

CLEAN ENERGY AUSTRALIA REPORT 2022



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INTRODUCTION



Kane Thornton
Chief Executive,
Clean Energy
Council

Australia's clean energy industry was irrepressible in 2021, with some of the country's largest wind and solar projects coming online and rooftop solar continuing its record-breaking run. When coupled with the rapid development of battery storage and hydrogen, Australia's clean energy future has never looked brighter.

The recent success of the Australian renewable energy industry makes it easy to forget just how far we've come. Back in 2015 when the Abbott Government threatened to abolish the Renewable Energy Target, there were serious doubts about the industry's survival, let alone its ability to provide a significant proportion of the country's electricity.

Yet just six years later, 32.5 per cent of Australia's electricity came from clean energy sources and the industry is growing faster than ever before. The acceleration of the renewable energy transition in 2021 shows that a future where Australia's electricity costs less, is more reliable and has zero emissions is no longer a possibility, it is a certainty.

The almost 3 GW of new large-scale capacity that was added in 2021 included some of Australia's largest renewable energy projects, with the country's three largest solar farms and two of its three largest wind farms all beginning to send power to the grid during the year. The rooftop solar sector also continued its remarkable run in 2021, adding 3.3 GW of new capacity to chalk up five record-breaking years in a row.

The battery sector made considerable strides in 2021, including the completion of Australia's largest battery and several other announcements of new projects that will provide the system with added

stability and capacity. The hydrogen sector's development also accelerated in 2021 on the back of several large investments by governments and the private sector.

Australia's troubled climate politics made some progress in 2021 when the country committed to a target of net-zero emissions by 2050. While this may signal that the end of Australia's decades-long climate wars is in sight, the Federal Government's failure to back the target with any meaningful policies shows that its leadership remains amiss.

Thankfully, the states and territories continue to fill this void, with South Australia reaching levels of renewable energy penetration never previously seen and New South Wales continuing its ambitious foray into renewables via several renewable energy zones.

More than any other year so far, 2021 signalled the inevitability of Australia's clean energy future as the country made big steps towards becoming a global clean energy export superpower. However, there is still much to be done and numerous challenges to overcome to ensure that the transition is as quick and seamless as possible. The rapid pace of the clean energy transition make this one of the most exciting industries to work in, and I can't wait to see how much more we can achieve, both in 2022 and in the years ahead.

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, hydrogen and emerging technologies along with more than 8500 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 by:

- providing a strong voice for our members
- standing up for the industry
- developing and driving effective policy and advocacy
- working with industry to continually improve standards and maintain integrity
- working closely with local, state and federal governments to increase demand for clean energy products
- providing services and initiatives to members and the wider industry that help to grow the sector
- promoting the clean energy industry.

2021 SNAPSHOT

The Australian renewable energy industry powered on in 2021, generating more clean energy than ever before and adding a record amount of new capacity.

The Australian renewable energy industry accounted for 32.5 per cent of Australia's total electricity generation in 2021, which represented an increase of almost 5 percentage points compared to 2020. In the past five years, the proportion of Australia's electricity that comes from renewables has almost doubled, increasing from 16.9 per cent in 2017 to 32.5 per cent this year.

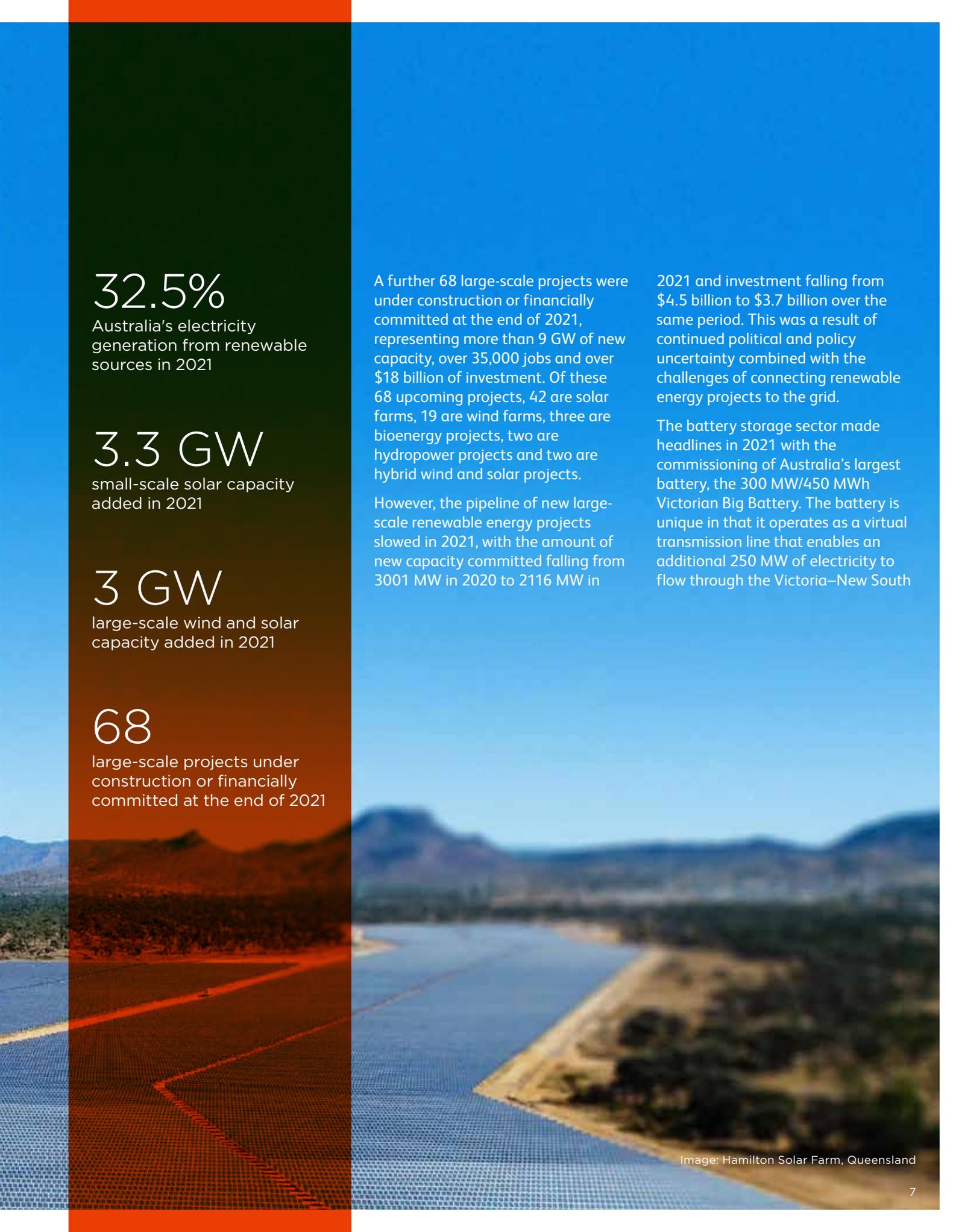
The growth in renewable energy generation was most keenly felt in the coal sector, which saw its share of total generation fall from 62.0 per cent in 2020 to 59.1 per cent in 2021.

The gas sector also saw a notable fall, with its proportion of total generation falling to 7.7 per cent in 2021, down from 9.9 per cent in 2020.

The growth of renewable energy in Australia in 2021 was again led by small-scale solar. The sector added 3.3 GW of new capacity during the year, representing the fifth year in a row that it has set a record for new installed capacity. Small-scale solar accounted for 24.9 per cent of Australia's total renewable energy generation in 2021, cementing its place as Australia's second-largest clean energy technology behind wind.

The large-scale sector also had a bumper year in 2021, adding 2955 MW of new capacity across 27 projects, which was almost 1 GW more than that added in 2020. The main reason for this significant increase in new capacity was the completion of some of Australia's largest wind and solar projects in 2021, which included the country's three largest solar farms and two of its three largest wind farms. The wind industry had a particularly strong year, adding 1746 MW of new capacity to register its third record-breaking year in a row.





32.5%

Australia's electricity generation from renewable sources in 2021

3.3 GW

small-scale solar capacity added in 2021

3 GW

large-scale wind and solar capacity added in 2021

68

large-scale projects under construction or financially committed at the end of 2021

A further 68 large-scale projects were under construction or financially committed at the end of 2021, representing more than 9 GW of new capacity, over 35,000 jobs and over \$18 billion of investment. Of these 68 upcoming projects, 42 are solar farms, 19 are wind farms, three are bioenergy projects, two are hydropower projects and two are hybrid wind and solar projects.

However, the pipeline of new large-scale renewable energy projects slowed in 2021, with the amount of new capacity committed falling from 3001 MW in 2020 to 2116 MW in

2021 and investment falling from \$4.5 billion to \$3.7 billion over the same period. This was a result of continued political and policy uncertainty combined with the challenges of connecting renewable energy projects to the grid.

The battery storage sector made headlines in 2021 with the commissioning of Australia's largest battery, the 300 MW/450 MWh Victorian Big Battery. The battery is unique in that it operates as a virtual transmission line that enables an additional 250 MW of electricity to flow through the Victoria–New South

2021 SNAPSHOT CONTINUED

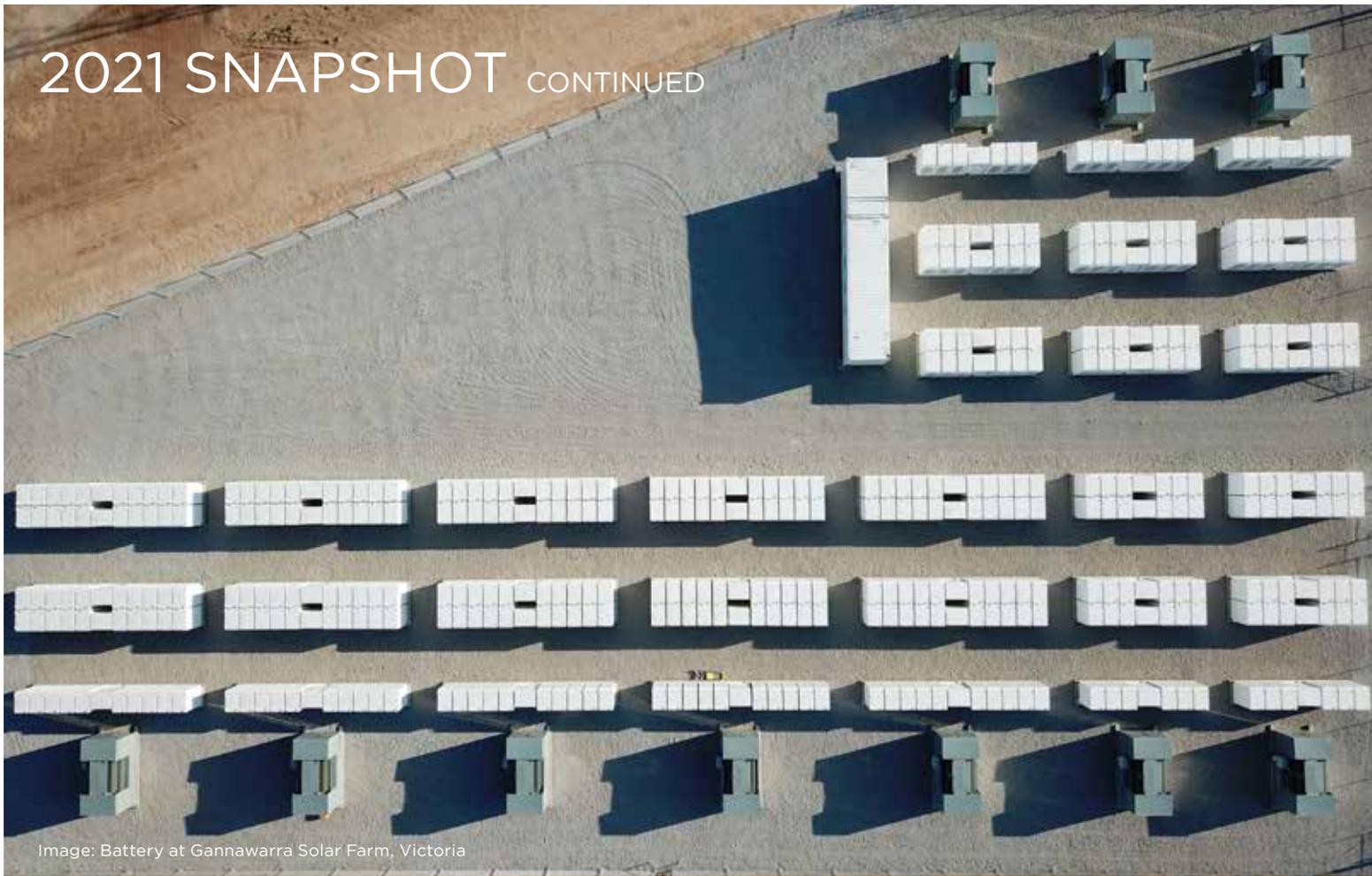


Image: Battery at Gannawarra Solar Farm, Victoria

Wales Interconnector. A further 30 utility-scale batteries were under construction at the end of 2021, representing a combined capacity and storage duration of 921 MW/1169 MWh.

The development of the hydrogen sector continued to accelerate in 2021, with the industry having a pipeline of more than 100 projects worth \$163 billion by the end of the year. The industry received significant government backing in 2021, led by the Federal Government's \$464 million Clean Hydrogen Industrial Hubs Program and the NSW Government providing up to \$3 billion in support to the industry. The private sector also upped its investment in 2021, with iron ore magnate Andrew Forrest leading the way via several announcements that will significantly boost the emerging sector.

Australian politics saw a landmark achievement in 2021 when the Federal Government committed Australia to a target of net-zero emissions by 2050 ahead of the COP26 summit. However, the government's refusal to back the target with any meaningful policy support and its continued assistance for the fossil fuel industry raised many questions about the sincerity of its commitment. In the final months of 2021, speculation was rife as to when the government would call the federal election. While predictions of a late-2021 poll didn't eventuate, the pre-election campaign was in full swing by the end of the year.

The lack of a federal energy policy didn't stop the states and territories in 2021, which continued to drive Australia's clean energy transition. South Australia broke several records in 2021 as the amount of the state's

electricity that came from renewable energy reached unparalleled levels. The most impressive measure of this occurred in late November when the state was powered entirely by wind and solar for 93 hours, making it the first gigawatt-scale grid in the world to achieve such a feat.

New South Wales formally declared Australia's first renewable energy zone (REZ) in 2021. The Central-West Orana REZ will host at least 3 GW of solar, wind and storage, generating \$5.2 billion of new investment and creating 3900 construction jobs. This is the first of five REZs planned for New South Wales, which will vastly increase the state's clean energy resources while reducing transmission costs.

