-scale, affordable and even transportable storage units for use in rural and regional Australia.

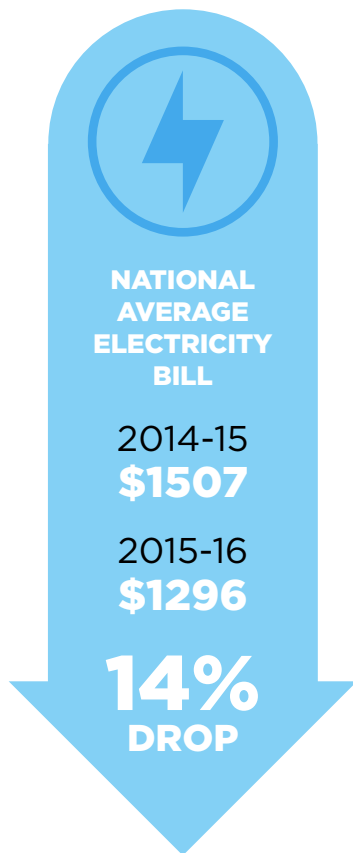
In November 2016, Nicola Wilkins from Downer was announced as the second recipient of the Clean Energy Council scholarship, as a stand-out candidate whose career has spanned consulting, international development, an MBA in renewable energy and PV system design.

Further rounds will be held in 2017 as part of the Clean Energy Council's Women in Renewables initiative.

ELECTRICITY PRICES

“Change is accelerating in the deeply connected energy sector; linking electricity and gas, spreading technological innovation across new energy services for consumers, and including other policy areas like the environment.”

– Australian Energy Market Commission, 2016



According to the Australian Energy Market Commission (AEMC), the national average annual residential electricity bill in 2015-16 was \$1296, down from \$1507 in the previous financial year.

A report in early 2017 from the Australian National University showed that power prices have increased less in South Australia over the last decade than the east coast states such as Queensland and New South Wales.¹⁵ In the decade to 2016, electricity price rises were highest in Queensland (136 per cent), Victoria (118 per cent) and New South Wales (109 per cent), noting each of these states currently have relatively low levels of renewable energy and high reliance on gas and/or coal generation. South Australian electricity prices rose 87 per cent, much less than those states more reliant on fossil fuels. Almost half (48 per cent) of the state’s energy demand is now met by renewable energy, compared with much lower levels in the eastern states.

Investment in the electricity network has been the primary driver in power bill increases for some time, but network spending contracted in 2016. Nonetheless, poles and wires still accounted for 40 to 55 per cent of power bills.¹⁶ Over the next two years however the AEMC expects wholesale costs – the cost of actually generating power – to rise. The closure of South Australia’s Northern power station in mid-2016, the retirement of Hazelwood

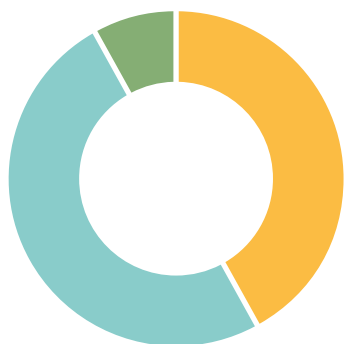
power station in Victoria and the changing network generation mix are expected to result in price rises over the next two years in all jurisdictions except Queensland and Tasmania.¹⁷

The power plant retirements and the beginning of Chief Scientist Alan Finkel’s review into national energy security mark a year of transition for the National Electricity Market towards more modern and lower emissions generation. Yet while the possibility of major market reform in the near future is welcome, a caustic political debate continues to leave Australia without major carbon and energy policy beyond the end of the decade. This uncertainty means necessary investments in our electricity system are not being made, and this is driving up power prices.

The falling cost of energy storage and solar, along with trials of smart technology such as virtual power plants, are showing strong potential to change the way customers and retailers interact with the grid, reducing costs for consumers and increasing grid flexibility.

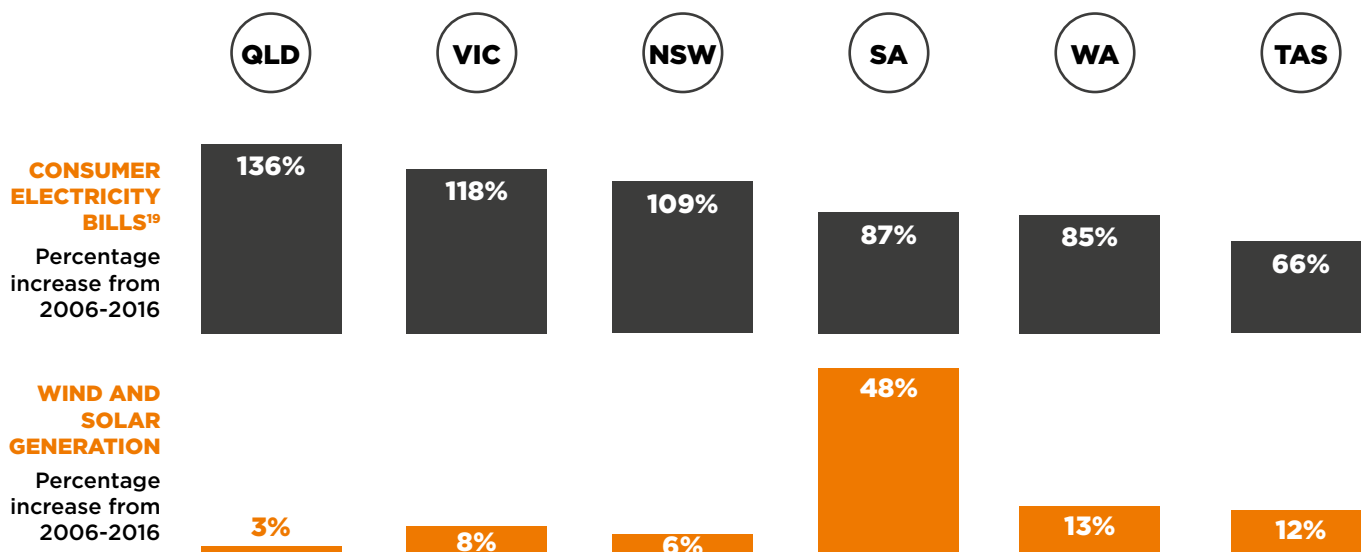
Average national residential electricity prices increased by 4.4 per cent from 2015/16 to 2016/17. They are expected to increase by 2.7 per cent in 2017/18 and 2.3 per cent in 2018/19, which is equivalent to an average annual increase of 2.5 per cent over the two years to 2018/19.

BREAKDOWN OF CHARGES IN DOMESTIC ELECTRICITY BILLS, 2015-16¹⁸



- Wholesale and retail **42%**
- Network costs **50%**
- Environmental policies **8%**

POWER PRICE INCREASES VS POWER FROM WIND AND SOLAR



NATIONAL SUMMARY OF SUPPLY CHAIN COST COMPONENTS²⁰

	2015-16 BASE YEAR		2016-17 CURRENT YEAR		2017-18		2018-19	
	c/kWh	\$/year	c/kWh	\$/year	c/kWh	\$/year	c/kWh	\$/year
Environmental policies	2.08	109	2.18	114	1.87	98	2.02	106
LRET	0.64	26	0.59	31	0.74	39	0.91	48
SRES	0.46	25	0.46	24	0.42	22	0.42	22
FIT schemes	0.84	38	0.91	48	0.84	44	0.61	32
Other state schemes	0.15	5	0.13	7	0.15	8	0.15	8
Regulated networks	12.24	642	12.07	633	12.20	640	12.38	649
Transmission	2.32	122	2.18	114	2.07	108	2.08	109
Distribution	9.92	520	9.89	519	10.14	532	10.29	540
Competitive market	10.38	545	11.55	606	12.41	651	12.71	667
Wholesale and retail								
TOTAL	24.71	1296	25.80	1353	26.49	1390	27.11	1422

15 B Phillips, ANU Centre for Social Research, *Research Note: Household Energy Costs in Australia 2006 to 2016*, February 2017

16 Australian Energy Market Commission, *2016 Residential Electricity Price Trends*, December 2016

17 N Harmsen, ABC News, *South Australian power bills to increase by \$115 after Hazelwood power station closure*, December 2016

18 Australian Energy Market Commission, *2016 Residential Electricity Price Trends*, December 2016

19 B Phillips, ANU Centre for Social Research, *Research Note: Household Energy Costs in Australia 2006 to 2016*, February 2017

20 Australian Energy Market Commission, *2016 Residential Electricity Price Trends Final Report*, page 191

ENERGY SECURITY



Bloomberg New Energy Finance figures released in 2017 showed that renewable energy is the cheapest power generation that can be built today,²¹ and Reputex analysis in March suggested that solar combined with energy storage is already cheaper than gas – and is continuing to fall rapidly in cost.²² Renewables are now winning the race on both affordability and reducing emissions.

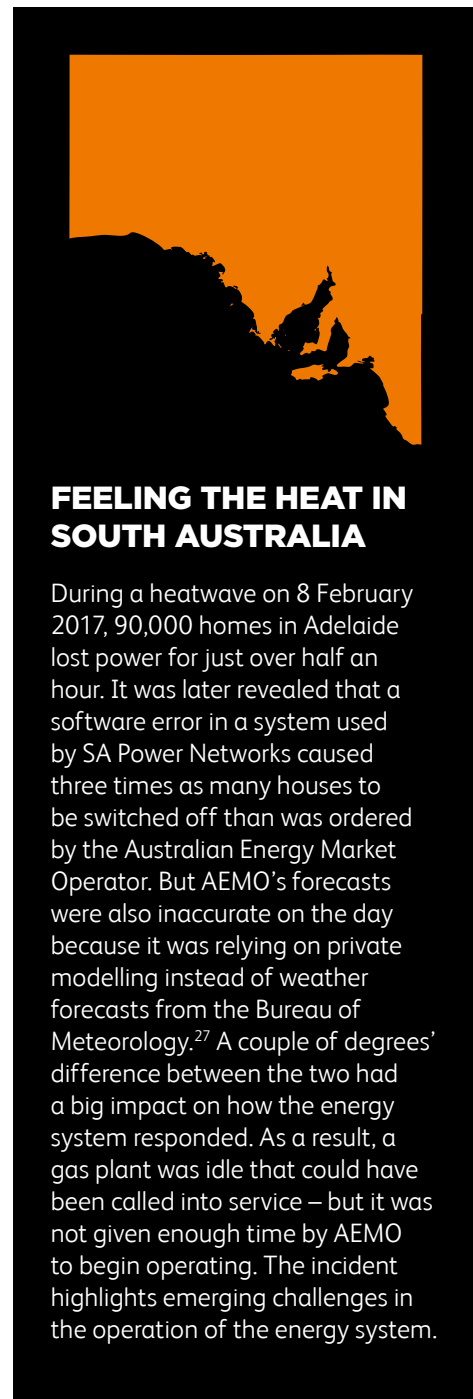
But the state-wide blackout in South Australia on 28 September 2016 led to the politicisation of energy policy and criticism of the state's use of renewable energy, which provided almost 50 per cent of its power during the year following the shutdown of its last coal-fired power plant. This was despite the Australian Energy Market Operator (AEMO) providing advice that the blackout was the result of a once-in-50-year storm, not renewable energy.²³

Analysis by the Clean Energy Council before the state-wide blackout showed that South Australia had met all the reliability standards set by AEMO for the last decade.²⁴ The state was as reliable as anywhere in the country following the closure of its last coal-fired power plant.