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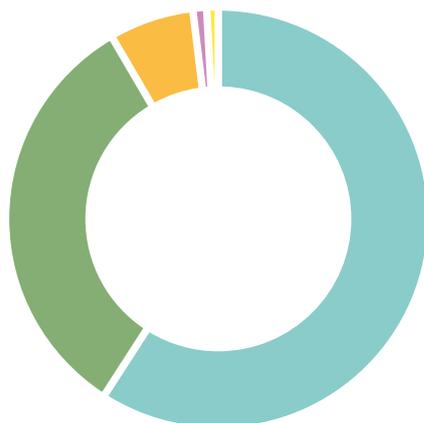
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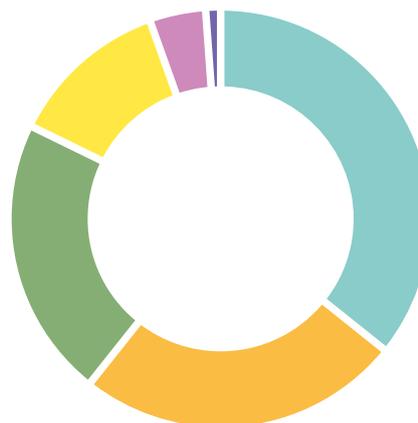
2021 SNAPSHOT CONTINUED

ANNUAL ELECTRICITY GENERATION IN 2021



Coal	59.1%
Renewables	32.5%
Gas	7.7%
Non-metered fossil fuels	0.6%
Liquids	0.1%

RENEWABLE GENERATION BY TECHNOLOGY TYPE



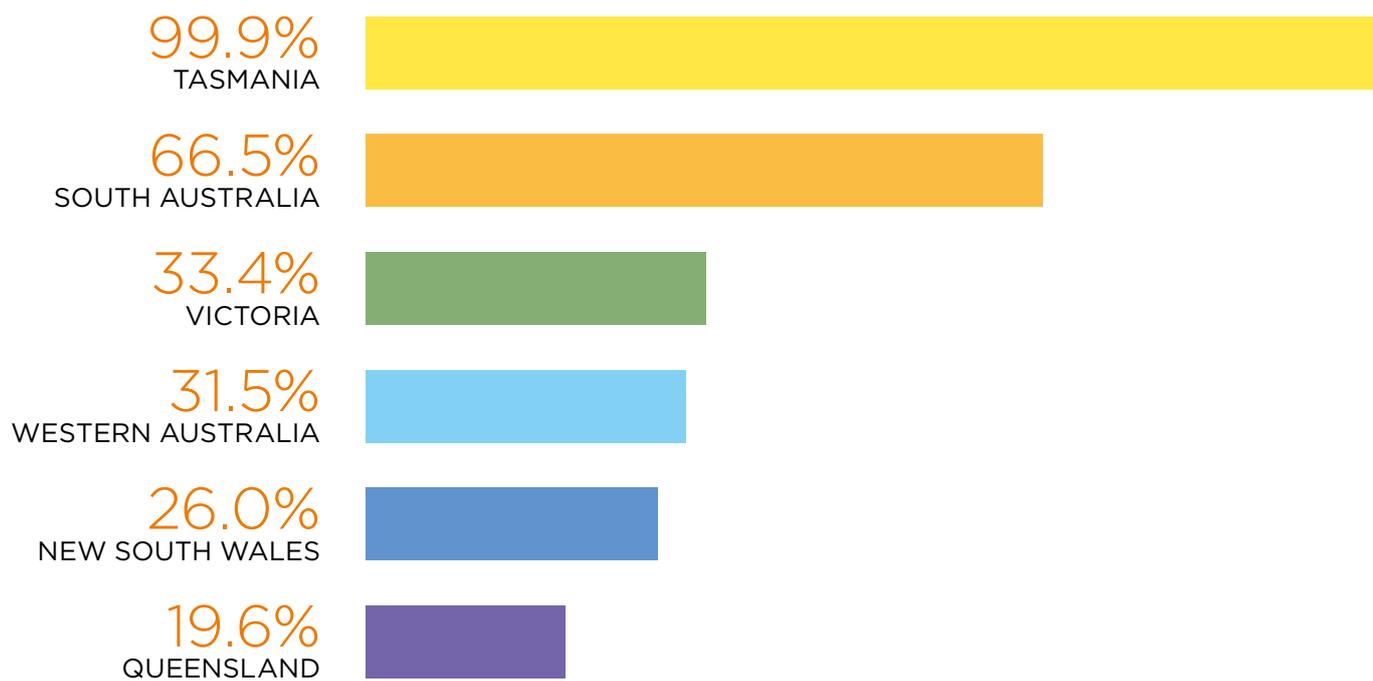
Wind	35.9%
Small-scale solar	24.9%
Hydro	21.6%
Large-scale solar	12.3%
Bioenergy	4.3%
Medium-scale solar	1.1%

RENEWABLE ENERGY GENERATION BY FUEL TYPE¹

TECHNOLOGY	GENERATION (MWH)	GENERATION (GWH)	PERCENTAGE OF RENEWABLE GENERATION	PERCENTAGE OF TOTAL GENERATION	EQUIVALENT NUMBER OF HOUSEHOLDS POWERED OVER THE COURSE OF THE YEAR
Wind	26,803,711	26,804	35.9%	11.7%	5,831,965
Small-scale solar PV	18,607,417	18,607	24.9%	8.1%	4,048,611
Hydro	16,127,522	16,128	21.6%	7.0%	3,509,034
Large-scale solar PV	9,166,577	9167	12.3%	4.0%	1,994,468
Bioenergy	3,187,047	3187	4.3%	1.4%	693,439
Medium-scale solar PV	786,692	787	1.1%	0.3%	171,169
NATIONAL	74,678,965	74,679	100.0%	32.5%	16,248,687

¹ Green Energy Markets. Electricity generation equivalent in households is calculated using a weighted national average consumption level of 4.596 MWh (from Australian Energy Market Commission, *Residential electricity price trends 2018*, 21 December 2018, aemc.gov.au/sites/default/files/2018-12/2018%20Price%20Trends%20-%20Final%20Report%20-%20CLEAN.PDF)

RENEWABLE ENERGY PENETRATION BY STATE AS A PROPORTION OF GENERATION

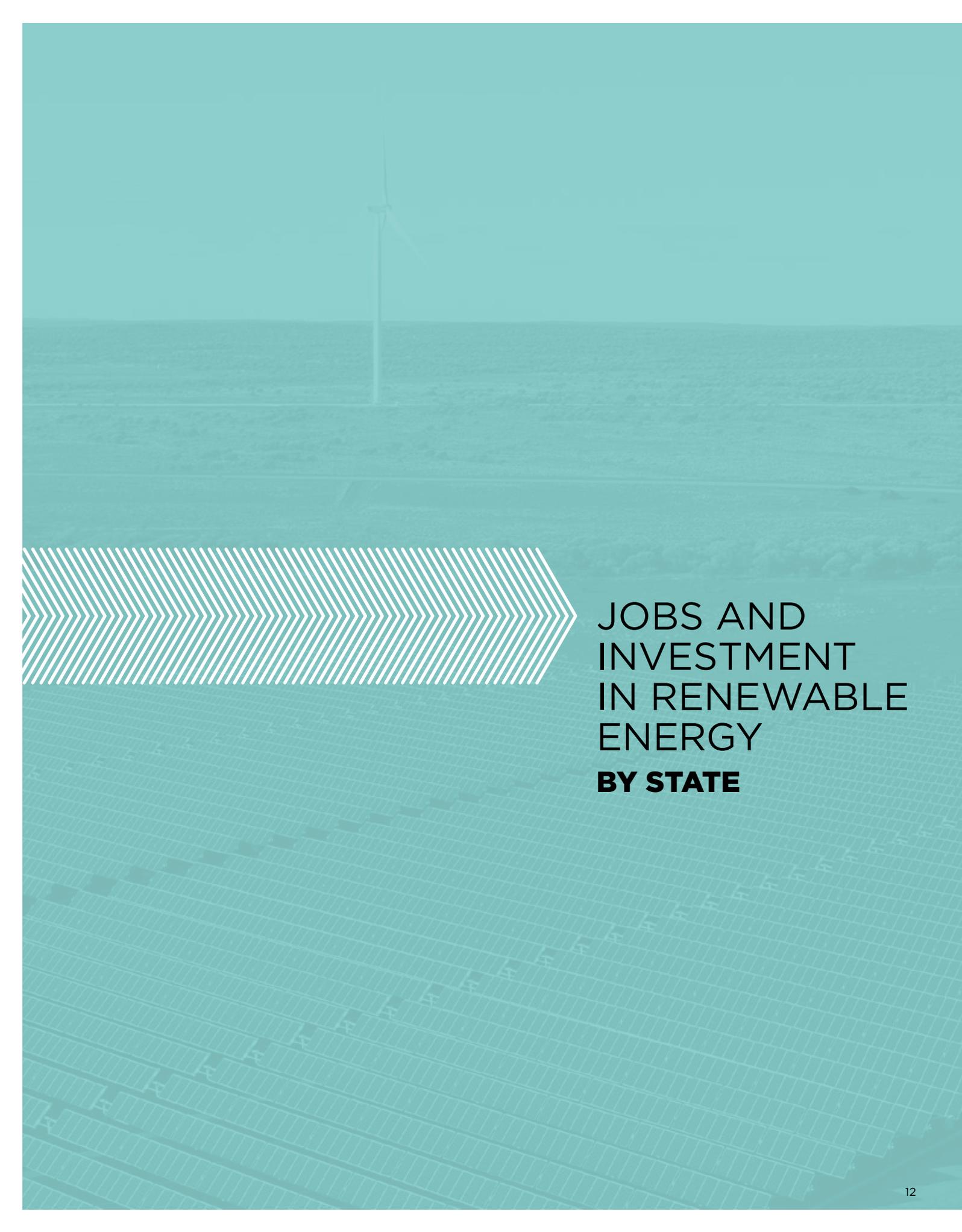


RENEWABLE ENERGY PENETRATION BY STATE²

STATE	TOTAL GENERATION (GWH)	FOSSIL FUEL GENERATION (GWH)	TOTAL RENEWABLE GENERATION (GWH)	PENETRATION OF RENEWABLES AS PROPORTION OF GENERATION	PENETRATION OF RENEWABLES AS PROPORTION OF CONSUMPTION
TAS	11,831	13	11,818	99.9%	102.1%
SA	13,252	4,437	8,815	66.5%	63.0%
VIC	51,831	34,502	17,328	33.4%	36.1%
WA	19,992	13,686	6,306	31.5%	31.5%
NSW	68,486	50,657	17,829	26.0%	24.1%
QLD	64,251	51,669	12,582	19.6%	20.2%
NATIONAL*	229,643	154,965	74,679	32.5%	32.5%

* Excludes NT and minor grids.

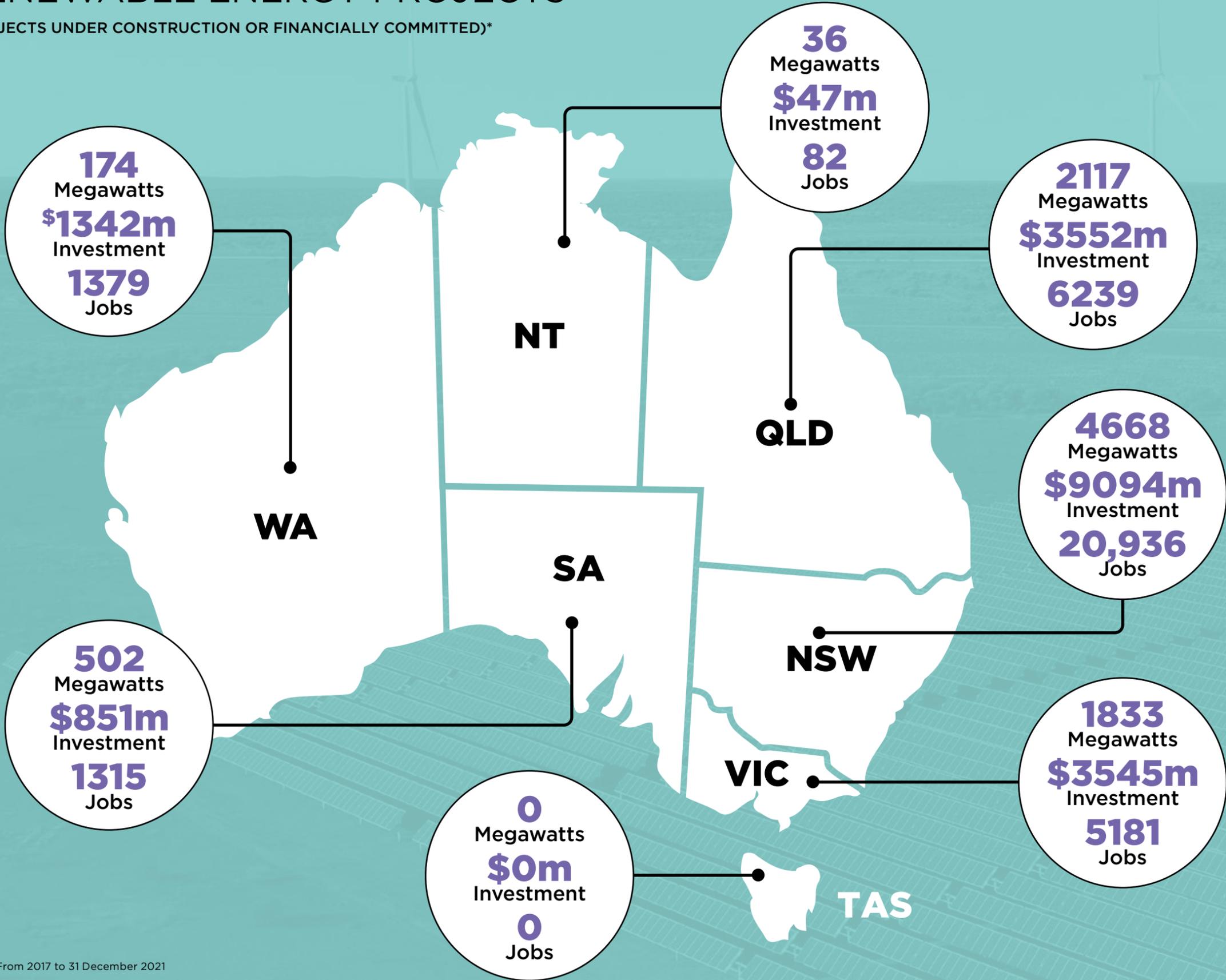
² Green Energy Markets. Total generation includes NEM and WEM data and small-scale solar. The ACT is part of the NSW region and there is no data available for the small NT grid.



JOBS AND
INVESTMENT
IN RENEWABLE
ENERGY
BY STATE

INVESTMENT AND JOBS FROM LARGE-SCALE RENEWABLE ENERGY PROJECTS

(PROJECTS UNDER CONSTRUCTION OR FINANCIALLY COMMITTED)*



TOTALS

9331
Megawatts

\$18.4b
Investment

35,132
Jobs

*From 2017 to 31 December 2021

PROJECT TRACKER

RENEWABLE ENERGY PROJECTS COMPLETED IN 2021

TECH	STATE	PROJECT	OWNER	CAPACITY (MW)
Wind	QLD	Coopers Gap Wind Farm	PowAR/Tilt Renewables	453
Wind	VIC	Dundonnell Wind Farm	PowAR/Tilt Renewables	336
Solar	NSW	Darlington Point Solar Farm	Edify/Fern Trading Development	275
Wind	NSW	Collector Wind Farm	RATCH-Australia	227
Wind	WA	Yandin Wind Farm	Alinta Energy	214
Solar	VIC	Kiamal Solar Farm	Total Eren	200
Wind	VIC	Bulgana Green Power Hub	Neoen	194
Wind	VIC	Berrybank 1 Wind Farm	Global Power Generation	180
Solar	NSW	Wellington Solar Farm	Lightsource BP	174
Wind	NSW	Crudine Ridge Wind Farm	CWP Renewables	134
Solar	VIC	Glenrowan West Solar Farm	Wirtgen Invest	130
Solar	VIC	Winton Solar Farm	Fotowatio Renewable Ventures	85
Solar	VIC	Yatpool Solar Farm	BayWa r.e.	81
Solar	WA	Chichester Solar Farm	Alinta Energy	60
Solar	NSW	Jemalong Solar Project	Genex Power	50
Solar	QLD	Maryrorough Solar Farm	Sentient Impact Group	35
Solar	QLD	Middlemount Solar Farm	SUSI Partners	34
Solar	NSW	Molong Solar Farm	AMP Energy	25
Solar	NT	Batchelor 2 Solar Farm	Merricks Capital	10
Solar	NT	Batchelor Solar Power Station	ENI Australia	10
Solar	NT	Manton Dam Solar Power Station	ENI Australia	10
Wind	VIC	Ferguson South Wind Farm	BayWa r.e.	7
Solar	SA	Morgan to Whyalla Pump Station 3	SA Water	7
Solar	SA	Morgan to Whyalla Pump Station 1	SA Water	6
Solar	SA	Morgan to Whyalla Pump Station 2	SA Water	6
Solar	SA	Morgan to Whyalla Pump Station 4	SA Water	6
Solar	QLD	Robina Town Centre Solar System	QIC	5

SMALL-SCALE RENEWABLE ENERGY

The growth of the small-scale solar sector continued unabated in 2021, adding 3.3 GW of new capacity to record its fifth-straight record-breaking year.

The small-scale solar sector added 3316 MW of new capacity in 2021, comfortably surpassing the previous record of 2963 MW set in 2020. This made 2021 the fifth year in a row that the sector has broken the record for new capacity, with the industry growing at an average of 39 per cent each year. The sector also broke the record for the number of systems installed for the second-straight year in 2021, with the 389,577 new solar installations overtaking the 370,156 systems installed in 2020.

Every state and territory besides the Northern Territory set new records for capacity in 2021 as households across

the country continued to embrace the benefits of rooftop solar. New South Wales once again installed the most new rooftop solar capacity in 2021, adding 996 MW throughout the year, followed by Queensland with 854 MW, Victoria with 681 MW and Western Australia with 367 MW.

The small-scale battery segment continued to build steadily in 2021, with approximately 34,731 household batteries with a combined capacity of 347 MWh installed during the year. This was a strong increase on the 23,796 batteries that were installed in 2020.

Victoria and New South Wales saw the most household battery installations in 2021 with 9000, followed by Queensland with 6500 and South Australia with 6000. Unsurprisingly, most of these states have government-backed household battery programs, demonstrating the sector's continued need for additional support to drive uptake.

The average size of a rooftop solar system increased to 8.51 kW in 2021, representing a more than threefold increase in the past 10 years. This highlights the significant cost reductions of solar panels and inverters over the past decade as economies of scale



Image: Rooftop solar installation, New South Wales

and technological improvements have brought solar prices to levels that would have scarcely been believable just a few years ago.

Despite the industry's strong performance in 2021, there were some signs that growth is beginning to slow. The industry's growth rate was lower in 2021 compared to previous years and was less than that forecast by some analysts. This could be down to a range of factors, including lower electricity prices, the impact of the COVID-19 pandemic and policies to limit or even charge rooftop solar for exporting to the grid. It remains to be seen whether this is just a one-off blip or the first signs that the industry is cooling slightly after several years of remarkable growth.

There were 1464 participating companies in the Clean Energy Council's

Approved Solar Retailer program at the end of 2021, an increase of 25 per cent on the previous year. The Clean Energy Council increased its compliance activity of the program in 2021, opening 430 cases against Approved Solar Retailers of which 112 resulted in compliance action. These actions are vital in maintaining the program's integrity and ensuring that Australian consumers are purchasing from a retailer that is committed to a high level of service and industry best practice.

The number of Clean Energy Council accredited installers passed 8500 for the first time in 2021, increasing by 13 per cent to 8682. The program's growth has closely matched that of the rooftop solar industry, with the number of accredited installers increasing in each of the past six years.

389,577

rooftop solar systems installed in 2021, a new record

39%

average yearly growth of small-scale solar capacity over the past five years

34,731

household batteries installed in 2021



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LARGE-SCALE RENEWABLE ENERGY



Image: Warwick Solar Farm, Queensland

27

large-scale projects
completed in 2021

2955 MW

new large-scale capacity
added in 2021

30

large-scale batteries under
construction at the end of 2021

The large-scale renewable energy industry had another strong year in 2021 as a large volume of new wind, solar and battery capacity entered the market and significant milestones were achieved at Australia's two latest hydro projects.

The large-scale renewable energy industry added 2955 MW of new capacity in 2021 across 27 projects. While the number of projects completed during the year was slightly down on the 32 seen in 2020, an additional 965 MW of capacity was added compared to 2020. This was largely due to the completion of some of Australia's largest wind and solar projects in 2021, with Australia's three largest solar farms and two of the country's three largest wind farms all being commissioned during the year.

Of the 27 projects completed in 2021, 19 were solar farms and eight were wind farms. However, despite only accounting for 30 per cent of total projects throughout the year, the wind sector was responsible for almost 60 per cent of new capacity.

A further 68 projects were under construction or financially committed at the end of 2021, representing more than 9 GW of new capacity, over 35,000 jobs and over \$18 billion of investment. Solar accounts for 42 of these new projects and wind accounts for 19, while the remainder are bioenergy plants, hydropower projects and hybrid projects deploying a combination of wind and solar.

The utility-scale battery sector continued to make strong progress in 2021, with the commissioning of the 300 MW/450 MWh Victorian Big Battery the sector's most significant development. The Victorian Big Battery overtook the Hornsdale Power Reserve as Australia's largest battery and offers a look into the future by acting as a virtual transmission line that enables an additional 250 MW of electricity to flow

through the Victoria–New South Wales Interconnector.

A further 30 large-scale batteries were under construction at the end of 2021 with a combined capacity and storage duration of 921 MW/1169 MWh. The two largest batteries currently being built are the 250 MW/250 MWh Torrens Island Battery in South Australia and the 150 MW/150 MWh Hazelwood Battery Energy Storage System in Victoria, both of which will be located at former fossil fuel power stations.

Two major hydro projects were under construction at the end of 2021, with both reaching significant milestones during the year. Tunnelling began on the 2000 MW/350,000 MWh Snowy 2.0 project in mid-2021, with more than 1 km of the project's main access tunnel excavated by the end of the year. Construction also began on the

250 MW/2000 MWh Kidston Pumped Hydro Storage Project in June after project developer Genex announced that it had secured financing for the project.

The large-scale sector's success in 2021 came despite ongoing challenges related to transmission investment and grid connection, both of which continued to affect the commissioning of existing projects and the development of new ones. However, with the Connections Reform Initiative – a collaboration between the Clean Energy Council and the Australian Energy Market Operator – implementing a series of reforms in 2022 and the development of renewable energy zones in New South Wales and Victoria, there is hope that a solution may finally be in sight.



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FEDERAL POLITICS



Image: Warwick Solar Farm, Queensland

Australia's commitment to a target of net-zero emissions by 2050 was a landmark achievement in the troubled history of Australian climate politics. However, the Federal Government's refusal to back the target with any meaningful policy support and continued assistance for the fossil fuel industry raised serious doubts about its commitment to achieving it.

The lightning rod of climate and energy policy was again one of the key issues in federal politics in 2021, despite the ongoing impact of the COVID-19 pandemic. Much of the policy debate centred on positioning for Australia to take to the COP26 summit, with unequivocal public support for the nation to play a more meaningful role in the global climate change response. The vehemence of this support put Prime Minister Scott Morrison on the back foot as he scrambled to come up with a credible target to take to COP26. This led to an unseemly public spat within the Coalition as several prominent Nationals members, including newly reinstated leader Barnaby Joyce, spoke out publicly against any form of increased climate commitment.

The Prime Minister's ability to eventually reach an agreement with his party to commit Australia to a target of net-zero emissions by 2050 was a landmark achievement in the history of Australian climate politics. However, the Federal Government's plan to reach the target – which included no new policies, no changes to interim targets and a heavy reliance on unnamed technologies and international offsets – raised many questions about the sincerity of its commitment.

Further doubts about the Federal Government's dedication to climate action were raised throughout the year by its continued support for the fossil fuel industry. This was most evident in the government's decision to invest



2050

federal target for Australia to reach net-zero emissions

\$464 M

investment in the Clean Hydrogen Industrial Hubs Program

43%

federal Labor's 2030 emissions reduction target

\$600 million in constructing a new gas-fired power plant in New South Wales. The changes that it made to the regulations governing the Australian Renewable Energy Agency, enabling it to provide funding to carbon capture and storage and potentially gas projects, were also seen by many as a thinly veiled attempt to prop up the ailing sector.

While the Federal Government didn't provide any additional support to Australia's clean energy transition in 2021, it did increase funding in the emerging hydrogen industry to \$464 million through its Clean Hydrogen Industrial Hubs Program. The program has identified seven prospective regions around Australia for the development of hydrogen hubs,

where hydrogen users, producers and potential exporters will be concentrated to allow for the creation of economies of scale.

The final months of 2021 were dominated by speculation about when the next federal election would be called. While many pundits' predictions of a late-2021 election to capitalise on the improving COVID-19 situation didn't come to fruition, the pre-election campaign was in full swing by the end of the year. In December, the Federal Labor party got the ball rolling when it announced that it would take an emissions reduction target of 43 per cent by 2030 to the election.

While short of the target that it took to the 2019 federal election and that being called for by business groups

such as the Business Council of Australia, this didn't stop the Coalition from immediately responding with a reshuffle of the scare campaign that it ran at the previous election. Whether or not this will be as successful in the coming election, which must be held in the first half of 2022, will be a decisive factor in Australia's future climate ambitions and the speed of the clean energy transition.



STATE POLICIES

The states and territories continued to lead Australia's renewable energy transition in 2021, demonstrating just what is possible with good policy and bipartisan support.

The remarkable success of state and territory renewable energy policies is borne out in the increasing share of clean energy, with some states and territories reaching levels of renewable penetration not seen anywhere else in the world.

With their renewable energy ambitions well and truly on track, many states and territories increased their focus on renewable hydrogen in 2021, introducing policies and projects that are helping to lay the foundation for Australia's next big export opportunity.



Image: Coonalpyn Solar Farm, South Australia



KEY INITIATIVES

- **Net-zero emissions target by 2025**
- **Big Canberra Battery system to establish a 250 MW network of distributed batteries**
- **\$300 million over five years to tackle climate change**

The ACT continued as a renewable energy leader in 2021, maintaining its position as one of the few jurisdictions in the world that gets 100 per cent of its energy from renewable sources. However, despite its world-leading status, the territory continued to look for new ways to improve its renewable energy credentials as it strives to achieve its ambitious goal of net-zero emissions by 2025.

In February 2021, the ACT Budget committed \$300 million to tackle climate change over the next five years. This included \$150 million towards interest-free loans of up to \$15,000 per household to install solar panels, battery storage and heat pumps, and \$100 million for the Big Canberra Battery system.³

The Big Canberra Battery system is a unique energy storage solution that involves the ACT Government establishing a 250 MW network of distributed battery systems across

Canberra that can be coordinated to operate as if they were one big battery. The distributed battery system will be used to increase network reliability by reducing pressure on the grid, better integrate the increasing supply of renewable energy in the network, reduce electricity price spikes and generate new revenue opportunities for the ACT.⁴ Although it is still only in the early planning stages, the battery and its innovative operating model demonstrates the exciting possibilities enabled by energy storage.

The ACT also looked at expanding its renewable energy expertise beyond its borders in 2021, with the Standing Committee on Environment, Climate Change and Biodiversity holding an inquiry into developing the ACT into a global exporter of renewable energy expertise. The inquiry focused on a range of topics, including boosting renewable energy research in the ACT, establishing the territory as a national

hub for renewable energy technologies, innovative funding for renewable energy projects and the opportunities for battery storage.⁵

Electricity prices were a contentious issue in the ACT in 2021, with a decision by the ACT's Independent Competition and Regulatory Commission resulting in consumer power bills increasing by almost \$200 per year.⁶ The increase was due to a 37 per cent rise in network costs and a 133 per cent increase in feed-in tariff payments to large-scale wind and solar generators, which came about because of the significant fall in wholesale prices caused by the COVID-19 pandemic.⁷

While the price increase was lower than that initially proposed by energy distributor Evoenergy, it still came as a significant blow to businesses and households in the ACT that were also dealing with lockdowns associated with the COVID-19 pandemic.

³ A Crowe, The Canberra Times, *The ACT plans to lead the nation on climate. But do our neighbours have other plans?*, 21 February 2021, [canberratimes.com.au/story/7122400/the-act-plans-to-lead-the-nation-on-climate-but-do-our-neighbours-have-other-plans](https://www.canberratimes.com.au/story/7122400/the-act-plans-to-lead-the-nation-on-climate-but-do-our-neighbours-have-other-plans)

⁴ M Mazengarb, RenewEconomy, *ACT seeks proposals for massive 250MW 'Big Canberra Battery' network*, 16 April 2021, [reneweconomy.com.au/act-seeks-proposals-for-massive-250mw-big-canberra-battery-network](https://www.reneweconomy.com.au/act-seeks-proposals-for-massive-250mw-big-canberra-battery-network)

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250 MW

size of the proposed Big
Canberra Battery

\$15,000

value of interest-free loans for
households to install solar and
batteries



Image: Sapphire Wind Farm, New South Wales



KEY INITIATIVES

- **50 per cent emissions reduction target by 2030**
- **\$3 billion in incentives for new hydrogen projects**
- **\$380 million over four years to support renewable energy zone development**

Political turmoil in NSW, which saw the resignation of Premier Gladys Berejiklian and Deputy Premier John Barilaro over a three-day period, didn't slow New South Wales' clean energy momentum in 2021, with a flurry of new announcements confirming the state's commitment to a rapid clean energy transition.

The most significant development was the formal declaration of Australia's first renewable energy zone (REZ). Located near Dubbo, the Central-West Orana REZ will host at least 3 GW of solar, wind and storage, generating \$5.2 billion of new investment and creating 3900 construction jobs. The next step will be for the NSW Government to hold a series of auctions to select the projects to be constructed in the REZ, and there is expected to be no shortage of bidders after an expression of interest (EOI) process held in 2020 received 27 GW worth of proposals, more than nine times the capacity of the REZ.⁸

Work is also continuing in the state's other REZs, with the NSW Government's EOI process for the New England REZ receiving more than 80 proposals worth 34 GW, well above the planned 8 GW capacity of the REZ. The New England REZ, which will be Australia's largest once completed, is expected to deliver approximately \$10.7 billion in investment and create 2000 construction jobs and 1300 ongoing jobs in the region in the state's north.⁹ The EOI process for the Hunter-Central Coast REZ also opened in late-2021.¹⁰

To help support all this activity, the NSW Government committed an additional \$380 million over four years to REZ investment in the state budget, bringing its total commitment to more than half a billion dollars. The additional \$380 million will be used to fund transmission upgrades in the Central West-Orana REZ and the establishment of a Consumer Trustee, Financial Trustee and Regulator to ensure that competition in the REZs benefits consumers.¹¹

The NSW Government also made a considerable commitment to establishing a hydrogen industry in the state in 2021, launching its hydrogen strategy in October. The strategy was accompanied by up to \$3 billion in incentives for new hydrogen projects, including waiving government charges on green hydrogen production, providing a 90 per cent exemption to network charges for electrolysers that connect to parts of the network with spare capacity and investing \$70 million in hydrogen hubs in the Illawarra and Hunter regions.¹²

Project EnergyConnect, the \$2.3 billion interconnector between NSW and South Australia, was approved in 2021, with both the NSW Government and ElectraNet giving the project the green light. The 900 km transmission line will be crucial in connecting new wind and solar projects to the grid as well as providing NSW with access to South Australia's increasing renewable energy exports.