One of the positives to come out of the blackout was an extensive review of national energy security led by the Chief Scientist Alan Finkel, which will deliver its final recommendations in 2017.

There is currently no stable federal government energy and carbon strategy or policy beyond 2020. Combined with the uncertainty created by policy changes over the last decade new investment in power generation has been insufficient to replace our ageing power system and ensure long-term system reliability.²⁵

The lack of long-term policy settings and increased political hostility between the federal, state and territory governments creates ongoing challenges and uncertainty for the energy sector. There is a growing voice of industries and peak bodies – such as the Business Council of Australia and the Australian Industry Group – calling on politicians to work together on the problem, which will only be solved via the challenging process of energy market reform. Prime Minister Malcolm Turnbull announced in March 2017 that the government is planning to expand the iconic Snowy Hydro Scheme by as much as 50 per cent to provide pumped hydro capabilities.²⁶



FEELING THE HEAT IN SOUTH AUSTRALIA

During a heatwave on 8 February 2017, 90,000 homes in Adelaide lost power for just over half an hour. It was later revealed that a software error in a system used by SA Power Networks caused three times as many houses to be switched off than was ordered by the Australian Energy Market Operator. But AEMO's forecasts were also inaccurate on the day because it was relying on private modelling instead of weather forecasts from the Bureau of Meteorology.²⁷ A couple of degrees' difference between the two had a big impact on how the energy system responded. As a result, a gas plant was idle that could have been called into service – but it was not given enough time by AEMO to begin operating. The incident highlights emerging challenges in the operation of the energy system.

21 J.Hill, Clean Technica, *New coal built most expensive energy option for Australia, according to BNEF*, February 2017

22 Reputex, Media release: *Renewables with storage now cheapest form of 'reliable' energy supply, surpassing gas*, 8 March 2017

23 The Australia Institute, *Freedom of Information requests for advice about SA blackout*, page 2, February 2017

24 Clean Energy Council, *The rise of renewables in South Australia briefing paper 1: Current state of play*, page 3, July 2016

25 J Peck, Morgan Stanley, *There's no energy market to fail*, The Australian Financial Review, page 46, 22 March 2017

26 Turnbull Government, Media release: *Securing Australia's energy future with Snowy Mountains 2.0*, 15 March 2017

27 P Jean, The Advertiser, *SA heatwave blackout could have been avoided if AEMO had used Bureau of Meteorology's weather forecast*, 23 February 2017

ENERGY STORAGE

“Instead of getting electricity from large power stations outside cities that’s fed across long power lines, sometimes from different states, households can now use power from the sun, captured and stored from their own roofs”²⁸

- ARENA CEO Ivor Frischknecht

 **6750**
battery installations
in 2016

13x
increase in installations in 2016
compared to 2015



Energy storage is a rapidly developing sector, and is now at a similar stage to where rooftop solar power was a decade ago, before a combination of plunging costs, high electricity prices and government incentives saw it spread quickly across the country.

As the transformation of the energy sector accelerates, the potential and role for various forms of energy storage is growing rapidly. Whether it be battery storage for the home or pumped hydro energy storage solutions, they can all play an important role in Australia’s future energy system.

Approximately 6750 batteries with a capacity of 52 MWh were installed in 2016, more than 13 times the 500 installations in 2015, according to consultancy SunWiz.²⁹ SunWiz predicts market growth in 2017 will be at least treble that of the year before.

According to the report, the New South Wales market accounted for a third of all installations, with Queensland

in second with 29 per cent. Although only 10 per cent of the installations were in South Australia, the state has the most favourable market conditions for batteries, given its superior solar resource, high electricity prices and support programs from the government, AGL and SA Power Networks. The research found some systems have a seven-year payback period before subsidies.

With the September state-wide blackout in South Australia leading to a national debate about energy security, grid-scale storage such as pumped hydro and battery arrays became the focus of intense interest late in 2016 and into the new year. The Victorian Government has called for expressions of interest to build a 20 MW battery array. The South Australian Government will fund 100 MW of battery storage to be completed in time for the 2017 summer. The Federal Government announced early in 2017 that the Australian Renewable Energy Agency (ARENA) would set aside

\$20 million for storage demonstration projects under its Advancing Renewables Programme.

In March 2017, Prime Minister Malcolm Turnbull announced plans for Snowy Hydro 2.0, which would expand the original scheme to include 2000 MW of pumped hydro storage. A feasibility study has also been announced into the expansion of Tasmania’s hydro power network to include up to 2500 MW of pumped hydro.

Several large-scale storage projects were completed in 2016, including the 2 MWh installation at the Sandfire Resources Copper Mine and the 1.1 MWh community installation at Alkimos Beach in Western Australia. The ACT announced the winners of the second round of its battery storage auction in 2016, and it aims to roll out 36 MW of storage across 5000 homes in the territory at subsidised rates by the end of the decade.

²⁸ S.Vorrath, One Step Off The Grid, *World’s largest virtual power plant trial a big hit with SA consumers*, December 2016. Available online: <https://onestepoffthegrid.com.au/worlds-largest-virtual-power-plant-trial-big-hit-sa-consumers/>

²⁹ W Johnston, SunWiz, *Believe the hype: Australia’s battery market is set for eye-watering growth*, 20 February 2017. Available online: <http://www.sunwiz.com.au/index.php/2012-06-26-00-47-40/73-newsletter/420-battery-market-hotter-than-previously-thought.html>

“United Energy has been looking at different ways in which we could drive innovation into the grid and came to the realisation that through the use of solar and storage technology, we could transform the very nature and function of the grid itself.”

– Karl Edwards
Customer Innovation and Growth Manager
United Energy

POWER PLANTS OF THE FUTURE VIRTUALLY HERE

Two ‘virtual power plants’ were trialled in Melbourne and Adelaide during 2016, providing a glimpse of the near future starring home storage technology with smart energy system management.

In 2016, utility company United Energy (UE) worked with Energy Makeovers and Clean Energy Council member Sunverge to install 50 kW of solar and energy storage on its distribution network. The combination of technologies was able to shave off energy use during peak times and reduce the money which

needed to be spent on extra poles and wires. Cloud-based software provided by Sunverge was used to operate energy storage units remotely, meaning they could be called on when needed to cut the strain on the power grid during busy evening periods and hot summer days. United Energy won the Clean Energy Council’s 2016 Innovation Award for the residential project.

In Adelaide, AGL embarked on a three-phase project that will connect 1000 home batteries to deliver 5 MW of

peaking capacity. This will make it the world’s largest solar virtual power plant once complete. Sunverge is also involved in this project, supplying batteries and control systems for its first phase. The Australian Renewable Energy Agency is providing up to \$5 million support towards the \$20 million project, which will pool disparate energy resources into a single power plant that is visible to the network and can provide high level reliability.



Bioenergy is renewable energy derived from biomass to generate electricity and heat. In Australia, bioenergy is typically produced from agricultural or forestry products or from municipal waste. While it can also produce liquid fuels for transport, this report is concerned with renewable energy power plants.

Bioenergy fuel sources are predominantly derived from agricultural, forestry and municipal residues and wastes. Sugar cane waste, known as bagasse, remains Australia's most common fuel source, however others such as landfill gas, sewage gas, urban biomass (including waste timber), energy crops and agricultural waste are also common sources of fuel.

In 2016, the sector saw continued evolution in project design and waste utilisation.

Yarra Valley Water's waste-to-energy facility in Wollert, Victoria was constructed in 2016 and is expected

to be fully commissioned in 2017. The site will be able to process up to 33,000 tonnes of organic commercial waste each year, generating enough biogas to run both the facility and a neighbouring sewage treatment plant. Waste will be delivered to the facility from markets and food manufacturers, keeping organics out of landfill and making recycling of commercial organic waste easier and more affordable for businesses.

MSF Sugar is investing \$75 million to build a 24 MW biomass plant to convert cane waste into energy at its Tableland sugar mill, inland from Cairns in Far North Queensland.

Construction on the plant was underway in 2017. If successful, the company plans to build another three similar power plants next to its other Queensland sugar operations in South Johnstone, Mulgrave and Maryborough.

Victoria-based demolition company City Circle Group is commissioning a waste-to-energy timber gasification plant to divert timber waste from civil construction away from landfill. The gasifier and 1 MW electricity generation facility will be housed in shipping containers, replacing a diesel generator to save 300,000 litres of diesel fuel annually. The plant is expected to begin operating in 2017.

BIOENERGY PLANTS IN COMMISSIONING PHASE AT END OF 2016

FUEL SOURCE	LOCATION	OWNER	STATE	CAPACITY (MW)
Landfill waste	Wollert	YarraValley Water	VIC	1
Timber waste	Brooklyn	City Circle Cement	VIC	1

LARGEST BIOENERGY PROJECTS

TECHNOLOGY	STATE	OWNER	LOCATION	COMMISSION YEAR	CAPACITY (MW)
Bagasse cogeneration	QLD	Sucrogen	Pioneer II	2005	68
Black liquor	VIC	Australian Paper	Maryvale	1976 - 1989	54.5
Bagasse cogeneration	QLD	Sucrogen	Invicta	1976 - 1996	50.5
Bagasse cogeneration	QLD	Mackay Sugar Ltd	Racecourse	2013	38
Bagasse cogeneration	NSW	Capital Dynamics	Broadwater II	2009	30



8.6%
of total clean
energy generated in
Australia in 2016



1.5%
of total Australian
electricity generated
in 2016



300K

litres of diesel saved
annually by City
Circle Group's
waste-to-energy
timber gasification
plant in Victoria

24 MW

size of biomass plant
being built by MSF
Sugar, to convert cane
waste into energy





Australia's hydro power plants were again the workhorses of Australia's renewable energy industry in 2016. Thanks to higher rainfall in key catchments compared to the previous year, hydro power rebounded to more typical levels in 2016, generating the largest share of renewable energy.

Australia has more than 120 operating hydro power stations. Most of the nation's hydroelectricity is generated by Hydro Tasmania's network of power plants and the Snowy River Hydro Scheme in New South Wales.

Low rainfall in Tasmania during 2015 and an extended outage of the Basslink interconnector, which connects it to the National Electricity Market via Bass Strait, led to low levels of water storage in early 2016. These low levels continued throughout the first part of 2016, but above average falls from May resulted in rebounding storage levels and high levels of generation at many key Tasmanian hydropower stations.

Tasmania's hydro generation was above average throughout the winter months but tapered off towards the end of the year to preserve dam storage levels. Overall, Tasmanian hydro power generation was broadly consistent with long-term averages.

The review of Australia's power system security by Chief Scientist

Alan Finkel includes consideration of Australia's future pumped hydro storage potential and how this could complement the development of other renewable energy technologies. The Australian National University will map Australia's pumped-hydro storage potential, with support provided by the Australian Renewable Energy Agency. The project, The Atlas of Pumped Hydro Energy Storage, will research integration of the technology into the electricity grid so that it can provide large-scale, reliable clean energy storage at national, state and regional levels.

Hydro Tasmania commenced major machine refurbishments in 2016 at Wayatinah, Liapootah and Cluny Power Stations.

In early 2017, Prime Minister Malcolm Turnbull announced a planned expansion of the Snowy Hydro Scheme to include pumped hydro capability.



HYDRO POWER'S CONTRIBUTION TO AUSTRALIAN ELECTRICITY GENERATION

YEAR	GENERATION (GWh)	CONTRIBUTION TO RENEWABLES	CONTRIBUTION TO TOTAL ELECTRICITY
2013	19,243	55.4%	8.2%
2014	14,555	45.9%	6.2%
2015	14,046	40.1%	5.9%
2016	17,747	42.3%	7.3%



42.3%
of total clean
energy generated in
Australia in 2016



7.3%
of total Australian
electricity generated
in 2016



Image: Meadowbank Power Station, Tasmania



Marine technology harnesses the momentum of ocean and river waves, tides, salinity and temperature differences to generate energy.

Marine energy technology and resources remain very promising, and a variety of research and development activity continues. However, no grid electricity was produced in Australia from marine energy in 2016.

Projects currently in the demonstration phase include Carnegie Energy's CETO 6 Project, located offshore of Garden Island in Western Australia. This new CETO unit has a targeted 1 MW capacity and is supported by the Australian Renewable Energy Agency.

BioPower Systems has progressed its bioWAVE project in Port Fairy, Victoria, completing project installation of a full-scale 250 kW pilot plant. The project is scheduled for operation and testing in 2017, with the intention of demonstrating the technology's capability at a grid-connected site for up to 12 months.

A 2.4 metre-wide tidal energy turbine is being tested by the Australian Maritime College (AMC) in the Tamar estuary in Launceston, Tasmania. Partnering with Sydney-based developers MAKO Tidal Turbines, the AMC will research full-scale turbines in a real-world environment. Tidal energy is very predictable, making it an exciting area for research and a good complement for battery technology.





Images: bioWAVE unit, Port Fairy Pilot Wave Energy Project, Victoria



Solar power capacity installed in 2016 recovered by approximately 6 per cent on 2015 figures. As the industry consolidated, the average system size increased while the number of installations reduced slightly across the country.

752

megawatts of new solar capacity installed

7%

increase on 2015

752 MW of new solar capacity was installed, an increase of 46 MW (7 per cent) compared to 2015 but still lower than any other year since 2010.

Queensland continues to lead the nation in photovoltaic (PV) installations, with eight of the top 10 solar postcodes in Australia located in the sunshine state. Bundaberg, Queensland again held the number one position, with over 33.7 MW now installed across the postcode. Mandurah and Hervey Bay

rounded out the top three national spots, while Lismore overtook Dubbo to lead all comers in New South Wales.

The average system size rose to 5.6 kW, driven up by an increase in commercial installations for businesses. There were 4305 accredited solar installers at the end of 2016, a modest increase of just over 160 compared to 2015. The growth was driven by Western Australia, Queensland and NSW, while numbers in Tasmania and Victoria dropped.

TOP TEN SOLAR POSTCODES IN AUSTRALIA - BY INSTALLATIONS

<p>#1</p> <hr/> <p>BUNDABERG QLD 4670</p> <p>10,528 installations</p> <p>33,728 kW capacity</p>	<p>#2</p> <hr/> <p>MANDURAH WA 6210</p> <p>10,003 installations</p> <p>25,418 kW capacity</p>	<p>#3</p> <hr/> <p>HERVEY BAY QLD 4655</p> <p>9729 installations</p> <p>27,333 kW capacity</p>	<p>#4</p> <hr/> <p>CALOUNDRA QLD 4551</p> <p>8571 installations</p> <p>23,686 kW capacity</p>	<p>#5</p> <hr/> <p>TOOWOOMBA QLD 4350</p> <p>7705 installations</p> <p>24,887 kW capacity</p>
<p>#6</p> <hr/> <p>WANGARA AND WANNEROO QLD 6065</p> <p>7114 installations</p> <p>22,576 kW capacity</p>	<p>#7</p> <hr/> <p>NERANG AND CARRARA QLD 4211</p> <p>6922 installations</p> <p>23,238 kW capacity</p>	<p>#8</p> <hr/> <p>IPSWICH QLD 4305</p> <p>6740 installations</p> <p>19,664 kW capacity</p>	<p>#9</p> <hr/> <p>MACKAY QLD 4740</p> <p>6388 installations</p> <p>25,623 kW capacity</p>	<p>#10</p> <hr/> <p>BEENLEIGH QLD 4207</p> <p>6353 installations</p> <p>20,670 kW capacity</p>



16%
of total clean
energy generated in
Australia in 2016



2.8%
of total Australian
electricity generated
in 2016

TOP SOLAR POSTCODE IN EACH STATE

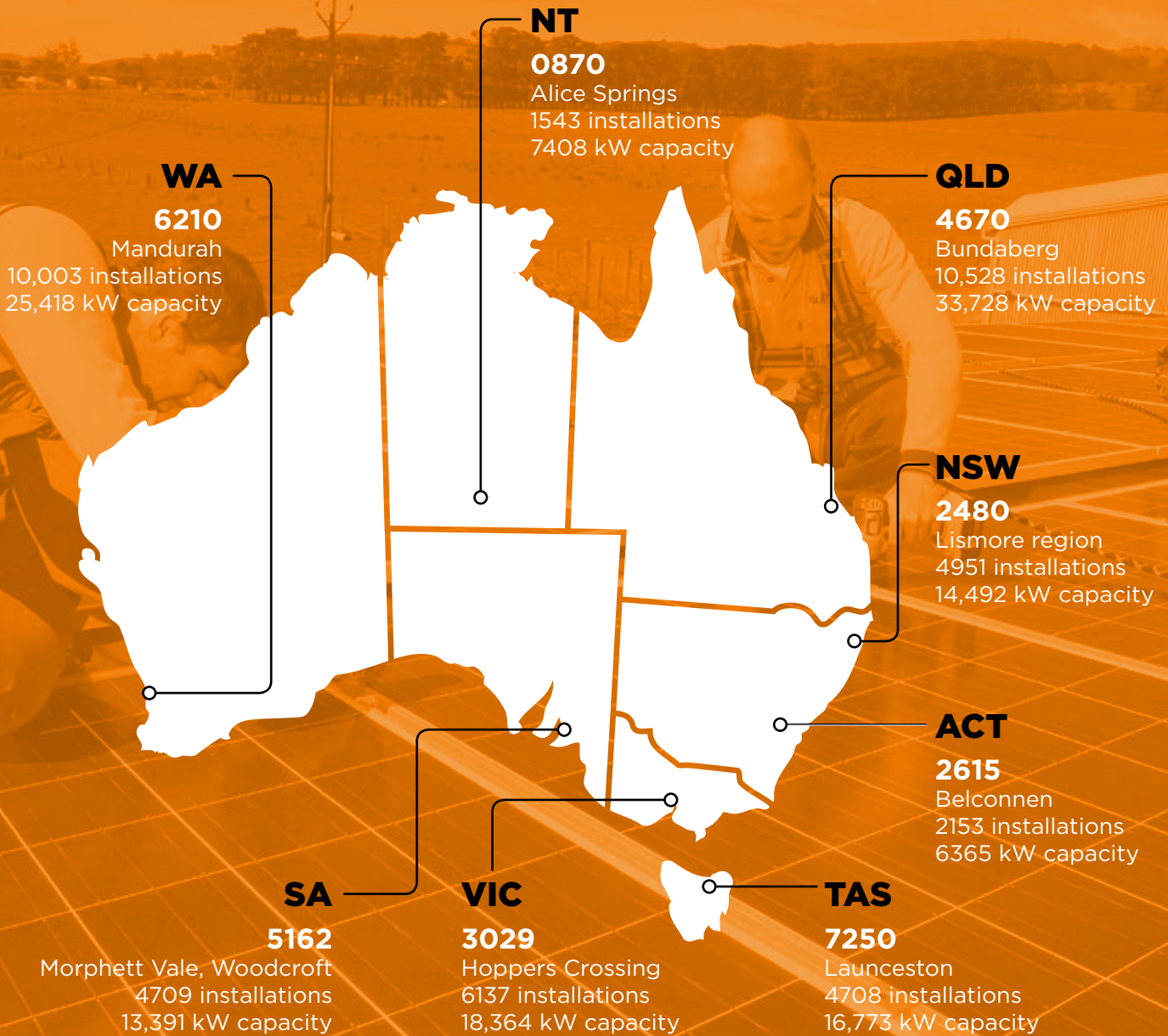
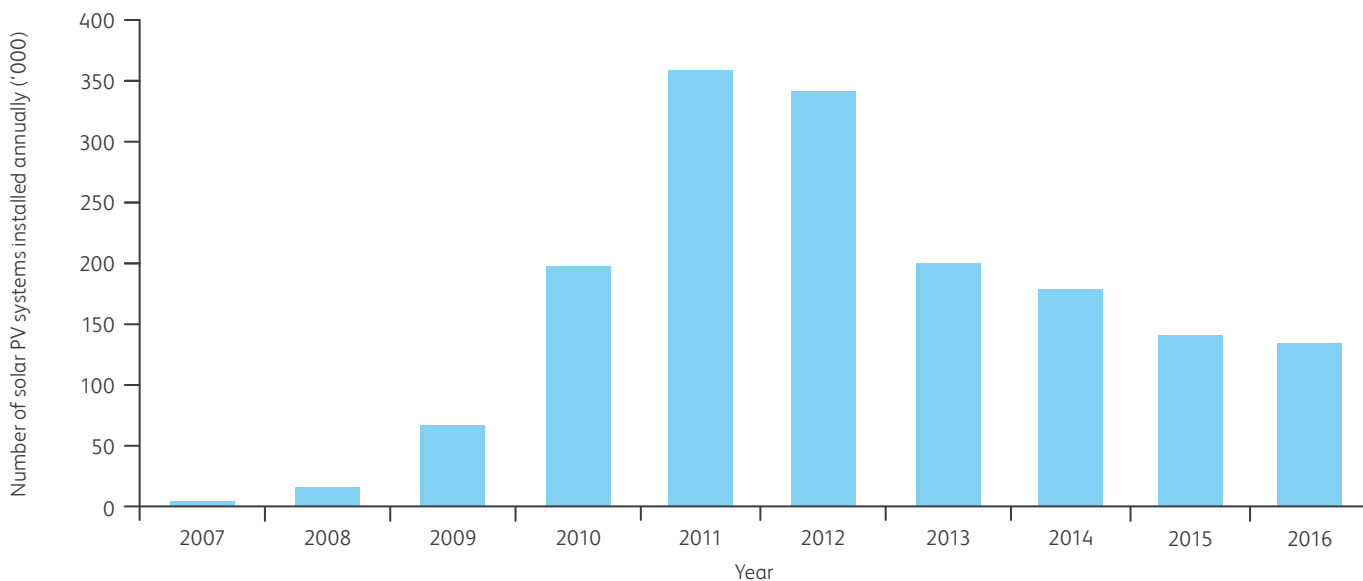