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26.0%
of New South Wales' electricity generation came from renewables in 2021*



24.1%
of New South Wales' electricity consumption was served by renewables in 2021*

* The NSW figure includes the ACT

Image: Sebastopol Solar Farm, New South Wales



KEY INITIATIVES

- **50 per cent renewable energy target by 2030**
- **35 MW battery to support the Darwin-Katherine grid**
- **\$2.8 million to extend the Home and Business Battery Scheme**

Despite facing some challenges in 2021, the Northern Territory continued to put measures in place to set itself up to achieve its target of 50 per cent renewables by 2030.

The Federal Government gave the NT's clean energy plans a boost in the 2021-22 budget, providing \$15 million towards the 35 MW battery that will be constructed to enable more renewable energy on the Darwin-Katherine grid and \$15 million to deploy microgrids to provide up to 10 remote Indigenous communities with more secure, reliable and affordable electricity by reducing their reliance on diesel generators.¹³

The NT Government also used the state budget to commit \$2.8 million to extend the Home and Business Battery Scheme to an additional 460 homes and businesses in the territory. The scheme provides successful applicants with \$6000 grants to buy and install a

rooftop solar system with a battery or add a battery to an existing system.¹⁴

Despite these positive developments, a report by the NT Utilities Commission in July 2021 highlighted the challenges still facing the NT if it is to reach its 50 per cent renewables target by 2030. The report forecast that renewable energy would account for just 23 per cent of consumption on the Darwin-Katherine grid and 14 per cent in Alice Springs by 2030 on current trends. It also highlighted a number of potentially significant risks for the territory's electricity system, including decreasing minimum system demand and a shortage of capacity to meet system security requirements.¹⁵

In response, the NT Government announced a comprehensive plan to address these issues while meeting its 2030 target. The plan involves the installation of more large- and small-

scale solar, the purchase of a second large-scale battery by 2024 and new "hydrogen compatible" gas generators, all at an estimated cost of \$30 million less than a "business as usual" scenario.

The Sun Cable project continued to make progress in 2021, with the project's backers announcing that the giant solar farm would be expanding from 14 GW to 17-20 GW and that the associated energy storage would also be increased from 30 GWh to 36-42 GWh.¹⁶ In 2021, the project, which will be located approximately halfway between Darwin and Alice Springs, was added to Infrastructure Australia's annual Infrastructure Priority Initiative List¹⁷ and signed a project development agreement with the NT Government.

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35 MW

size of a new battery to support the Darwin-Katherine grid

\$15 M

value of support to deploy up to 10 microgrids in remote Indigenous communities



Image: Yulara Solar Farm, Northern Territory



KEY INITIATIVES

- **50 per cent renewable energy target by 2030**
- **\$1.5 billion top up of the state's renewable energy fund**
- **Proposed 1 GW pumped hydro system at Borumba Dam**

Queensland took some important steps towards its goal of 50 per cent renewable energy by 2030 in 2021, making significant investments in new renewable capacity and storage. However, the state's clean energy progress has slowed in comparison to its peers in recent years as other jurisdictions have increased their ambitions and accelerated their renewable energy transitions.

In an effort to boost the Queensland clean energy industry, the Queensland Government announced a \$1.5 billion top-up of the state's renewable energy fund, bringing the total available funds to \$2 billion. The fund will be used to help state-owned power companies increase their renewable generation and storage capacity and allow the government to invest in new hydrogen projects and clean manufacturing jobs.¹⁸

A report by the Auditor-General in November looked at the state's clean energy progress, warning that Queensland may fail to achieve its 50 per cent renewable energy by 2030

target if current trends continue. The report also raised concerns about the effect that the \$2 billion renewable energy fund would have on private sector investment in the state.¹⁹ In the months before the report was released, the Queensland Government announced that it was developing a 10-year energy plan for the state, which will hopefully address some of the concerns raised in the report.

The other big electricity event in Queensland in 2021 was an explosion at the Callide coal-fired power station in May, which plunged much of the state into blackout and sent prices skyrocketing. Thankfully, the state's wind farms and the Wivenhoe pumped hydro scheme were able to step in to help restore power, but the event served to highlight the growing unreliability of Australia's ageing coal-fired power fleet.

Storage was a major focus in Queensland in 2021, with both pumped hydro and battery storage receiving significant boosts. After several false starts, construction on the 250 MW

Kidston pumped hydro project began in April 2021. The project received a \$147 million funding package from the Queensland Government to help it finance a new transmission network link to allow it to connect to the main grid upon completion, which is expected in 2024.

It could be joined by a similar project after the Queensland Government opened a tender process for a 1 GW pumped hydro system at Borumba Dam in the state's south-east. While the proposed project is still only in the very early stages of development, if constructed it would be one of the largest storage systems in the country.²⁰

Queensland also connected its first large-scale battery to the grid in 2021 when the 100 MW/150 MWh Wandoan South battery came online in May. The battery is the first of several planned for the state, with a 150 MW system planned for installation at the Tarong coal-fired power station.²¹

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19.6%
of Queensland's
electricity generation
came from renewables
in 2021



20.2%
of Queensland's
electricity
consumption
was served by
renewables in 2021



Image: Gatton Solar Research Facility, Queensland



KEY INITIATIVES

- **100 per cent renewable energy target by 2030**
- **330 kV interconnector between SA and NSW approved**
- **250 MW battery announced at Torrens Island gas-fired power station**

The eyes of the world were on South Australia in 2021 as the amount of the state's electricity that came from wind and solar reached unparalleled levels.

Of all the records broken in SA in 2021, the most impressive was the one set in late November, when the state was powered entirely by wind and solar over a 93-hour period. This was a record for a gigawatt-scale grid anywhere in the world and shows how close the state is to reaching its goal of 100 per cent renewable energy by 2030.²²

The catalyst for SA's record-breaking run was a decision by the Australian Energy Market Operator to reduce the amount of gas generation required to ensure grid stability from at least 240 MW to 80 MW following the commissioning of four synchronous

condensers across the state.²³ This largely removed the requirement for wind and solar farms to curtail their output, allowing them to produce enough clean energy to meet all of SA's local demand while still having capacity to export to other states.

SA's role as a clean energy exporter received a major boost in 2021 with the approval of Project EnergyConnect, a new 330 kV interconnector between SA and New South Wales. The project will vastly improve SA's energy security and will likely remove the need for any synchronous generation in the state, clearing the way for SA to be powered entirely by wind and solar generation.²⁴

The other benefit of SA's remarkable clean energy transition is a significant fall in household electricity prices,

with a report by the Essential Services Commission of South Australia finding that average market prices had dropped by \$111 in the first half of the 2020-21 financial year.²⁵

The unique situation in SA, where supply is increasingly outstripping demand, has made the business case for large-scale batteries extremely attractive. For example, throughout September and October, the state's existing fleet of batteries were paid to charge due to negative wholesale electricity prices.²⁶ This resulted in the announcement of several new batteries in 2021, including a 250 MW battery at the Torrens Island gas-fired power station²⁷ and a 150 MW battery at the former Holden car manufacturing plant in Adelaide.²⁸

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66.5%
of South Australia's
electricity generation
came from renewables
in 2021



63.0%
of South Australia's
electricity
consumption
was served by
renewables in 2021



Image: Starfish Hill Wind Farm, South Australia



KEY INITIATIVES

- **200 per cent renewable energy target by 2040**
- **Net-zero emissions target by 2030**
- **\$100,000 towards hydrogen cluster initiative at Bell Bay**

Tasmania's abundance of hydro power assets means that it is one of the few jurisdictions in the world that gets all its power from renewable energy. However, the job is far from done, with the state working towards its targets of 200 per cent renewables by 2040 and net-zero emissions by 2030.

To help it get to these ambitious targets, the Tasmanian Government announced the creation of Renewables, Climate and Future Industries Tasmania (ReCFIT) in 2021. The new agency will advise the government on Tasmania's strategic direction on climate change, renewable energy growth and the development of new industries such as renewable hydrogen.

Tasmania also legislated the country's most ambitious net-zero target in 2021, committing to carbon neutrality by 2030. While some criticised the policy for not being ambitious enough considering that Tasmania has had net-zero emissions for six of the past seven years, the fact that the target is legislated will require the government of the day to continue pursuing reductions.

Progress on Project Marinus, a second interconnector between Tasmania and the mainland and a key enabler of the Battery of the Nation initiative, was a tale of two reports in 2021. In June, a study by TasNetworks found that the project would lead to savings of up to 70 million tonnes of CO₂ equivalent and reduce electricity prices across the National Electricity Market.²⁹ However, another report released in November found that the falling costs of battery storage would likely make the project redundant.³⁰ The other major sticking point for the project is who will fund it, with the Tasmanian Government calling on those on the mainland to make a significant contribution to the project's construction.

The Tasmanian Government surprised many in March when it called a snap state election for May, more than a year ahead of schedule. Renewable energy and climate change largely took a back seat during the campaign as both major parties focused more strongly on COVID-19, the economy, health and housing.

However, clean energy commitments from the incumbent Liberal government included \$10 million in interest-free loans for sports clubs to install solar panels, \$5 million for solar panels on schools and \$100,000 towards the hydrogen cluster initiative at Bell Bay. The Labor opposition matched the Liberals' \$5 million school pledge and promised \$20 million in interest-free loans for batteries. Unsurprisingly, the Greens' election commitments were far more comprehensive, pledging to ban the generation of non-renewable energy in the Tasmanian electricity grid and increase the installation of rooftop solar on public housing.³¹

After a messy campaign dominated by preselection infighting and candidate resignations, the election resulted in the status quo being maintained, with both the Liberal and Greens winning the same number of seats and Labor losing just one seat to an independent.

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99.9%
of Tasmania's
electricity generation
came from renewables
in 2021



102.1%
of Tasmania's
electricity
consumption
was served by
renewables in 2021



Image: Granville Harbour Wind Farm, Tasmania



KEY INITIATIVES

- **50 per cent renewable energy target by 2030**
- **VRET2 auction to add 600 MW of new renewable energy capacity**
- **240 MW battery announced for the Mornington Peninsula**

The first signs of Victoria reaching its ambitious target of 50 per cent renewable energy by 2030 emerged in 2021 as renewables accounted for more than half of the state's energy mix for a short period for the first time in January.³² This mark was bettered throughout the year, culminating in renewables accounting for 66 per cent of total generation and more than 70 per cent of local demand in August.³³

Victoria's clean energy ambitions continued in 2021 with the launch of VRET2, the state's second renewable energy auction. Launched in August, VRET2 is calling for an additional 600 MW of large-scale wind, solar and hydro capacity across the state's six planned renewable energy zones (REZs). The auction will generate \$1 billion in investment and create more than 2000 new jobs in the state, with the successful projects expected to be announced towards the end of 2022.³⁴

The Victorian Government also committed to powering all government-owned enterprises, including schools and hospitals, with renewables by 2025 during the year. This initiative came as part of the Victorian Government's long-awaited interim emissions reduction targets, which put the state on the path to reducing its emissions by 28-33 per cent by 2025 and 45-50 per cent by 2030 compared to 2005 levels, before reaching its ultimate goal of net-zero emissions by 2050.³⁵

With the addition of so much large-scale renewable energy across the state in the past few years, Victoria's focus shifted to consolidating these gains through utility-scale battery investments in 2021. The most significant of these was the 300 MW/450 MWh Victorian Big Battery, which began operation in December. The battery, which has taken the mantle of Australia's largest battery, will operate as a virtual transmission line

during the summer months, increasing the capacity of the Victoria–New South Wales Interconnector by 250 MW.³⁶ This was just one of several battery announcements made in the state in 2021, including a 240 MW/480 MWh battery in the Mornington Peninsula and 20 utility-scale batteries scattered across the state's REZs.

Rooftop solar continued to perform strongly in Victoria in 2021, with the Victorian Government's Solar Homes program passing 1 GW of installed systems during the year. Despite significant teething problems when it first started in 2019, the Solar Homes program has been an overwhelming success, increasing the proportion of homes with rooftop solar in Victoria from 14 per cent to 22 per cent in just two years.³⁷

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33.4%
of Victoria's electricity
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36.1%
of Victoria's
electricity
consumption
was served by
renewables in 2021

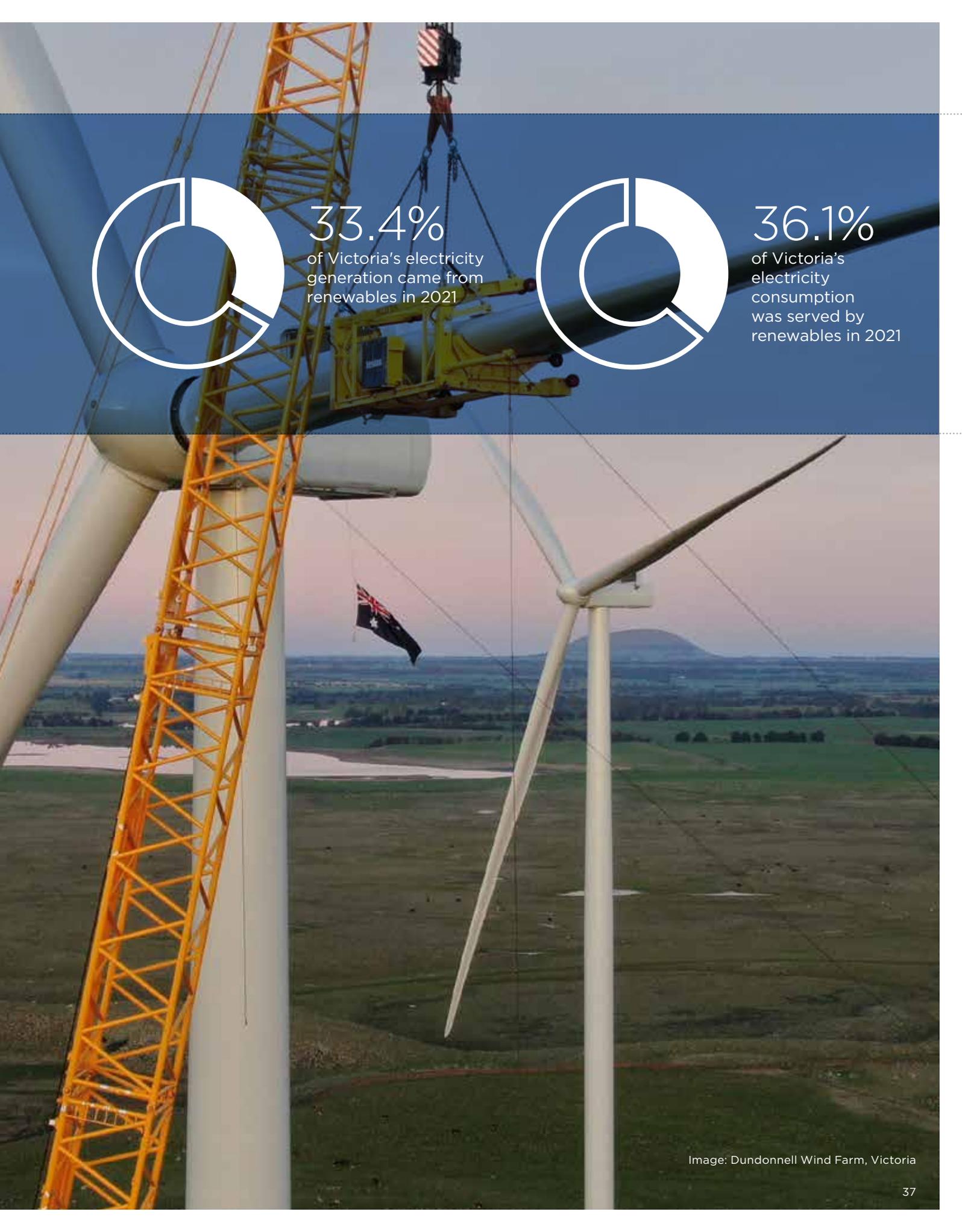


Image: Dundonnell Wind Farm, Victoria



KEY INITIATIVES

- **Commitment to a 2030 emissions reduction target**
- **\$50 million to stimulate demand for hydrogen in the transport and industrial sectors**
- **\$118 million to develop hydrogen hubs in the Pilbara and the state's mid-West**

Western Australia continued to make steady progress on its clean energy ambitions in 2021, with wind and solar providing almost a third of all electricity used across Perth and the South West in the 12 months to July 2021³⁸ and rooftop solar accounting for as much as 65 per cent of electricity consumption on WA's main grid at certain times throughout the year.³⁹

In December 2021, the WA Government announced that it was working on a 2030 emissions reduction target, bringing it in line with almost every other Australian state and territory. The target will first be applied to state government agencies in 2022, before being expanded to other sectors of the economy in the following year.