Image: Solar installers, South Australia

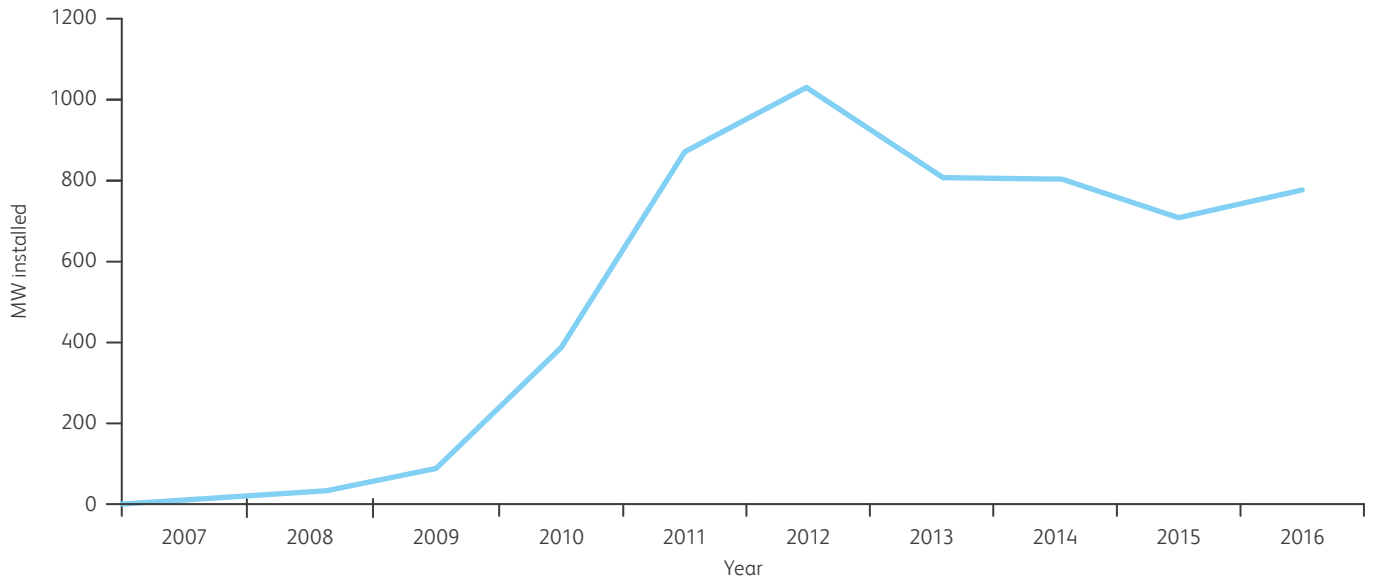
ANNUAL SOLAR PV INSTALLATIONS³⁰



INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
2007	102	779	26	475	1037	26	828	262	3535
2008	278	2890	88	3087	3456	161	2036	2068	14,064
2009	803	14,008	215	18,283	8569	1452	11,847	11,157	66,334
2010	2323	69,988	637	48,697	16,705	1889	35,676	22,293	198,208
2011	6860	80,272	401	95,303	63,553	2475	60,214	51,667	360,745
2012	1522	53,961	513	130,252	41,851	6364	66,204	42,653	343,320
2013	2411	33,998	1024	71,197	29,187	7658	33,332	21,600	200,407
2014	1225	37,210	1026	57,748	15,166	4207	40,061	23,496	180,139
2015	1066	33,484	1197	39,510	12,084	2020	31,360	20,799	141,520
2016	999	29,796	1793	35,717	12,682	2580	26,506	25,302	135,374
TOTAL*	17,619	357,438	7024	501,387	205,946	28,882	308,977	221,533	1,648,805

*Total includes pre-2007 installations

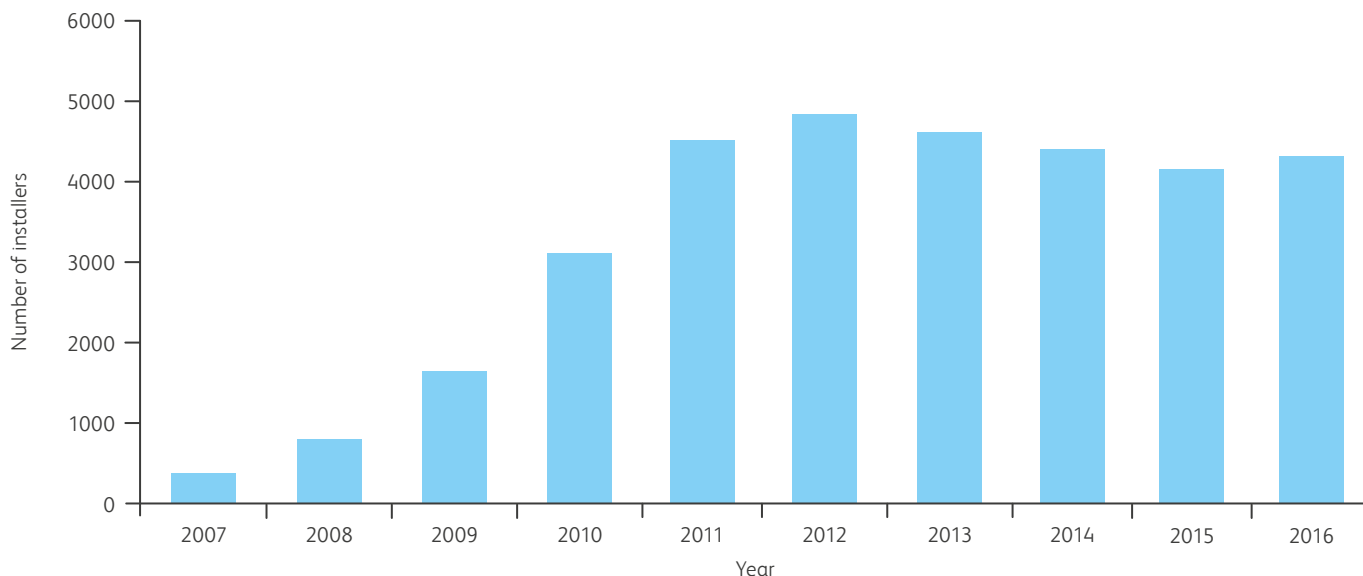
ANNUAL INSTALLED CAPACITY OF SOLAR PV (MW)³¹



INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
2007	0.20	1.15	0.17	0.65	1.66	0.04	1.09	0.63	5.57
2008	0.48	4.12	0.42	4.08	4.84	0.23	2.84	2.89	19.90
2009	1.22	18.27	0.48	23.90	12.09	1.68	13.33	13.62	84.60
2010	5.25	146.08	1.36	90.27	33.01	6.03	57.82	45.25	385.06
2011	17.24	186.47	1.56	220.66	161.88	11.77	137.04	135.26	871.88
2012	5.05	138.36	2.10	409.27	136.59	40.24	202.72	104.42	1038.75
2013	10.83	127.72	4.82	262.11	140.06	62.61	128.03	71.34	807.52
2014	5.08	163.76	5.80	242.28	81.87	37.74	167.91	97.23	801.66
2015	6.09	176.45	8.74	192.58	66.36	9.51	151.15	95.94	706.81
2016	6.82	166.91	12.39	205.19	75.65	12.02	142.12	131.68	752.78
TOTAL*	58.29	1130.20	38.04	1651.63	716.55	181.89	1005.17	698.54	5480.30

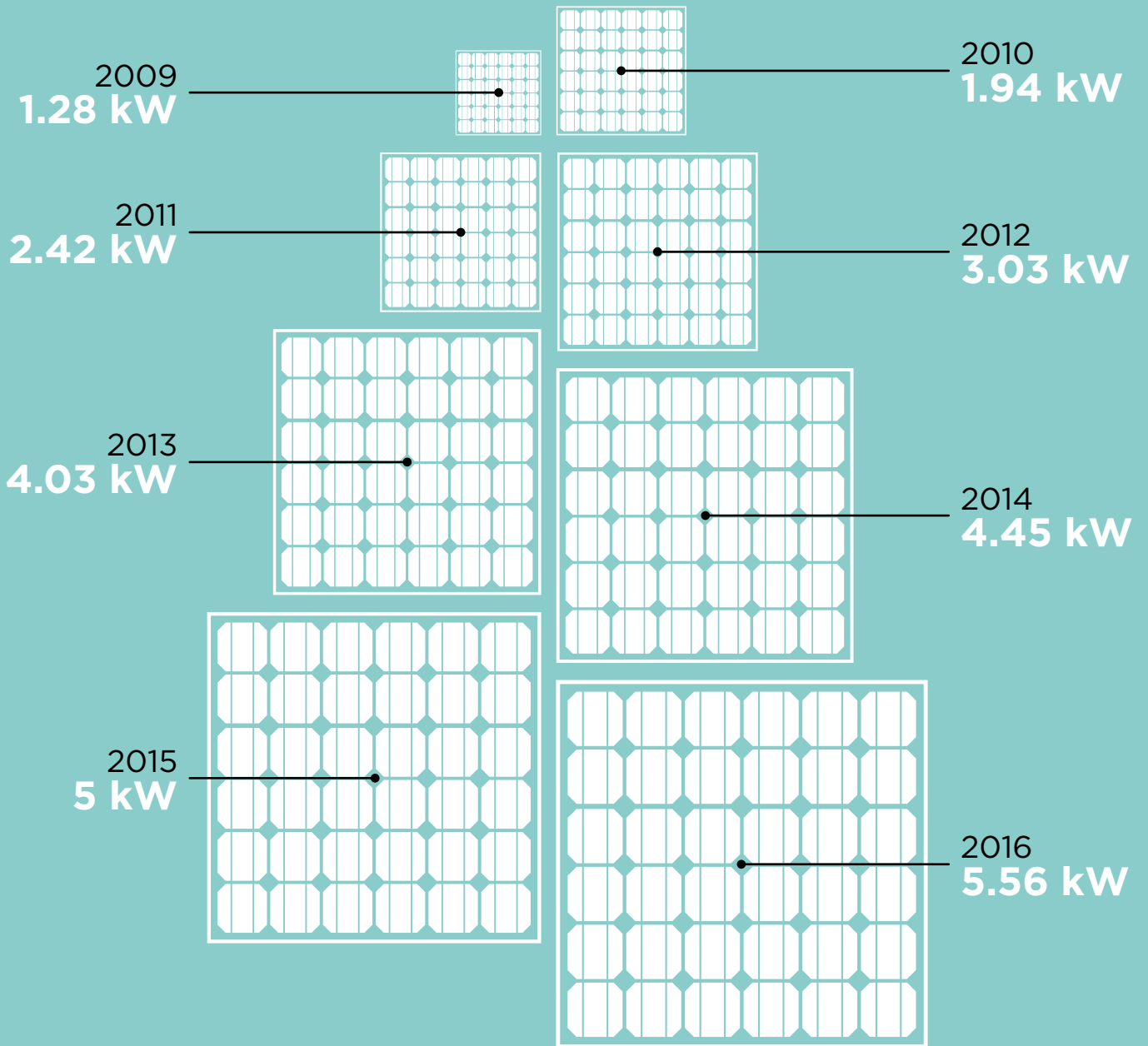
*Total includes pre-2007 installations

TOTAL NUMBER OF ACCREDITED INSTALLERS AND DESIGNERS



YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	TOTAL
2007	6	95	13	73	25	14	66	46	338
2008	11	192	11	143	57	24	245	95	778
2009	28	360	16	349	130	43	473	220	1619
2010	46	879	16	675	252	45	754	414	3081
2011	53	1034	22	1187	593	71	1004	531	4495
2012	48	948	28	1391	650	120	1122	514	4821
2013	44	894	41	1336	604	144	1093	439	4595
2014	908	44	401	1263	1075	47	521	137	4396
2015	916	44	384	1151	998	51	490	109	4143
2016	951	56	465	1188	974	70	500	101	4305

NATIONAL AVERAGE SYSTEM SIZE (KW)





The economics of large rooftop systems improves with each passing year, making medium-scale solar power an increasingly common feature at businesses and schools.³²

68

medium-scale solar projects commissioned in 2016

23

megawatts of new capacity

In 2016, 68 new medium-scale solar projects were commissioned, adding 23 MW of new capacity to bring the total of solar capacity in this category up to approximately 200 MW. About 40 of these projects are larger than 500 kW.

The sector is expanding quickly as a diverse range of businesses, schools and organisations decide to maximise the use of roof space to reduce their electricity bills. Many of these projects are commissioned by clients with high daytime power usage and specific system design and management requirements.

New projects commissioned in 2016 include a 1.8 MW off-grid solar installation at Ayers Rock

Resort built and operated through an availability leasing partnership between Epuron and Voyages Indigenous Tourism Australia. The system is made up of five component arrays at different locations within the resort.

Other projects commissioned included a 326 kW system on the Alice Plaza in Alice Springs, a 529 kW system at Sydney's Barangaroo casino precinct and a 503 kW system on the Canberra Hospital. The hospital is the ACT Government's largest energy user, and the new system is expected to save almost \$500,000 a year through the solar system installation and a number of energy efficiency measures.



³² Large-scale solar is defined as 5 MW capacity and above, in line with the Australian Renewable Energy Agency and the industry's general definition of the term. Previous copies of Clean Energy Australia listed projects 1 MW and above but these projects are now included in the definition of medium-scale solar.



1.1%
of total clean
energy generated in
Australia in 2016



0.2%
of total Australian
electricity generated
in 2016



SOLAR INNOVATION SHINES IN ROCKHAMPTON

Installers Dimitar Iliev and Jeff Hoare won a Clean Energy Council Solar Design and Installation Award in 2016 for a \$1.2 million, 517 kW commercial solar project in Rockhampton Queensland. Dobinsons Spring and Suspension, established in 1953 to produce premium quality 4x4 accessories and suspension components, approached the team at GEM Energy seeking energy independence and a solution to rising electricity costs.

Innovative project design for the business addressed a number of unique challenges. Solar extraction fans were implemented to reduce extreme heat build-up, allowing for better module performance and an improved work environment for staff. The operational characteristics of multiple furnaces were changed to manage rapid load fluctuations and create a smoother operation of the heating elements, allowing system ramp-up to meet demands. The system was also future-proofed so that a compatible energy storage solution could be installed at a later date.

Image: Dobinsons Spring and Suspension project, Rockhampton, Queensland



Remarkable cost reductions combined with the relatively fast construction timelines of large-scale solar have made it apparent that the technology will play a much greater role in meeting the Renewable Energy Target than was expected just a few years ago.

Seven new large-scale solar projects became operational in 2016, making it another strong year for a technology which is rapidly coming of age. Improvements in local supply chains are driving innovation in the way projects are designed and built, as well as supporting a strong construction industry with specialist skills.

The 56 MW Moree Solar Farm in New South Wales developed by Fotowatio Renewable Ventures (FRV) was the largest of the year and the second largest in the country behind the 102 MW Nyngan solar plant, developed by AGL and First Solar. The 25 MW Barcaldine Solar Farm, planned and developed by Elecnor in Queensland, was also notable.

At the close of 2016, 12 solar projects larger than 5 MW in size were operational. With the exception of one solar thermal plant, the solar farms used photovoltaic technology, and together they provided 319 MW of generation capacity. While there remains strong interest and potential for both large-scale solar thermal and Concentrated Solar Power throughout Australia, these technologies have not yet been able to be deployed at scale. The Australian Renewable Energy Agency (ARENA) continues to support feasibility and project assessments throughout the country, with the hope of improving the commercial viability for these forms of large-scale solar.

In 2015, ARENA announced a \$100 million funding round to encourage 200 MW of new large-scale solar projects to drive down costs and increase competitiveness. ARENA was ultimately able to support more than double that capacity in 2016 due to dramatic cost reductions over the course of the funding round.

Funding was announced for 480 MW of solar capacity in September across a dozen projects. These were split across Queensland (six projects), New South Wales (five projects) and Western Australia (one project). Many of these are expected to commence construction in 2017.

LARGE-SCALE SOLAR PLANTS COMMISSIONED IN 2016

TECHNOLOGY	LOCATION	OWNER	STATE	INSTALLED CAPACITY (MW)
Solar PV	Moree Solar Farm	Fotowatio Renewable Ventures (FRV)	NSW	56
Solar PV	Barcaldine	Elecnor	QLD	25
Solar PV	Mugga Lane	Maoneng Australia	ACT	13
Solar PV	Williamsdale	Impact Investment Group	ACT	10
Solar PV	De Grussa Mine	Sandfire Resources NL	WA	10
Solar PV	Darwin Airport	UGL	NT	5.5
Solar PV	Normanton	Scouller Energy and Canadian Solar	QLD	5



1.2%
of total clean
energy generated in
Australia in 2016



0.2%
of total Australian
electricity generated
in 2016



12

solar projects larger
than 5 MW operational
at the close of 2016

319

megawatts of
capacity provided
by these 12 projects

480

megawatts of
capacity funded by
ARENA in 2016



SOLAR

LARGE SCALE: PROJECTS OVER 5 MW IN SIZE (CONTINUED)



TOP FIVE PLANTS BY SIZE

#1

NYNGAN, NSW

Solar PV
Owner: AGL
Commissioned: 2015

102 MW

#2

MOREE, NSW

Solar PV
Owner: FRV
Commissioned: 2016

56 MW

#3

BROKEN HILL, NSW

Solar PV
Owner: AGL
Commissioned: 2015

53 MW

#4

BARCALDINE, QLD

Solar PV
Owner: Elechor
Commissioned: 2016

25 MW

#5

ROYALLA, ACT

Solar PV
Owner: FRV
Commissioned: 2014

20 MW

TRACKING LOCAL SUCCESS WITH MOREE SOLAR FARM

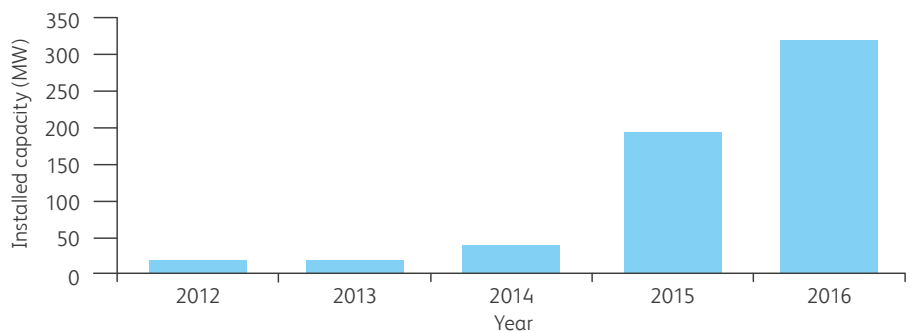
Moree Solar Farm began exporting clean energy into the National Electricity Market in March 2016. The 56 MW project, developed by Fotowatio Renewable Ventures (FRV), was the second largest in the country behind the Nyngan solar plant in New South Wales. Consisting of more than 220,000 solar panels, it is also the first large-scale solar project in the country to use a single-axis tracking system. The project's PV modules follow the sun's path across the sky to maximise power output. Approximately 300 people were employed during its construction.

The solar farm was supported by a \$102 million grant from the Australian Renewable Energy Agency and \$47 million debt financing from the Clean Energy Finance Corporation. FRV initially took on the merchant risk for the project, but signed a 15-year power purchase agreement with Origin Energy several months after it became operational. The agreement covers all the electricity generated by the plant and was Origin's first foray into Australian large-scale solar.