Emissions reduction and renewable energy were major issues heading into the WA state election in March, with both major parties offering

comprehensive policy platforms. In a surprising twist, it was the Liberal party that offered up the most ambitious proposals, including a 100 per cent renewable energy target by 2030, the construction of a 4.5 GW wind and solar facility, and the closure of all state-owned coal-fired power stations by 2025.

In comparison, the incumbent Labor government offered a more modest set of policies that included a commitment to install 1000 stand-alone power systems and fit out schools with rooftop solar.⁴⁰ This resulted in the strange situation of the Labor party criticising the Liberals for promoting unrealistic clean energy and climate targets.

The Liberals' bold climate platform was not able to save it at the ballot box though, with Labor recording the biggest electoral victory in Australian history and in the process consigning

the Liberal party to just two seats, which wasn't even enough for it to maintain its position as the official opposition party in the state.

WA continues to explore the enormous possibilities offered by hydrogen, with the WA Government announcing two significant investments in 2021. In September, the government created a \$50 million fund to stimulate local demand for renewable hydrogen in transport and industrial settings and drive investment in the sector.⁴¹ The government then committed a further \$118 million to support the creation of hydrogen hubs in the Pilbara and the state's mid-West in November.⁴² When added to the large hydrogen projects already proposed in the state, including the Asian Renewable Energy Hub in the Pilbara and the Western Green Energy Hub along the south coast, WA is setting itself up to be a major future player in the global hydrogen market.

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31.5%
of Western Australia's
electricity generation
came from renewables
in 2021



31.5%
of Western
Australia's electricity
consumption
was served by
renewables in 2021

Image: Agnew Hybrid Renewable Microgrid Solar and Wind Farm, Western Australia

EMPLOYMENT

Employment in the renewable energy industry continued to grow in 2021, but skills shortages in key clean energy occupations will need to be addressed.

Renewable energy employment was a key selling point for both major political parties in 2021 as they looked to boost their environmental credentials in the leadup to the 2022 federal election. The Federal Government promised a significant boost to clean energy jobs in regional Australia in 2021 as part of its negotiations with the Nationals to get support for a net-zero by 2050 target ahead of the COP26 summit.⁴³ A significant proportion of these jobs will come from hydrogen, with the government committing \$464 million towards the construction of seven hydrogen hubs in regional areas as part of its Technology Investment Roadmap, which it says will create 130,000 new jobs by 2030.

In December, the federal Labor party released its climate policy, which it claims will result in the creation of 604,000 new jobs. These will come from a range of new initiatives, including upgrading the electricity grid, installing community batteries and developing new industries in regional Australia via a Powering the Regions Fund. In addition, the Labor party pledged to fund 10,000 new energy apprentices and develop a \$10 million New Energy Skills Program that will work to ensure that training pathways are fit for purpose.⁴⁴

These policies will help to address growing skills shortages, which Infrastructure Australia has described

as “a public infrastructure workforce crisis”.⁴⁵ Of particular concern for the clean energy industry is a shortage of engineers, electrical line workers, electricians and skilled wind power technicians. The COVID-19 pandemic has had a significant impact on the availability of skilled workers, with both state and international border closures preventing the arrival of much-needed expertise at some renewable energy projects.

In an attempt to address these issues, the Clean Energy Council established the Skills and Training Directorate in 2021. The directorate brings together people from industry and higher education to identify the skills required across the sector and put together tangible and reliable plans to ensure that the supply of skilled resources is aligned with demand.

A significant milestone was achieved in September 2021 when it was announced that renewable energy units within the Electrotechnology Training Package will undergo their first updates in a decade to support the renewable energy workforce having the skills and knowledge needed for the clean energy transition. This will result in the update of training package materials to enable the electrotechnology workforce to develop the necessary skills for installing and maintaining renewable

energy technologies used by domestic and commercial customers.

The industry also looked to address the lack of employment data in the Australian energy sector in 2021. While studies such as the Clean Energy Council’s *Clean Energy at Work* report have provided valuable snapshots of employment statistics in the industry, there has not been a systematic survey of the Australian clean energy sector since 2002. As a result, the Clean Energy Council joined several industry bodies in a joint letter to Federal Minister for Energy and Emissions Reduction Angus Taylor calling on governments to support the establishment of an Australian Energy and Employment Report. This report would survey employment in the traditional, new and renewable energy industries to provide better insights into trends across the entire energy sector and address knowledge gaps.

The next five years will be particularly challenging for the industry as existing skills shortages are likely to be exacerbated by increasing construction in renewable energy zones, competition from other infrastructure projects and the rapid development of the hydrogen sector.

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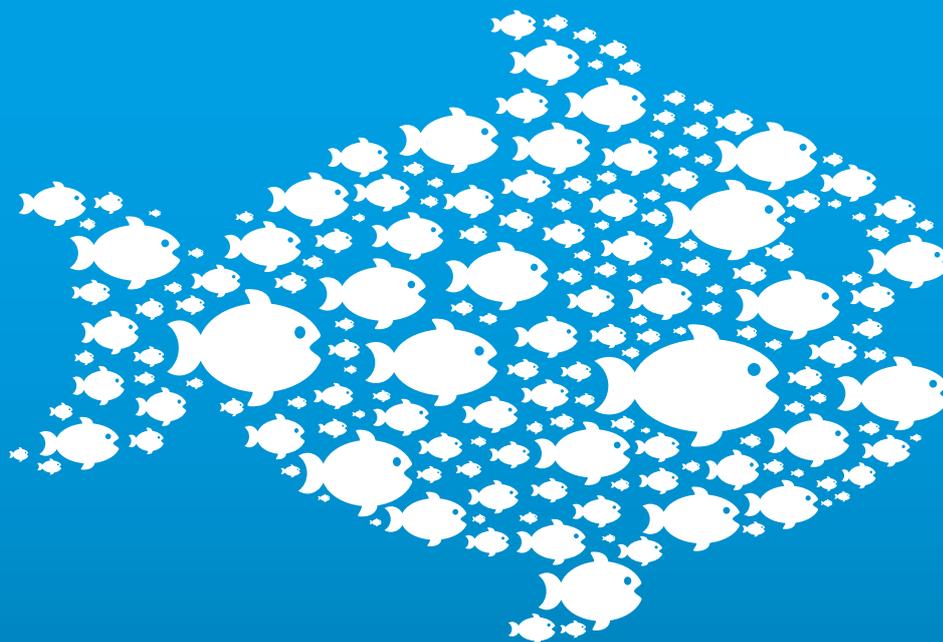
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EMPLOYMENT CONTINUED

CASE STUDY UNDERSTANDING CLEAN ENERGY DIVERSITY THE FIRST STEP TO IMPROVEMENT

Research by the Diversity Council of Australia⁴⁶ has found that diverse and inclusive organisations are three times more likely to be effective, five times more likely to be innovative and three times more likely to provide excellent customer service.

To see whether these benefits apply to the Australian renewable energy industry, the Clean Energy Council joined forces with the Australian Power Institute and the Electrical Trades Union in 2021 to conduct the first-ever survey into diversity within the Australian clean energy workforce. The survey asked respondents to answer questions relating to education, cultural background, age, sexuality and disability to ascertain the professional and social identities that make up the clean energy industry.

The result of the survey was *Empowering Everyone: Diversity*

in the Australian Clean Energy Sector, a report providing a comprehensive snapshot of the demographic makeup of the people that work in the Australian renewable energy industry. The report is a critical addition to the understanding of diversity in the industry that will be used to develop programs and strategies to create a more inclusive and equitable clean energy sector and provide a baseline for improvement in the coming years.

The report is another example of the Clean Energy Council's commitment to achieving greater diversity in the Australian renewable energy industry, which was further bolstered in 2021 with the awarding of the inaugural Chloe Munro Scholarship for Transformational Leadership and the launch of a mentoring program to help women further their careers in the clean energy industry.

FEMALE REPRESENTATION IN THE ENERGY WORKFORCE



39%

Australian clean energy workforce



50%

Australian workforce 2021⁴⁷



32%

Renewables - global⁴⁸



23%

Oil and gas - Australia⁴⁹



22%

Oil and gas - global⁵⁰



16%

Coal - Australia⁵¹

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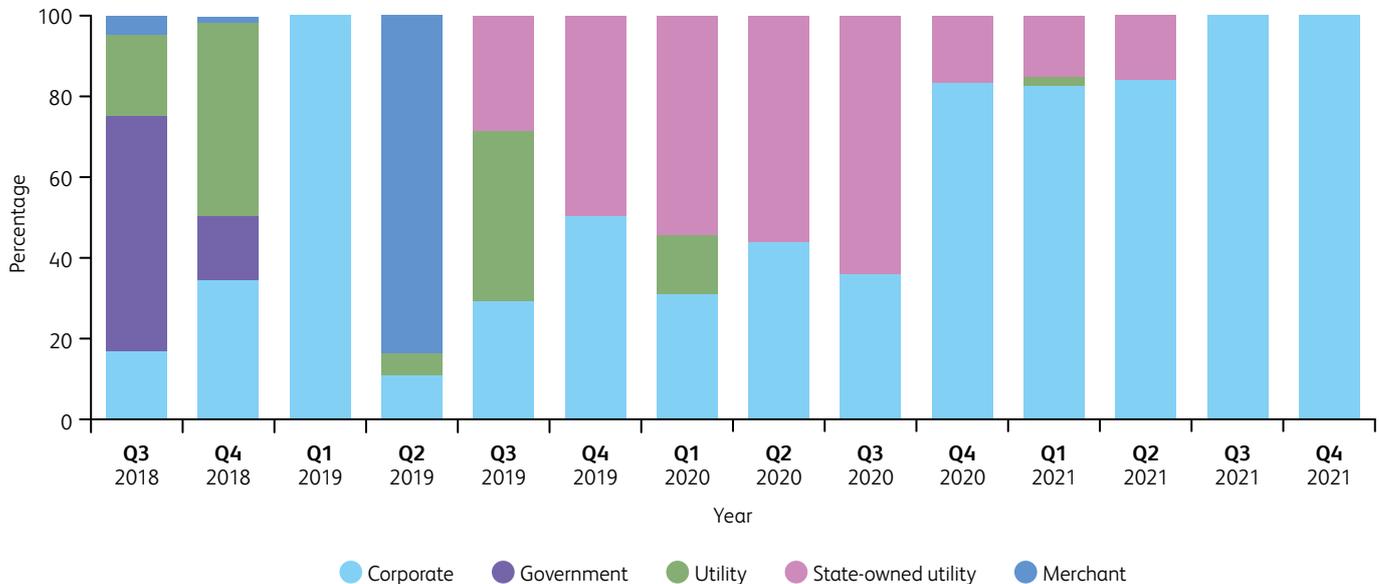


Image: Warwick Solar Farm, Queensland

RENEWABLES FOR BUSINESS

While not reaching the heights of 2020, corporate renewable power purchase agreements (PPAs) had another strong year in 2021. There were 18 corporate renewable PPAs announced in 2021, directly contracting just over 800 MW.

CORPORATE PPA MARKET SEGMENTS, 2018-21⁵²



Since 2017, there have been at least 110 corporate power purchase agreements (PPAs) negotiated, contracting over 4 GW of renewable energy generation.

Some of the noteworthy deals in 2021 included:

- BHP (Olympic Dam): 159 MW with the Port Augusta Renewable Energy Park in South Australia
- Sun Metals: 277 MW with the Macintyre Wind Farm in Queensland
- Victorian Energy Collaboration: a council buyers group negotiated an 80 MW deal with the Dundonell Wind Farm
- Woolworths: 65 MW with the Bango Wind Farm in NSW

- Telstra: 56 MW with the Crookwell 3 Wind Farm in NSW.

For the past two years, corporate PPAs and contracts signed by publicly owned retailers have almost entirely constituted the market for large-scale renewable energy deals.

The PPA market is now being driven by buyers with sustainability goals. In the early years, corporate PPA market growth occurred primarily from buyers seeking relief from electricity price shocks, but the primary catalyst for buyers entering the market now is a net-zero or sustainability target. For the second year running, over 60 per cent of buyers nominated non-price factors as the primary driver for interest in PPAs in the Business Renewables Centre Australia's annual survey.

The corporate PPA market appears to be shifting away from wholesale to retail PPAs. Where in past years there was a bifurcated market with large buyers signing wholesale PPAs directly with projects and mid-sized buyers signing retail PPAs with their retailer as an intermediary, there was a swing amongst large buyers to retail PPAs in 2021. The retail PPA market has continued to develop with a range of offerings for buyers with different goals and risk appetites – from large-scale generation certificate (LGC)-only deals that sit alongside standard retail contracts to fixed-price PPAs through to PPAs with wholesale price exposure.

The corporate PPA market now includes a diversity of buyer and deal sizes with growth at both ends of the market.

Some of the other notable trends in 2021 were:

- The growth of LGC-only PPAs due to discounts on offer for longer-term deals and pressure to achieve net-zero targets.
- Lower investment in new projects, which reflects grid and wholesale headwinds for the industry, the establishment of new renewable energy zones (REZs), and the growth of retail PPAs with smaller buyers that prefer shorter-term contracts with operating projects. For some, the growth in PPAs with operating projects is worrying as a source of investment in new projects, for others it is a positive sign of a new secondary market that will ultimately lead to investment in new projects as retailers make deals to service this demand.

Advisers and developers are generally positive about the impact that REZs will have on corporate renewable PPAs.

There have been questions as to whether REZs might ‘crowd out’ corporate PPAs. However, the market expectation appears to be that they will continue to play a significant role.

The corporate PPA market has proven resilient in 2021. Even amongst the turbulence of the COVID-19 pandemic and lower wholesale electricity market conditions, corporate PPAs have remained a significant source of investment for large-scale renewable energy.

110+

corporate PPAs negotiated since 2017

>4 GW

renewable energy generation supported by corporate PPAs since 2017

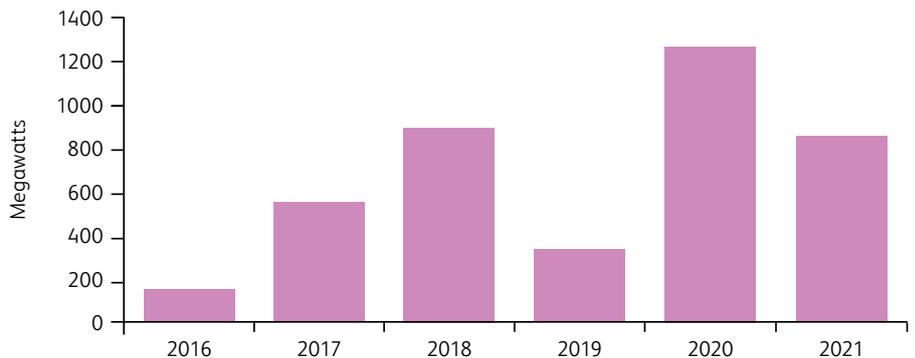
>60%

buyers nominating non-price factors as the primary driver for PPA investment

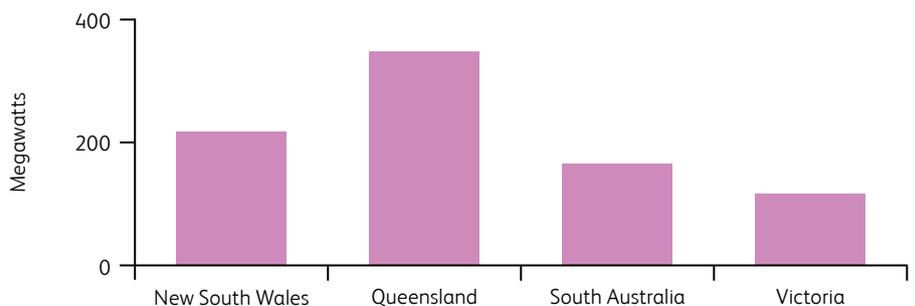
277 MW

size of the PPA signed by Sun Metals with the Macintyre Wind Farm

CORPORATE PPA VOLUMES, 2016–2021⁵²

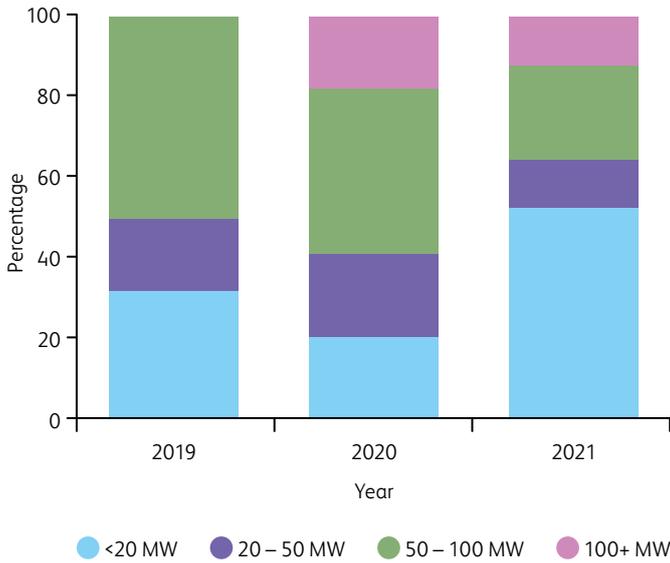


CORPORATE RENEWABLE PPAs BY STATE, 2021⁵²

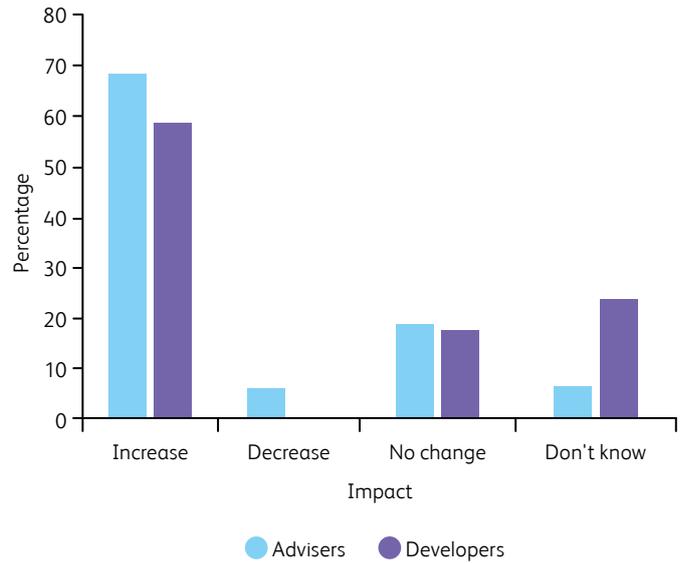


RENEWABLES FOR BUSINESS CONTINUED

CORPORATE PPAs BY SIZE, 2019-21⁵³



IMPACT OF REZs ON CORPORATE RENEWABLE PPAs⁵³



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WHAT'S THE PRIMARY DRIVER FOR YOUR INTEREST IN CORPORATE RENEWABLE PPAS?⁵³



CORPORATE SOCIAL RESPONSIBILITY GOALS

18%
2020

16%
2021



REPUTATION

8%
2020

12%
2021



GREENHOUSE EMISSIONS OR RENEWABLE ENERGY TARGETS

37%
2020

34%
2021



LOWER ELECTRICITY PRICES

12%
2020

13%
2021



ENERGY PRICE CERTAINTY

21%
2020

19%
2021

INTERNATIONAL UPDATE

290 GW

renewable capacity added worldwide in 2021

60%

increase in renewable energy capacity expected between 2020 and 2026

4800 GW

anticipated global renewable capacity by 2026

77%

growth in the electrified transport sector in 2021

Annual renewable energy capacity reached its highest-ever level in 2021 as countries increased their climate ambition ahead of the COP26 summit in Glasgow.

Almost 290 GW of new renewable energy generation capacity was added around the world in 2021, representing a 3 per cent increase on the previous record of 280 GW set in 2020.⁵⁴ Of the new capacity added in 2021, solar accounted for more than half, followed by wind and hydropower.

On the investment front, global spending on renewable energy increased by 6.5 per cent in 2021 to US\$366 billion, which was also a new record for the sector.⁵⁵ China led the way during the year, spending US\$266 billion, followed by the US with US\$114 billion. Countries in the Asia-Pacific region accelerated their spending in 2021, accounting for four of the top 10 biggest spenders on the energy transition in 2021.⁵⁶

Renewable energy capacity is expected to increase by over 60 per cent

between 2020 and 2026 to reach more than 4800 GW, which is equivalent to the current global capacity of fossil fuels and nuclear combined.⁵⁷ This is largely a result of the increased climate ambitions that countries took to the COP26 summit in November.

However, while investment in the clean energy transition has increased by more than 185 per cent over the past decade, investment levels will need to triple to US\$2.1 trillion per year from 2022 to 2025 and then double again to US\$4.2 trillion between 2026 and 2030 if the world is to reach its goal of net-zero emissions by 2050.⁵⁸

While much of this growth will come from the booming electrified transport sector, which grew by 77 per cent in 2021, the energy storage sector is also expected to be a major contributor. A report by the US Department

of Energy's Energy Information Administration found that battery capacity in the US is expected to increase by at least 1000 per cent over the next several years.⁵⁹ This trend will also be seen in Australia, with analysts predicting that total battery capacity will increase more than fivefold to 12.8 GW by 2030.⁶⁰

Global interest in the hydrogen sector also grew in 2021, with 17 countries having adopted national hydrogen strategies by the end of 2021 and more than 20 others actively developing theirs. By mid-2021, the global capacity of electrolyzers for hydrogen production stood at just over 300 MW. However, with a further 350 projects currently under development, global capacity is expected to increase to at least 54 GW by 2030.⁶¹

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ELECTRICITY PRICES

Electricity prices fell to an eight-year low in 2021 as lower wholesale prices due to new wind and solar generation and reduced demand caused by the COVID-19 pandemic began to flow through to consumers.

Retail electricity prices fell to their lowest level since 2013 in 2021, representing annual savings of more than \$275 for residential customers since prices were at their peak. Price reductions have accelerated in recent years, falling by 2 per cent in 2019-20 and 6 per cent in 2020-21 to save customers \$128 on their annual electricity bills in the past two years alone.⁶²

The decline in electricity prices is largely due to a reduction in wholesale prices, which have fallen across the National Electricity Market (NEM) in recent years because of the rapid influx of new wind and solar generation and reduced demand caused by the COVID-19 pandemic. The impact of renewable energy on prices was evident throughout the country in 2021, with wholesale prices averaging negative \$12/MWh during daytime hours in the 2021 March quarter in South Australia⁶³ and \$0.01/MWh during daytime hours in Victoria in August and September.⁶⁴ In total, there were 3662 instances of negative wholesale electricity prices seen across the NEM throughout the year.⁶⁵

However, these remarkable falls in wholesale electricity prices were offset by the increasing unreliability of fossil fuel plants. In May, an explosion at Queensland's Callide coal-fired power plant sent wholesale prices skyrocketing across the NEM, which more than doubled in the June quarter and saw Queensland record its highest-ever June quarterly average of \$141/MWh.⁶⁶ While a one-off incident such as that which occurred at Callide could be written off as a freak occurrence, a report by the Australian Energy Regulator found that there were almost 1000 days of cumulative "baseload outages" in the second quarter of 2021 alone, with almost half of these outages unplanned.⁶⁷

In good news for consumers and businesses, the falling price trends of recent years are expected to continue into 2022. According to the Australian Energy Market Commission, annual electricity bills are forecast to fall by 5.7 per cent between 2021 and 2024, representing a saving of \$77 for Australian households.⁶⁸ This will

primarily be due to further declines in wholesale electricity prices as more renewable energy generation comes online and retailers continue to adjust their market offers to match the rapid reductions in wholesale prices.

While electricity price reductions of up to 10 per cent will be seen across the NEM states, electricity prices in the ACT will rise over the next three years. This is due to a decision by the ACT's Independent Competition and Regulatory Commission to increase power bills by almost \$200 per year⁶⁹ to account for a 133 per cent increase in feed-in tariff payments to large-scale wind and solar generators. Ironically, this was due to a significant fall in wholesale prices caused by the COVID-19 pandemic.⁷⁰ However, there is some slight relief for ACT consumers on the horizon, with prices expected to fall back to \$2081 per year in 2023/24 after rising to \$2226 in the 2022/23 financial year.⁷¹

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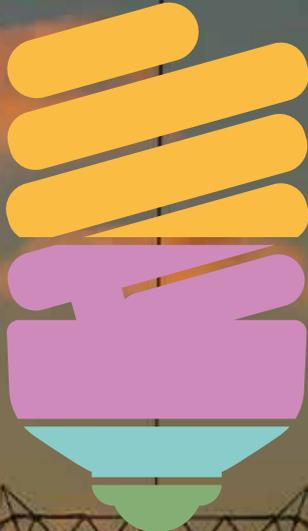
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71 Australian Energy Market Commission, *Residential electricity price trends 2021 - final report*, 25 November 2021, aemc.gov.au/sites/default/files/2021-11/2021_residential_electricity_price_trends_report.pdf

72 Ibid.

73 Ibid.

WHAT MAKES UP YOUR POWER BILL, 2020-21⁷²



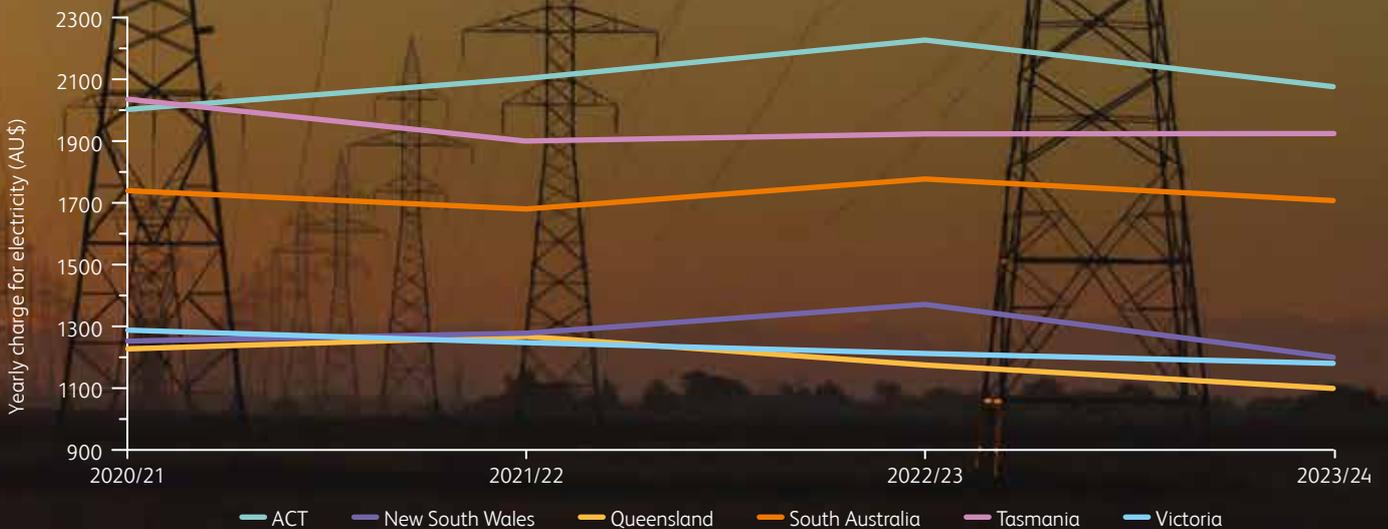
\$603
poles and wires

\$467
generating electricity

\$150
electricity company costs

\$122
environmental costs

EXPECTED RESIDENTIAL ELECTRICITY PRICES, 2020-24⁷³



Note: Western Australia and the Northern Territory were not included in the AEMC's 2021 analysis due to accurate data not being available.

TRANSMISSION

10,000 km

transmission needed to connect consumers with diverse generation sources

\$29 B

net benefit of projects identified by AEMO within the optimal development path

9x

increase in utility-scale renewable energy needed by 2050

Things kicked up a gear in the transmission space in 2021, both in terms of large transmission projects reaching major milestones as well as significant developments in the regulatory space that will shape things to come for many years.

Project EnergyConnect (PEC) reached a major milestone in May 2021, with the new 330 kV interconnector obtaining final regulatory approval from the Australian Energy Regulator. PEC is the first major new AC interconnector to be constructed in the National Electricity Market (NEM) since the Queensland–NSW Interconnector commenced operation in 2001. The 900 km asset is expected to be completed by 2025/26 and will significantly enhance the ability to share renewable energy between South Australia and New South Wales.

The difficulties in getting PEC approved highlighted the importance of reassessing the regulatory frameworks that support new transmission investment. The Australian Energy Market Commission commenced work on its Transmission Planning and Investment Review in August 2021, which will consider reforms to the existing regulatory frameworks to deliver timely and efficient delivery of transmission services.

Also on the regulatory front, 2021 saw the Australian Energy Market Operator (AEMO) publish the third of its biennial Integrated System Plans (ISP). The draft ISP was published in December 2021 and represented a step change in terms of the ambition of its forecasts.

AEMO identified that, as part of its main forecast for the NEM out to 2050, significant investment was needed to:

- drive a ninefold increase in utility-scale renewable energy capacity, most of this built in coordinated renewable energy zones (REZs)
- treble the firming capacity that can respond to a dispatch signal, including utility-scale batteries and pumped hydro storage, to manage the rapid exit of thermal coal generation – noting that there is the potential for 14 GW of thermal coal capacity to exit by 2030.

AEMO's forecast also identified the need for more than 10,000 km of new transmission to be built to connect geographically and technologically diverse low-cost generation and firming with consumers. The transmission projects identified by AEMO within the optimal development path were found to deliver \$29 billion in net market benefits.

Importantly, AEMO built into this optimal development path a degree of flexibility, recognising the economic benefits of going early with transmission build as opposed to a just-in-time approach. This takes the form of the staging of several major transmission projects, including VNI

West and Humelink, both of which are recognised as critical to supporting NEM decarbonisation.