LARGE-SCALE PLANTS UNDER CONSTRUCTION AT END OF 2016

TECHNOLOGY	LOCATION	OWNER	STATE	CAPACITY (MW)
Solar PV	Sunshine Coast Solar Farm	Sunshine Coast Council	QLD	15
Solar PV	Lakeland Solar & Storage Project	Conergy - Lakeland Solar & Storage P/L	QLD	10.8
Solar PV	Gullen Range Solar Farm	New Gullen Range Wind Farm	NSW	10

CUMULATIVE INSTALLED CAPACITY (MW)



YEAR	2012	2013	2014	2015	2016
CUMULATIVE INSTALLED CAPACITY (MW)	19.3	19.3	39.3	194.3	318.8

SOLAR WATER HEATING



More than one million solar hot water systems are now installed in homes and businesses across Australia, following the installation of approximately 50,000 units in 2016.

Solar water heating refers to either a solar hot water system that heats water using energy from the sun, or heat pumps which use warmth from the air. Water heating can be expensive and energy intensive. Solar water heating helps households make substantial savings on their power bills and reduces emissions by as much as three tonnes a year compared to an electric hot water system.

The uptake of solar water heating peaked in 2009, when Federal Government rebates were introduced to make the technology more attractive ahead of a planned phase-out of electric hot water systems.

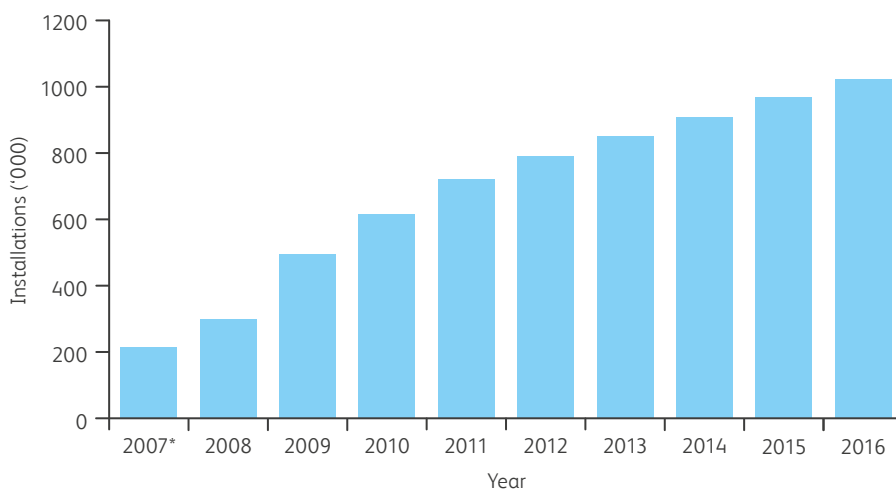
Since then solar water heating has continued to lose market share, with sales down 15 per cent in 2016 on the year before. This drop was seen across all states and territories except Tasmania, which increased sales slightly. The Northern Territory saw the largest drop, with sales down nearly 40 per cent.

New South Wales and Queensland households have installed the most systems to date, with more than 250,000 units in each state.

TOTAL INSTALLED SOLAR HOT WATER HEATERS BY STATE



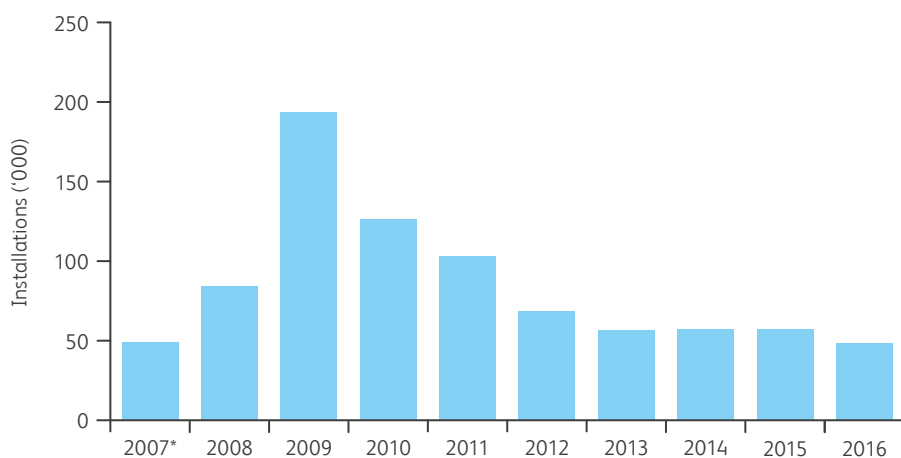
CUMULATIVE SOLAR WATER HEATER INSTALLATIONS IN AUSTRALIA



CUMULATIVE SOLAR WATER HEATER INSTALLATIONS IN AUSTRALIA

YEAR	2007*	2008	2009	2010	2011	2012	2013	2014	2015	2016
CUMULATIVE INSTALLATIONS	212,423	297,808	492,503	619,596	724,646	794,112	852,411	911,139	969,766	1,019,319

ANNUAL INSTALLATIONS OF SOLAR WATER HEATERS



ANNUAL INSTALLATIONS OF SOLAR WATER HEATERS

INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
2007	453	8765	1414	16,830	2869	350	9157	11,139	50,977
2008	1001	20,203	1236	23,330	5103	906	21,208	12,398	85,385
2009	1974	85,456	1731	36,659	8794	2269	42,120	15,692	194,695
2010	960	38,525	1303	34,262	6812	1433	27,733	16,065	127,093
2011	1038	25,331	1267	30,937	5444	1725	26,446	12,862	105,050
2012	734	10,810	1171	18,973	3473	899	21,594	11,812	69,466
2013	453	9145	884	13,410	2983	827	19,608	10,989	58,299
2014	451	9641	1026	13,433	1930	962	20,613	10,672	58,728
2015	572	8609	1063	11,799	2557	803	23,019	10,205	58,627
2016	497	6963	660	9793	1914	822	20,514	8390	49,553

*includes pre-2007 totals



Wind energy is the lowest-cost form of new large-scale energy generation in Australia and will be a major contributor to the national Renewable Energy Target (RET).



2106

turbines in 79 wind farms across Australia

4327

megawatts of generating capacity

Three new wind farms began operating in 2016, adding 44 turbines and just under 140 MW of generating capacity to the grid. Two of these projects – Hornsdale Stage 1 and Coonooer Bridge – were successful in securing contracts in the first round of the ACT Government's wind auctions.

Together with these projects, Australia has 79 operating wind farms, 2106 turbines and a generating capacity of 4327 MW. These figures place Australia 17th in the world for wind power, according to the Global Wind Energy Council.³³

The 2016 figures represent the lowest total capacity commissioned in a calendar year since 2004, as the policy uncertainty driven by the extended review of the RET under the Abbott Government, combined with long project lead times, continued to wash through the industry.

However, with restored investment confidence and a variety of state renewable energy policies creating additional incentives, the wind sector has been ramping up activity ahead of the final years of the RET. At the close of 2016, eight wind farms were under construction or on their way to begin construction. Seven of these are expected to be completed in 2017, adding 687 MW of generating capacity to the grid.

If all are completed as expected, this will be the highest total capacity commissioned in a calendar year in the history of the Australian wind industry.

Technological advances in the sector also featured strongly in 2016. Wind turbines are now larger and more efficient, as well as making use of intelligent technology. Rotor diameters and hub heights increased to capture more energy per turbine. The White Rock Wind Farm and Sapphire Wind Farm in the Glen Innes region of north-eastern NSW use some of the largest turbines in the country, with 121 metre and 126 metre rotor diameters respectively. The maturing technology means fewer turbines will be needed to produce the same energy, and wind farms will have increasingly sophisticated adaptive capability.

Many states and territories have recognised the regional investment opportunities on offer, introducing a variety of measures to capture a slice of the pie. The ACT Government conducted its final reverse wind auction in 2016, which will help it deliver Australia's most ambitious renewable energy target of 100 per cent by 2020. The successful projects were Neoen's 109 MW Stage 3 Hornsdale Wind Farm based in South Australia, and Union Fenosa Wind Australia's 91 MW Crookwell 2 wind farm in New South Wales.