Specifically, AEMO identified the following projects as actionable:

- New England REZ Transmission Link, to be delivered by July 2027
- Sydney ring reinforcing, to be delivered by July 2027
- Humelink, with early works in 2024 and an implementation target of 2026
- Marinus Link, with Cable 1 to be delivered by July 2029 and Cable 2 by July 2031
- VNI West, with early works in 2026 and an implementation target of July 2031.

2021 also saw the continued integration of battery storage with transmission. The concept of 'virtual transmission' gained traction with the development of the Victorian Big Battery, a 300 MW/450 MWh Tesla battery built by Neoen located outside of Geelong. The battery is contracted to provide a 250 MW reserve during the summer months and is capable of discharging at full output for 30 minutes, which allows AEMO to increase flows between NSW and Victoria.



Image: Murra Warra Wind Farm, Victoria

This clever utilisation of the rapid speed and versatility of battery storage technologies provides a glimpse of the way that transmission and storage assets will be co-optimised in future to deliver a secure and lower cost supply of energy to customers.

Other major developments included the declaration of the Central West Orana (CWO) REZ by the NSW Government in November 2021. Part of the NSW Electricity Infrastructure Roadmap, the CWO REZ is the first of several developments being progressed by the NSW Government, with the target of delivering 10,000 MW of renewable generation to NSW customers. Key transmission assets will be constructed to enable the REZ, including dedicated lines in the Central West and New England areas.

The NSW Government undertook extensive consultation throughout 2021 to develop the detailed policy that will underpin investment in the REZ. Working closely with industry, the NSW Department of Planning, Industry and Energy has established new frameworks for managing access, reducing investment risk, delivering critical system services and connecting new generators. Work will continue on this throughout 2022, with physical construction of the CWO REZ expected to commence by the end of the year.

CASE STUDY GRID CONNECTION BOTTLENECKS SET TO CLEAR AS INDUSTRY TAKES THE INITIATIVE

Since July 2018, the Clean Energy Council has conducted the Clean Energy Outlook Confidence Index, a bi-annual survey of senior leaders from across the clean energy industry that measures investment confidence, employment trends and the industry's major business challenges. While investment confidence and employment metrics have fluctuated widely over the years, a constant in every survey has been that challenges relating to the grid connection process have been rated the most critical business challenge for renewable energy project proponents.

To address concerns with the delays and the increasing complexity of grid connections, the Clean Energy Council and the Australian Energy Market Operator brought together our members, network service providers and other industry stakeholders in early 2020 to form the Connections Reform Initiative (CRI).

Working throughout 2021 and featuring many of the industry's most senior decision makers, the CRI explored a range of solutions

to address the systemic concerns involving all parties in the connection process to ensure that the system can safely and securely take on the high number of large-scale renewable energy projects that are and will continue to register to connect to Australia's power systems.

This significant project culminated in the release of the Connections Reform Roadmap in December 2021, which provides a series of recommendations to help speed up the connection process, lower the cost of connection, improve hosting capacity and system strength, and allow for firmer connection process timeframes. Implementation work on several of these recommendations has already begun, with further reform work to continue throughout 2022.

After years of frustration that has slowed the deployment of new clean energy generation, deterred investment in the sector and cost project proponents millions of dollars, the bottlenecks that have plagued the grid connection process for so long may finally be cleared.

ENERGY RELIABILITY

Renewable energy stepped up to ensure the reliability of the electricity system in 2021 following several major outages at ageing fossil fuel generators. With clean energy's role in Australia's energy future now assured, focus is shifting to maintaining reliability as more renewable energy is integrated into the system.

The biggest issue affecting reliability in 2021 was an incident at the Callide coal-fired power station in Queensland on 25 May. An explosion and subsequent fire at the plant, which is one of the newest in Australia, cut off power to more than 400,000 Queensland homes and businesses and sent prices skyrocketing to the maximum of \$15,000/MWh.⁷⁴ Several renewable energy assets stepped in to stabilise the electricity system during the crisis, with the Wivenhoe pumped hydro facility generating 530 MW over a four-hour period to help meet demand⁷⁵ and the battery at the Hornsdale Power Reserve providing invaluable synthetic inertia services.⁷⁶

This was just one of several major outages at coal-fired power stations throughout the year, with sudden shutdowns at Victoria's Yallourn and Loy Yang A power stations in January⁷⁷ and almost 1000 days of cumulative "baseload outages" in the second quarter of 2021⁷⁸ serving as further examples of the increasing vulnerability of Australia's ageing coal-fired power fleet.

However, the growing penetration of renewable energy means that the threat caused by such sudden

outages to the stability of the entire electricity system has significantly diminished. This was reinforced by the Australian Energy Market Operator's (AEMO) 2021 Electricity Statement of Opportunities, which forecast that there would be no reliability gaps in the next five years and that any gaps in the subsequent five years would be met by planned renewable energy generation and storage.⁷⁹ This positive outlook for reliability comes despite the retirement of several fossil fuel plants over the period, including the Liddell coal-fired power plant in 2023, the Eraring power station in 2025 and the Yallourn power station in 2028.⁸⁰

In fact, the acceleration of Australia's clean energy transition in recent years is forcing energy market bodies to plan for the continued influx of renewable energy generation rather than the exit of fossil fuel plants when considering the reliability of the electricity system. In July, AEMO stated that it was already working to ensure that the electricity system would be capable of handling periods of 100 per cent renewable energy generation by 2025.⁸¹ While this may still seem some way off considering that Australia only got 32.5 per cent of its electricity from renewables in 2021, the experience

of South Australia, which regularly experienced periods of 100 per cent renewable generation in 2021 without any impact on reliability, shows that such a landmark achievement is not too far from reality.

The phenomenal uptake of rooftop solar has also begun to have an impact on the reliability of the electricity system, with authorities in some parts of Australia introducing measures such as export limits and remote disconnection in 2021 to ensure the stability of the network. The Australian Energy Market Commission also worked on this issue in 2021, releasing a rule change that recommended giving distribution networks the ability to charge rooftop solar customers to export power to the grid. This would fundamentally change the value proposition of rooftop solar, but if its implementation is well managed and completed in conjunction with reforms proposed by the Energy Security Board to create a more reciprocal two-way market between rooftop solar owners and electricity providers, it could have significant benefits for both consumers and the ongoing reliability of Australia's increasingly renewable energy system.

CASE STUDY CAMPAIGNING FOR A RENEWABLE FUTURE



If you watched any free-to-air TV, catch-up TV or online video last year, there's a fair chance you would have heard the phrase "yeah, but" a few times. This was the catchphrase in a series of advertisements launched by the Clean Energy Council in 2021 as part of the Australian renewable energy industry's first-ever national campaign to promote the benefits of clean energy.

Called *Renewable Energy is Here Now*, the campaign was designed to ease the doubts that cautious Australians have about clean energy by informing them of the remarkable gains that the industry has already made and convincing them that a future powered by 100 per cent clean energy is not only possible, but that the transition is already underway and will benefit us all in day-to-day life as well as the planet.

Such a campaign was necessary to counter the political and media attacks over the past decade that have resulted in negative perceptions of renewable energy around reliability and cost being grossly exaggerated, while cost savings, employment opportunities and climate benefits have been ignored.

The campaign, which also featured on billboards around the country, was seen more than 4.5 million times by everyday Australians in 2021, creating a groundswell of popular support that will hopefully empower our leaders to remove roadblocks and get serious about accelerating the clean energy transition.

Renewable Energy is Here Now is an exciting new phase for the Australian renewable energy industry. For the first time, it projected the industry into the lives of everyday Australians, promoting the remarkable gains already made and the unprecedented opportunities that lie ahead. The hope is that this will permanently shift the narrative surrounding Australia's energy transition and further accelerate the country towards a clean energy future.

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TECHNOLOGY PROFILES

Several renewable energy technologies experienced record years in 2021, with the small-scale solar and wind sectors recording their fifth- and third-straight record-breaking years respectively. The large-scale solar sector also had a strong year in 2021, bouncing back to add more than a gigawatt of new capacity.

The importance of hydropower was underlined by its role in stabilising the

grid after major outages throughout the year, while the bioenergy sector continued to make a meaningful contribution to the country's clean energy generation.

The emergence of the battery storage and hydrogen sectors also accelerated in 2021, with Australia's largest battery coming online during the year and more than 100 hydrogen projects worth \$163 billion under development.



Image: Warwick Solar Farm, Queensland



BATTERY STORAGE



The battery storage sector continued to make steady progress in 2021, with the commissioning of the Victorian Big Battery a headline achievement. Continued strong interest in both large-scale and household batteries means that the sector is poised to expand exponentially in the coming years.

The commissioning of the 300 MW/450 MWh Victorian Big Battery in December 2021 was a significant milestone for battery storage in Australia. Not only is the battery the country's largest – and one of the largest in the world – the range of services that it can deliver provides a snapshot of the crucial role that batteries will play in our clean energy future.

In addition to storing and discharging electricity when needed

and providing vital system strength services to the electricity grid, the Victorian Big Battery operates as a virtual transmission line during the summer months, enabling an additional 250 MW of electricity to flow through the Victoria–New South Wales Interconnector. This helps to ensure supply during periods of peak demand and offers a cheaper alternative to costly network upgrades. The use of large-scale batteries as virtual transmission is

expected to increase in the coming years, with the Australian Energy Market Operator signalling its intention to embrace the concept in its draft 2022 Integrated System Plan.⁸²

Thirty large-scale batteries were under construction at the end of 2021 with a combined capacity and storage duration of 921 MW/1169 MWh. Of these, the two largest are the 250 MW/250 MWh Torrens Island

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30

large-scale batteries under construction at the end of 2021

921 MW

combined capacity of large-scale batteries currently under construction

34,731

small-scale household batteries installed throughout 2021

Battery in South Australia and the 150 MW/150 MWh Hazelwood Battery Energy Storage System in Victoria. Interestingly, both will be located at former fossil fuel power stations, utilising the existing transmission links to provide power into the grid.

A number of other significant battery announcements were made throughout 2021, including Origin's plan to build a 700 MW/2400 MWh battery at its Eraring coal-fired power

plant in NSW, Neoen's proposal for a 500 MW/1000 MWh battery to be located west of Sydney and EnergyAustralia's plan to build a 350MW/1400 MWh battery at Victoria's Yallourn coal-fired power station.⁸³

The ACT Government announced plans for a different type of battery installation in 2021, proposing to build a 250 MW network of distributed batteries located across the territory that will be able to

be coordinated and operated as if they are a single big battery. The distributed battery system would be used to increase network reliability, better integrate the increasing supply of renewable energy and reduce electricity price spikes.⁸⁴

The battery sector suffered a setback of sorts in 2021 when a rule change by the Australian Energy Market Commission ignored a recommendation by the Australian Energy Market Operator to exempt

TECHNOLOGY PROFILES
BATTERY STORAGE (CONTINUED)

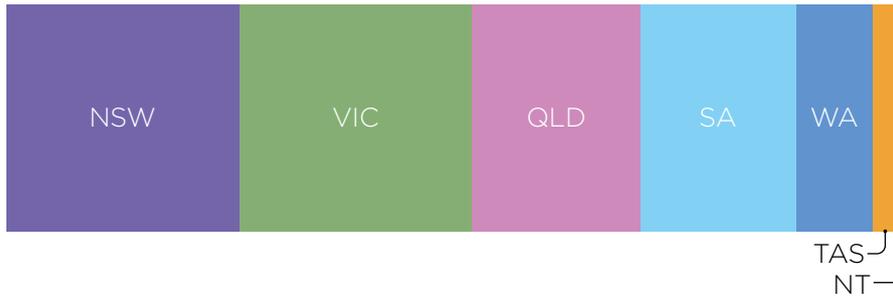
batteries from network charges when charging. The new rule could result in energy storage providers and consumers paying twice for network charges and affect the viability of new projects. It also places batteries at a commercial disadvantage to coal and gas generators, which aren't required to pay network charges.⁸⁵

The small-scale battery segment continued to build steadily in 2021, with approximately 34,731 household batteries with a combined capacity of 347 MWh installed during the year. This was a strong increase on the

23,796 batteries that were installed in 2020 as households took advantage of falling battery prices.

Victoria and New South Wales saw the most household battery installations in 2021 with 9000, followed by Queensland with 6500 and South Australia with 6000. Unsurprisingly, most of these states have government-backed household battery programs, highlighting the sector's continued need for additional support to drive uptake.

NUMBER OF SMALL-SCALE BATTERIES INSTALLED IN 2021 (ESTIMATE)⁸⁶



State	Systems	Capacity (MWh)
NSW	9000	90
VIC	9000	90
QLD	6500	65
SA	6000	60
WA	3000	30
TAS	900	9
NT	331	3
TOTAL	34,731	347

* Note: Due to the lack of a universal national government support program covering batteries, data on installation numbers is incomplete and highly uncertain.

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Image: Victorian Big Battery, Victoria

TECHNOLOGY PROFILES
BATTERY STORAGE (CONTINUED)

UTILITY-SCALE BATTERY SYSTEMS UNDER CONSTRUCTION AT THE END OF 2021⁸⁷

STATE	PROJECT	OWNER	LOCALITY	SIZE
SA	Torrens Island Battery	AGL	Torrens Island	250 MW/250 MWh
VIC	Hazelwood Battery Energy Storage System	Engie	Hazelwood	150 MW/150 MWh
ACT	Capital Battery	Neoen	Jerrabomberra	100 MW/200 MWh
WA	Perth (Kwinana) Big Battery	Synergy	Kwinana	100 MW/200 MWh
NSW	Wallgrove Grid Battery	Transgrid	Wallgrove	52 MW/78 MWh
NSW	New England Solar Farm	UPC/AC Renewables	Uralla	50 MW/50 MWh
WA	Koodaideri Mine Solar Farm	Rio Tinto	Newman	45 MW/12 MWh
WA	Pilbara Project Energy Connect Battery Energy Storage System	Fortescue Metals	Chichester	42 MW/13 MWh
NT	Darwin-Katherine Battery Energy Storage System	Territory Generation	Darwin	35 MW/20 MWh
VIC	Bulgana Green Power Hub	Neoen	Joel South	20 MW/34 MWh
WA	BHP Leinster Nickel Mine	TransAlta Southern Cross Energy	Mount Keith	10 MW/5 MWh
SA	Adelaide Desalination Plant Solar Farm Stage 1	SA Water	Adelaide	6 MW/12 MWh
NT	Katherine Solar Power Station	Eni Australia	Cossack	6 MW/3 MWh
VIC	West Gippsland Battery	E22	Longwarry	5 MW/8 MWh
WA	Gold Fields Gruyere Mine Microgrid	APA Group	Cosmo Newbery	4 MW/4 MWh
NSW	Narellan Shopping Centre Solar Project	CEP.Energy	Narellan	4 MW/10 MWh
VIC	Mortlake South Wind Farm	ACCIONA	Kolora	5 MW
QLD	Black River Substation	Energy Queensland	Townsville	4 MW/8 MWh
QLD	Tanby Substation	Energy Queensland	Yeppoon	4 MW/8 MWh
QLD	Bargara Substation	Energy Queensland	Bundaberg	4 MW/8 MWh
QLD	Torquay Substation	Energy Queensland	Hervey Bay	4 MW/8 MWh
QLD	Torrington Substation	Energy Queensland	Toowoomba	4 MW/8 MWh
SA	Happy Valley Reservoir	SA Water	Happy Valley	4 MW/10 MWh
SA	Ikea Adelaide Battery System	Epic Energy	Adelaide Airport	3 MWh
VIC	RayGen Power Plant	Raygen Resources	Carwarp	3 MW/50 MWh
NT	Jabiru Hybrid Renewable Project	EDL	Jabiru	3 MW/5 MWh
QLD	Dalby Solar Farm - Stage 1	Fotowatio Renewable Ventures	Dalby	3 MW/5 MWh
QLD	Kennedy Energy Park	Windlab	Hughenden	2 MW/4 MWh
WA	Garden Island Microgrid	Carnegie Clean Energy	Garden Island	2 MW/1 MWh
SA	Aldinga Wastewater Treatment Plant Reserve	SA Water	Aldinga	1 MW/1 MWh

CASE STUDY

BATTERIES PEAKING EARLY IN AUSTRALIA'S CLEAN ENERGY RACE

The rapid emergence of utility-scale battery storage in recent years has led to a reimagining of how electricity grids can be operated. Not only can batteries be used to meet demand when output from wind and solar dips, but they have also been used to provide vital frequency control and ancillary services, synthetic inertia and virtual transmission. And thanks to a study released by the Clean Energy Council in 2021, peaking services can now be added to the growing list of services that batteries can provide.