³³ Global Wind Energy Council, *Global Wind Report 2015*, April 2016, page 11



30.8%
of total clean
energy generated in
Australia in 2016



5.3%
of total Australian
electricity generated
in 2016

TOP FIVE PLANTS BY SIZE

#1

MACARTHUR, VIC

Owner: AGL
Commissioned: 2012

420 MW

#2

SNOWTOWN 2, SA

Owner: Trustpower
Commissioned: 2014

270 MW

#3

COLLGAR, WA

Owner: UBS IIF / REST
Commissioned: 2012

206 MW

#4

WAUBRA, VIC

Owner: ACCIONA Energy
Commissioned: 2009

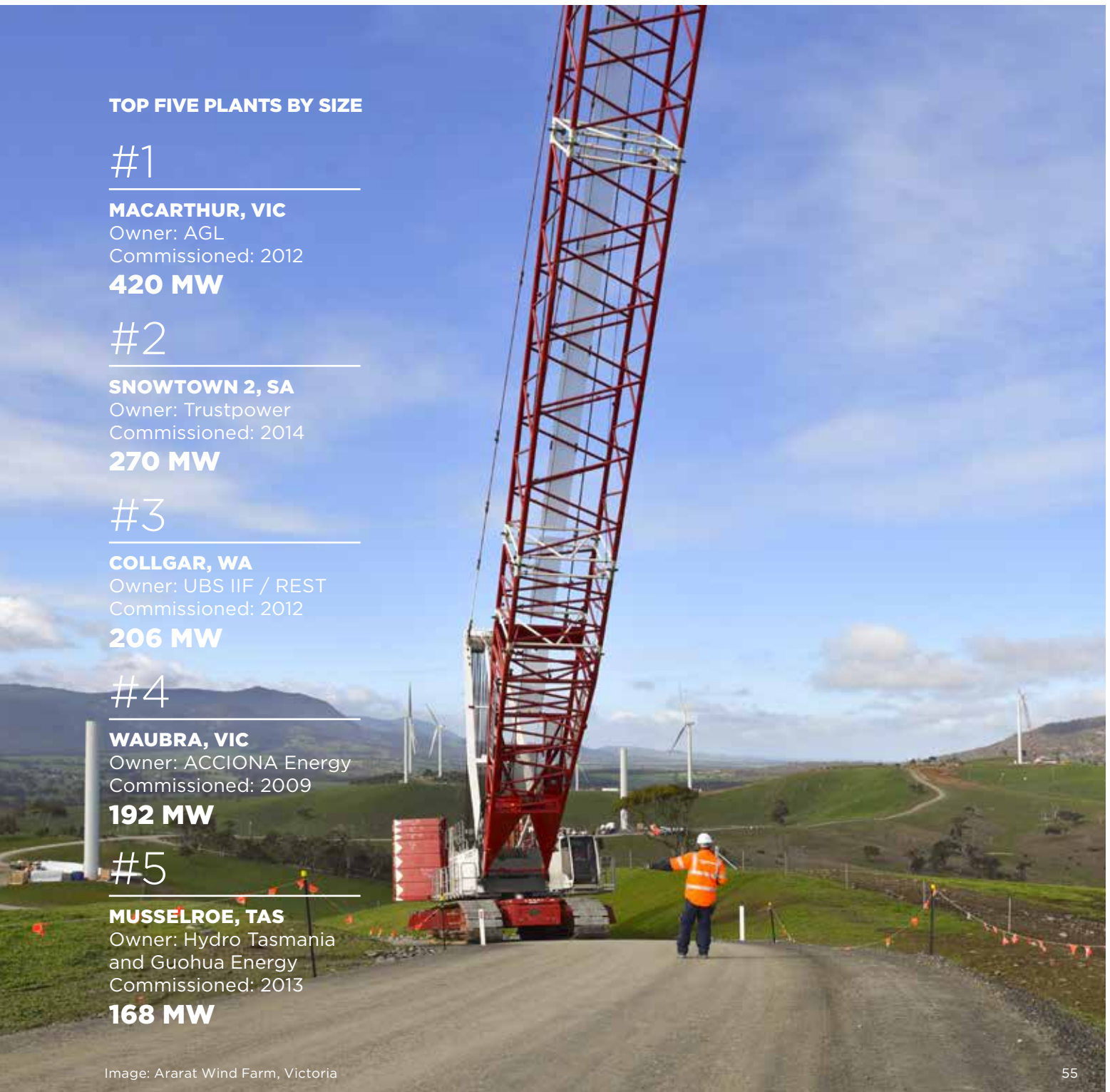
192 MW

#5

MUSSELROE, TAS

Owner: Hydro Tasmania
and Guohua Energy
Commissioned: 2013

168 MW



TECHNOLOGY PROFILES

WIND POWER (CONTINUED)

It is anticipated that wind farms will make a significant contribution to meeting state targets in Victoria and Queensland. The NSW Government is working through a new strategic plan for the state's Climate Change Fund that could include reverse wind auctions.

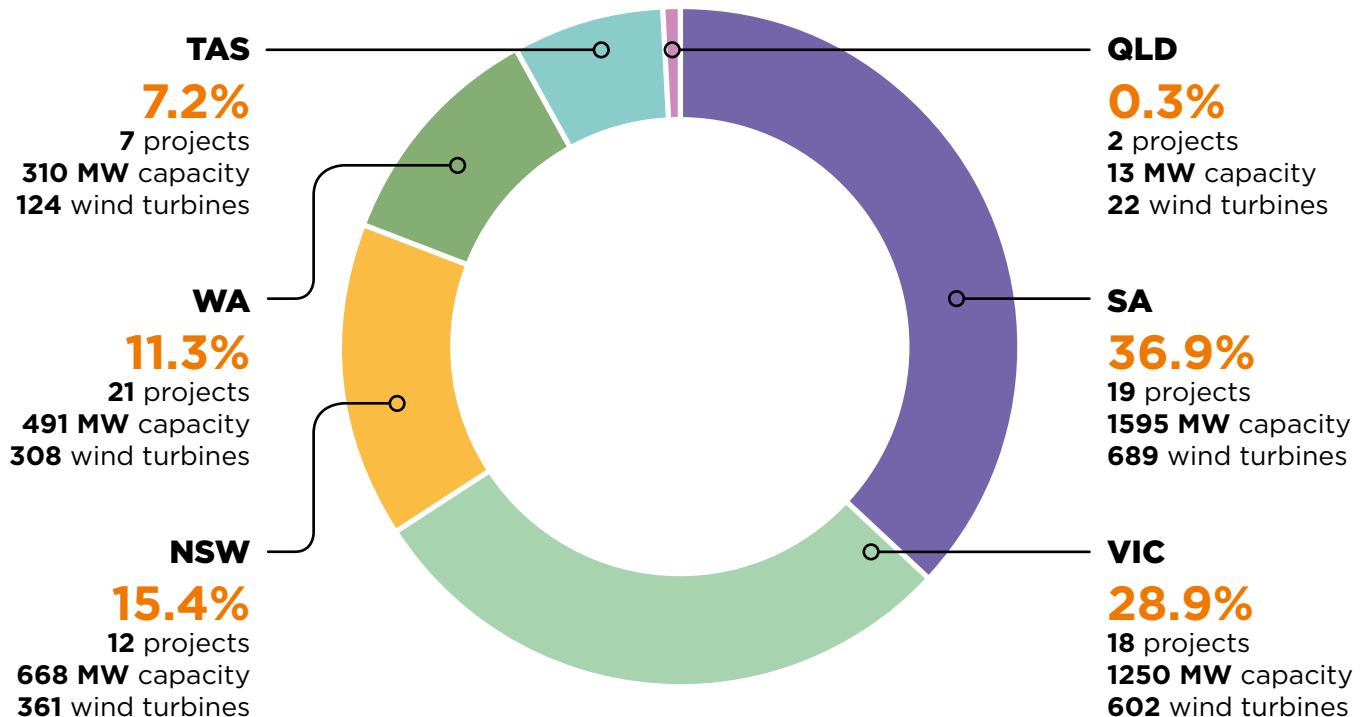
The National Wind Farm Commissioner, appointed by the Federal Government in 2015 for three years, actively visited wind farms and met with community and industry representatives in 2016. The Commissioner worked with the industry to develop

complaint handling and community engagement procedures, and will continue to monitor and support the development of the sector and its interaction with the community.

WIND FARMS COMMISSIONED IN 2016

OWNER	LOCATION	STATE	CAPACITY (MW)
Neoen	Hornsedale Stage 1	SA	100
Windlab	Coonooer Bridge	VIC	19.8
Palisade and Northleaf Capital	Waterloo Stage 2	SA	19.8

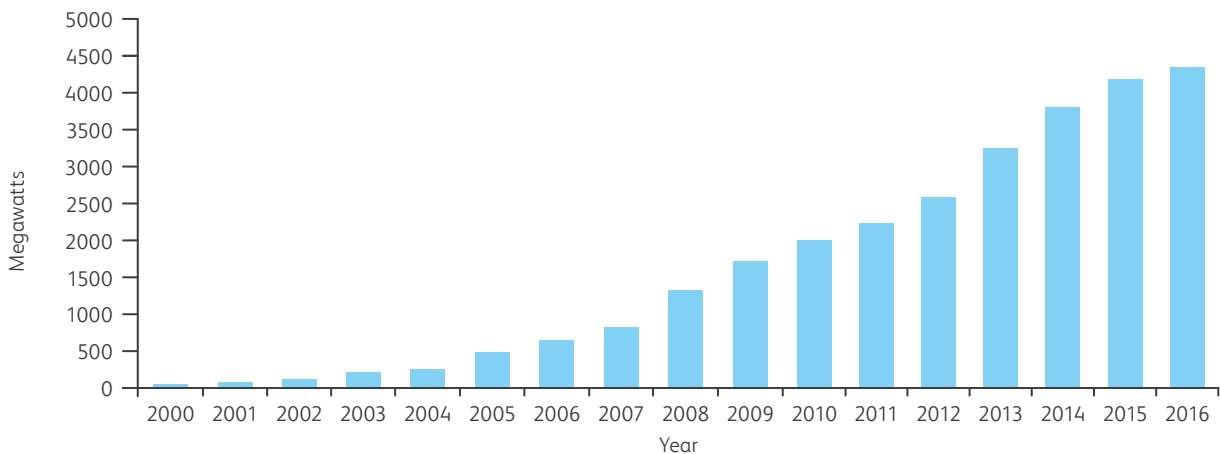
PERCENTAGE OF WIND CAPACITY BY STATE



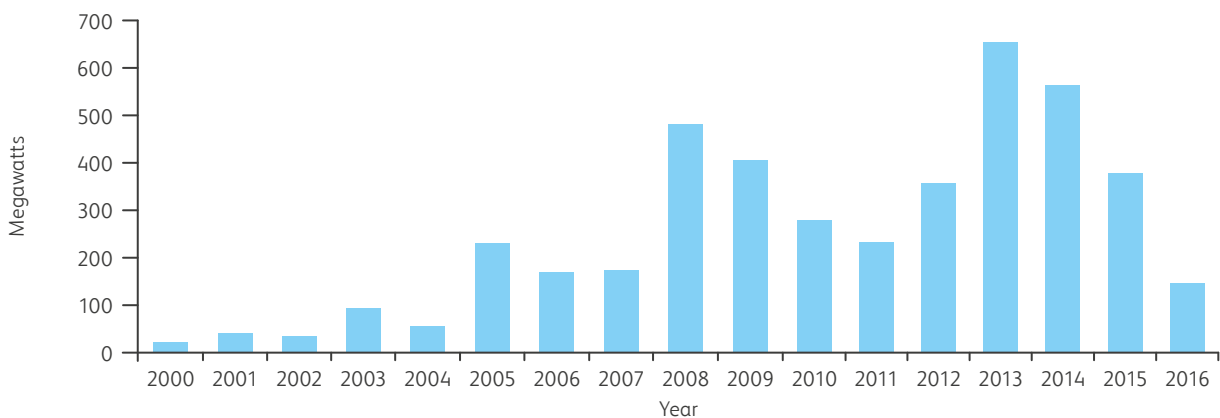
WIND FARMS UNDER CONSTRUCTION AND COMMITTED AT END 2016

OWNER	LOCATION	STATE	EXPECTED COMMISSION YEAR	INSTALLED CAPACITY (MW)
RES (Renewable Energy Systems) Australia	Ararat	VIC	2017	240
RATCH	Mt Emerald	QLD	2018	180
Goldwind Australia	White Rock Stage 1	NSW	2017	175
Neoen and Megawatt Capital	Hornsedale Stage 3	SA	2017	109
Neoen and Megawatt Capital	Hornsedale Stage 2	SA	2017	100
Windlab	Kiata	VIC	2017	30
Pacific Hydro	Yaloak South	VIC	2017	29
EDL	Cooper Pedy	SA	2017	4

CUMULATIVE INSTALLED WIND CAPACITY IN AUSTRALIA

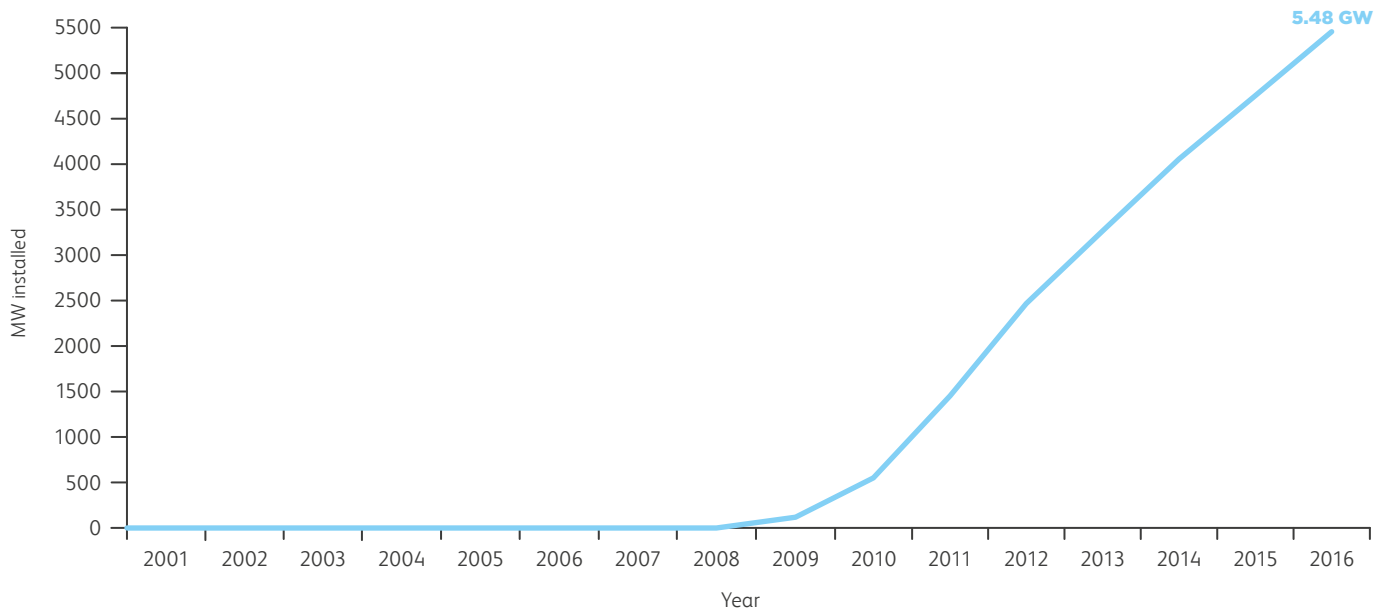


ANNUAL INSTALLED WIND CAPACITY IN AUSTRALIA



APPENDICES

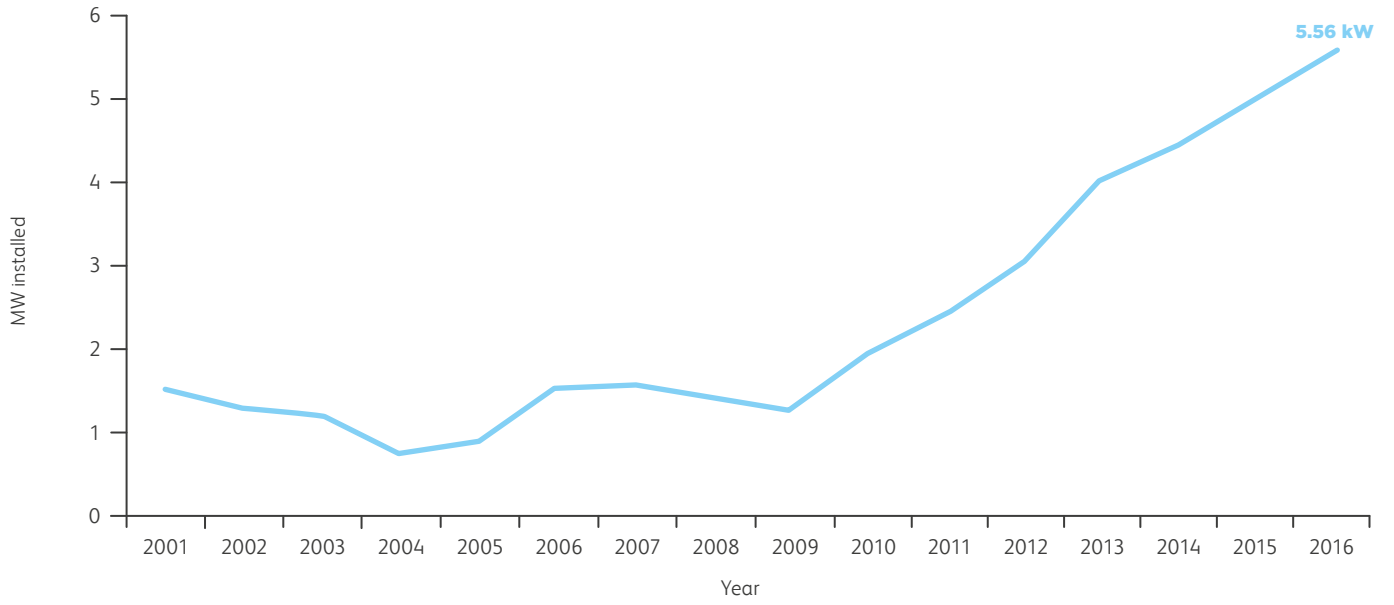
CUMULATIVE INSTALLED CAPACITY OF SOLAR PV IN AUSTRALIA (MW)³⁴




INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
2001	7	62	7	61	126	2	113	34	412
2002	10	236	11	110	330	11	255	55	1018
2003	15	378	21	178	876	17	439	81	2004
2004	21	495	38	285	1269	22	616	95	2841
2005	26	671	98	422	1865	32	827	142	4082
2006	53	917	202	619	2542	34	1133	285	5784
2007	249	2063	368	1271	4200	72	2219	910	11,350
2008	725	6185	791	5353	9036	301	5062	3798	31,249
2009	1944	24,454	1269	29,257	21,125	1981	18396	17,421	115,845
2010	7192	170,530	2626	119,530	54,135	8011	76,216	62,666	500,904
2011	24,432	356,996	4186	340,191	216,014	19,783	213,256	197,926	1,372,782
2012	29,481	495,351	6289	749,465	352,604	60,023	415,971	302,346	2,411,528
2013	40,306	623,073	11,111	1,011,576	492,666	122,628	543,997	373,689	3,219,044
2014	45,383	786,834	16,906	1,253,855	574,539	160,367	711,903	470,919	4,020,704
2015	51,469	963,288	25,647	1,446,432	640,898	169,875	863,050	566,861	4,727,518
2016	58,287	113,0198	38,039	1,651,625	716,549	181,891	1,005,167	698,541	5,480,297

³⁴ SunWiz

NATIONAL AVERAGE SOLAR PV SYSTEM SIZE (kW)³⁵





The Clean Energy Council thanks the following members and industry stakeholders for providing some of the stunning photographs in this report:

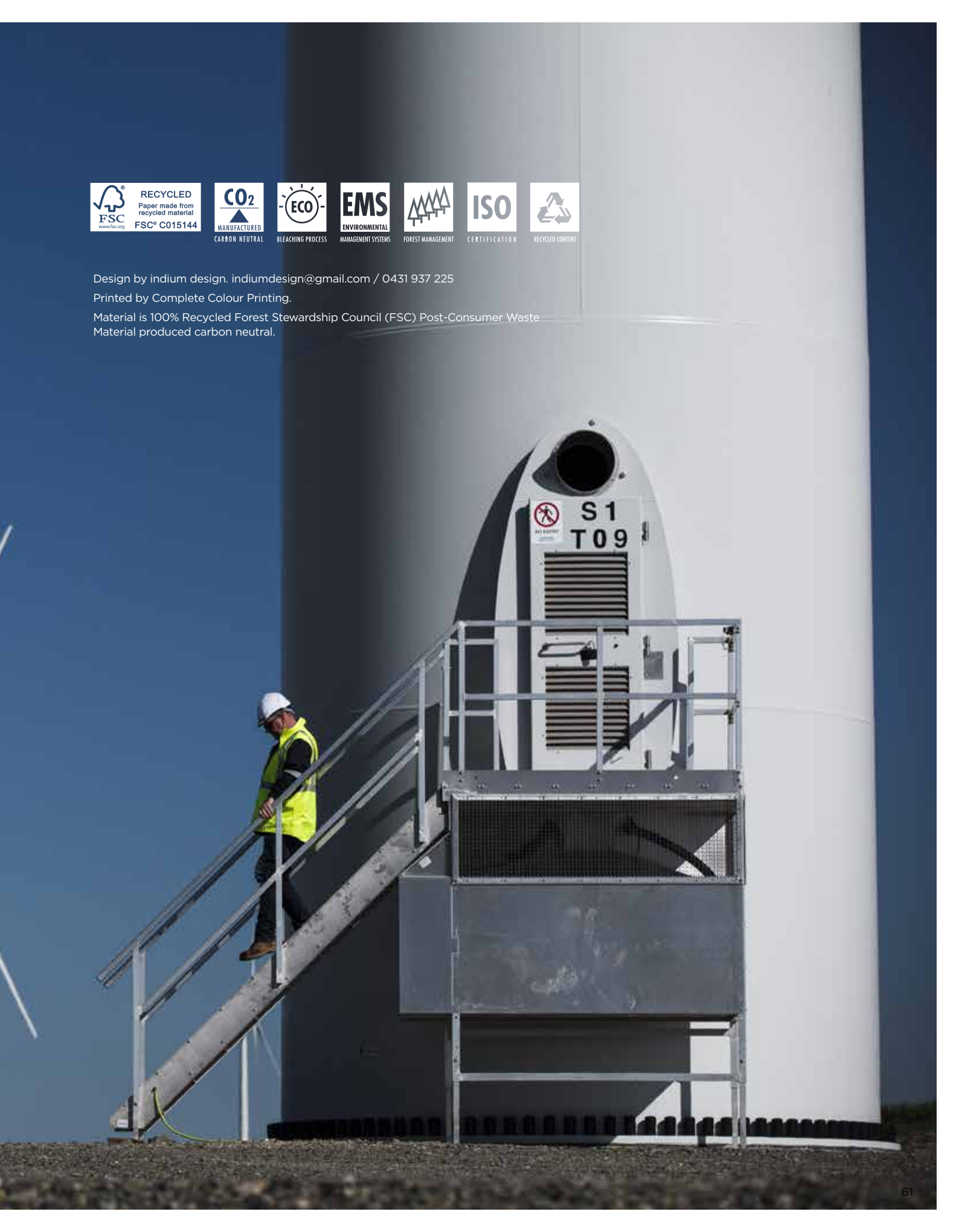
- > BPS (BioPower Systems)
- > CPS National
- > Energy Action
- > Enertech Solar
- > First Solar
- > GEM Energy
- > Hydro Tasmania
- > Neoen
- > RES Australia
- > Siemens
- > Suntrix

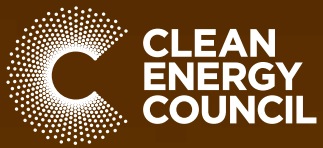


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