The study, *Battery Storage: The New, Clean Peaker*, compared a new 250 MW

gas peaker with a new 250 MW four-hour grid-scale battery, finding that large-scale battery storage is already a far superior choice than gas for electricity peaking services, based on cost, flexibility, services to the network and emissions.

On cost, a four-hour battery provides cost savings of more than 30 per cent on a levelised cost of energy basis and capital costs are 25 per cent cheaper than for a gas peaker. In addition, batteries provide a superior peaking service compared to gas, offering a faster ramp rate, higher accuracy and better-quality frequency response.

The advantages of using battery storage for peaking services will only grow in the coming years as their cost continues to fall due to technological advances and increased economies of scale and the risks to gas power plants, such as rising gas prices and emissions reduction initiatives, steadily grow.

Given the considerable advantages of battery storage, their use for electricity peaking services is a no-brainer that will reduce energy bills and improve reliability while accelerating Australia's transition to a clean energy future.

Powerful thinking is reshaping the way we power regional WA

By always thinking about how we can create new energy solutions in some of the toughest environments on earth.

It's this type of thinking that's seen us create Australia's first green hydrogen plant in Denham; successfully power Onslow with 100% renewable energy in a demonstration of advanced microgrid technology, and also create renewable energy storage solutions for some of WA's most remote regional towns.

Just think what we could do together.



horizonpower.com.au/powerfulthoughts

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*Owned by the
people of WA*

**HORIZON
POWER**



Bioenergy delivers numerous benefits and can help overcome a range of challenges in Australia, including employment and economic development in regional communities, enhancing energy and fuel security, waste minimisation and emissions reduction.

3187 GWh

Australia's total bioenergy generation in 2021

26,200

full-time jobs created by the Federal Government's Bioenergy Roadmap

\$33.5 M

ARENA funding to support Australia's bioenergy sector

The release of Australia's Bioenergy Roadmap by Minister for Energy and Emissions Reduction Angus Taylor, the first of its kind in Australia and a record commitment from the Australian Government to bioenergy, was a significant milestone in 2021. Developed by the Australian Renewable Energy Agency (ARENA) on behalf of the Australian Government, the investment

signifies the validity and value of the Australian bioenergy industry going forward.

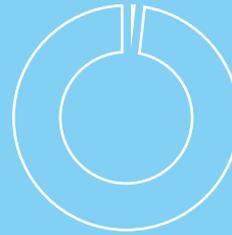
The roadmap includes new analysis that confirms the adoption of key technologies which would see \$10 billion added to Australia's GDP by 2030 and 26,200 full-time jobs created, mostly in regional areas, as well as confirming that bioenergy has the potential to provide up to

40 per cent of Australia's total energy consumption by the 2050s.

The roadmap has elevated the highest ranked market opportunities and highlighted that the industry and government's focus must be on expanding bioenergy's market share in hard-to-abate sectors such as renewable industrial heat generation, sustainable aviation fuels and biomethane grid injection.



4.3%
of total clean energy
generated in Australia
in 2021



1.4%
of total Australian
electricity generated
in 2021

Significant emissions reductions, fuel security and waste reduction are identified as key outcomes of increased bioenergy usage that will create a better future for Australia.

To support the implementation of the roadmap, the government has committed \$33.5 million to ARENA to further support Australia’s bioenergy sector through co-funding additional research and the development and deployment of advanced sustainable aviation and marine biofuels.

Throughout 2021, the bioenergy industry worked closely with the Clean Energy Regulator to develop an Emissions Reduction Fund method for biomethane.

Biomethane projects can earn carbon credits for reduction in emissions when:

- biogas is captured, upgraded to biomethane and combusted
- biomethane is used in place of natural gas.

The draft biomethane method package builds on existing waste methods by including biomethane project activities. This increases the opportunities to deliver abatement and create Australian Carbon Credit Units.

The level of interest and development of bioenergy projects has only accelerated in 2021, and it is anticipated that this trajectory will continue with increased engagement from both local and international industry players.

Other significant bioenergy initiatives that were announced or delivered in 2021 include:

- Qantas announced its first major purchase of green jet fuel as a result of corporate customers such as professional services firms offering to pay extra for more sustainable flying options
- Optimal Group and BOC explored the development of Australia’s first bioLNG facility at the BOC Westbury micro-LNG Plant in Westbury, Tasmania
- two state-of-the-art bioethanol-fuelled buses hit the road in Mackay, Queensland
- Yarra Valley Water continued work on a waste to energy facility in Lilydale, Victoria, with construction scheduled to begin in late 2022
- MicroBioGen successfully demonstrated the production of both high-protein food and low-carbon bioethanol from non-food material using a single biological agent
- ARENA committed \$3.9 million to Renergi Pty Ltd for the development of the next phase of its energy from waste technology in Western Australia.

BIOENERGY PRODUCTION BY STATE, 2021⁸⁸



State	GWh
QLD	1114
NSW	1072
VIC	713
WA	144
SA	116
TAS	29
TOTAL	3187

HYDRO AND PUMPED HYDRO



While hydro's contribution to Australia's total renewable generation fell again in 2021, recognition of the technology's importance to the clean energy transition continues to grow.

10%

annual increase in hydro generation in 2021

The hydro sector generated 16,128 GWh of clean electricity in 2021, which was a 10.2 per cent increase compared to 2020. This resulted in hydro's contribution to Australia's total electricity generation increasing to 7.0 per cent in 2021, up from 6.4 per cent the previous year. However, the technology's contribution to Australia's renewable generation fell from 23.3 per cent in 2020 to 21.6 per cent in 2021 as substantial amounts of new wind and solar generation entered the market.

The continued importance of hydro was highlighted in May when an explosion at the Callide coal-fired power station in Queensland resulted in a significant disruption to the electricity system. In the immediate aftermath of the incident, the Wivenhoe pumped hydro facility quickly ramped up to meet a significant proportion of the unmet demand, generating 530 MW over a four-hour period.⁸⁹ This served as a

2000 MW

capacity of Snowy 2.0 project

timely reminder of the unique ability of hydro to offer important system security services and rapidly provide for unmet demand.

The two major hydro projects currently under construction in Australia – Snowy 2.0 and the Kidston Pumped Storage Hydro Project – reached significant milestones in 2021. Tunnelling began on the 2000 MW/350,000 MWh Snowy 2.0 project in mid-2021, with more than 1 km of the project's main access tunnel excavated by the end of 2021.⁹⁰ The project also launched its precast factory in October, which will produce the 130,000 concrete segments that will line the tunnels of the project.⁹¹ Snowy 2.0 is on schedule to begin providing power in 2025, with full completion of the project expected in 2026.

Work on the Kidston Pumped Storage Hydro Project started in June after project developer Genex announced that it had secured financing for the project.⁹² The innovative

1 GW

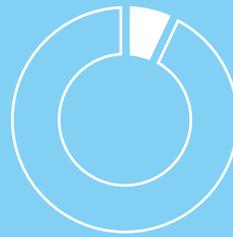
size of a proposed new pumped hydro project at the Borumba Dam in Queensland

250 MW/2000 MWh project, which will pump water between two disused goldmines in the central Queensland town of Kidston, will get its power from a co-located 50 MW large-scale solar farm, with plans to expand this capacity with a second 270 MW solar farm and a 150 MW wind farm. The Kidston project is expected to be completed by 2024.

The Kidston project is just the fourth pumped hydro project to be constructed in Australia, and the first in several decades,⁹³ but this could soon change. In June, the Queensland Government committed \$22 million for a detailed design and cost analysis of a 1 GW pumped hydro project at the Borumba Dam near Gympie,⁹⁴ while the NSW Government announced in July that it was looking to develop a 3 GW pipeline of new pumped hydro projects by providing \$50 million grants to fund early studies into new projects.⁹⁵



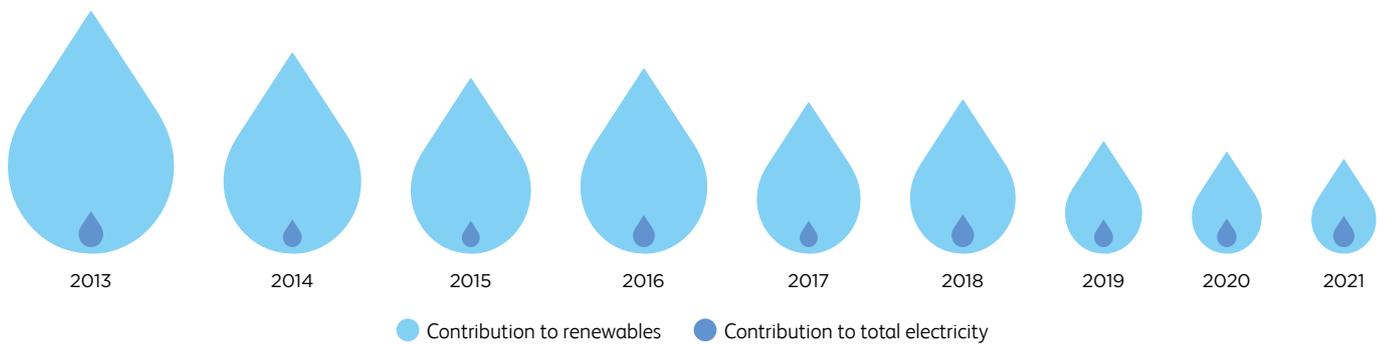
21.6%
of total clean energy
generated in Australia
in 2021



7.0%
of total Australian
electricity generated
in 2021

HYDROPOWER'S CONTRIBUTION TO AUSTRALIAN ELECTRICITY GENERATION⁹⁶

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%
2017	13,331	34.6%	5.9%
2018	17,002	35.2%	7.5%
2019	14,166	25.7%	6.2%
2020	14,638	23.3%	6.4%
2021	16,128	21.6%	7.0%



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HYDRO AND PUMPED HYDRO (CONTINUED)

CASE STUDY

OLD IS NEW AGAIN AS HYDROPOWER RAMPS UP TO PLAY A KEY ROLE IN A CLEAN ENERGY FUTURE

In its 2020 Integrated System Plan, the Australian Energy Market Operator (AEMO) forecast that up to 50 GW of large-scale renewable generation will be needed by 2040 to replace retiring coal-fired power stations. Integrating this massive influx of new renewable generation will be a significant

challenge, with AEMO estimating that it will take up to 19 GW of new dispatchable resources to ensure the continued stability of the electricity system.

However, with batteries not yet able to economically provide the necessary

storage duration and the hydrogen sector not developed enough to provide megawatt-scale energy generation, much of the burden of supporting Australia's renewable energy transition will fall on one of the oldest forms of clean energy – hydropower.





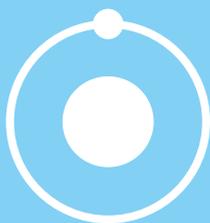
A report released by the Clean Energy Council in 2021, *Hydropower: The Backbone of a Reliable Renewable Energy System*, shows that the hydropower industry is very well placed to meet this challenge.

For more than 100 years, hydropower has been the backbone of the Australian power system, providing a low-cost and dependable supply

of energy as well as a wide range of crucial system services. As the proportion of renewable energy generation increases, hydropower will play an important role by replacing the system security services traditionally provided by fossil fuel generation, responding to prolonged periods of low wind and solar output, and helping to avoid costly curtailment of wind and

solar energy by storing excess energy for later use.

With the proper support and market mechanisms, a technology that has already provided generations of Australians with clean, reliable energy will play a crucial role in our energy future, acting as the final piece of the puzzle in the complete decarbonisation of Australia's electricity system.



Governments and businesses continued to strongly back the hydrogen industry in 2021, with more than 100 projects worth \$163 billion under development at the end of the year.

The biggest commitment to the hydrogen industry in 2021 came through the Federal Government's Clean Hydrogen Industrial Hubs Program. The \$464 million program has designated seven regions in Australia for the construction of hydrogen hubs, where hydrogen users, producers and potential exporters will be concentrated to create economies of scale.

The Australian Renewable Energy Agency made its first foray into hydrogen in 2021 when it allocated more than \$100 million to three renewable hydrogen pilot projects that will produce hydrogen for export and blending into existing natural gas pipelines.⁹⁷ The Clean Energy Finance Corporation also made its first hydrogen investment in 2021, providing \$12.5 million to a project that will produce renewable hydrogen to power the world's heaviest fuel cell trucks.⁹⁸

The other major federal initiative in 2021 was the establishment of a Guarantee of Origin scheme for hydrogen. The scheme will allow

hydrogen customers to determine the emissions associated with the hydrogen they are buying and the source and type of technology used to manufacture it, providing assurance that the hydrogen they are purchasing comes from 100 per cent renewable sources.

The most notable announcement at the state level in 2021 was the release of the NSW Government's Hydrogen Strategy. The strategy will provide up to \$3 billion in support for the hydrogen industry in NSW by waiving government charges on renewable hydrogen production, providing exemptions to network charges and investing \$70 million in hydrogen hubs.⁹⁹ Other major state announcements included the Queensland Government increasing its renewable energy fund to \$2 billion to include hydrogen projects¹⁰⁰ and the WA Government providing up to \$118 million to support the creation of two hydrogen hubs.¹⁰¹

Private sector investment in hydrogen increased dramatically in 2021, with iron ore magnate Andrew Forrest leading

the charge. Through the newly created Fortescue Future Industries, Forrest made several major announcements during the year, including a commitment to invest 10 per cent of the Fortescue Metals Group's profits into renewable energy and hydrogen¹⁰², a proposal to build a \$1 billion renewable hydrogen power station in NSW¹⁰³ and plans to construct a 250 MW renewable hydrogen production facility in Tasmania.¹⁰⁴

Other major hydrogen announcements made by the private sector in 2021 included a proposed 8 GW renewable hydrogen facility in WA to be built by Total Eren and Province Resources,¹⁰⁵ a 200 MW solar to hydrogen plant in Queensland by Eco Energy World that will produce 33,000 tonnes of renewable hydrogen¹⁰⁶, and a proposal by a consortium of leading energy businesses to build a \$2 billion "hydrogen valley" in NSW.¹⁰⁷

97 M Ludlow and A Macdonald-Smith, The Australia Financial Review, *ARENA tips \$100m into three hydrogen projects*, 5 May 2021, [afr.com/companies/energy/arena-tips-100m-into-three-hydrogen-projects-20210504-p57otr](https://www.afr.com/companies/energy/arena-tips-100m-into-three-hydrogen-projects-20210504-p57otr)

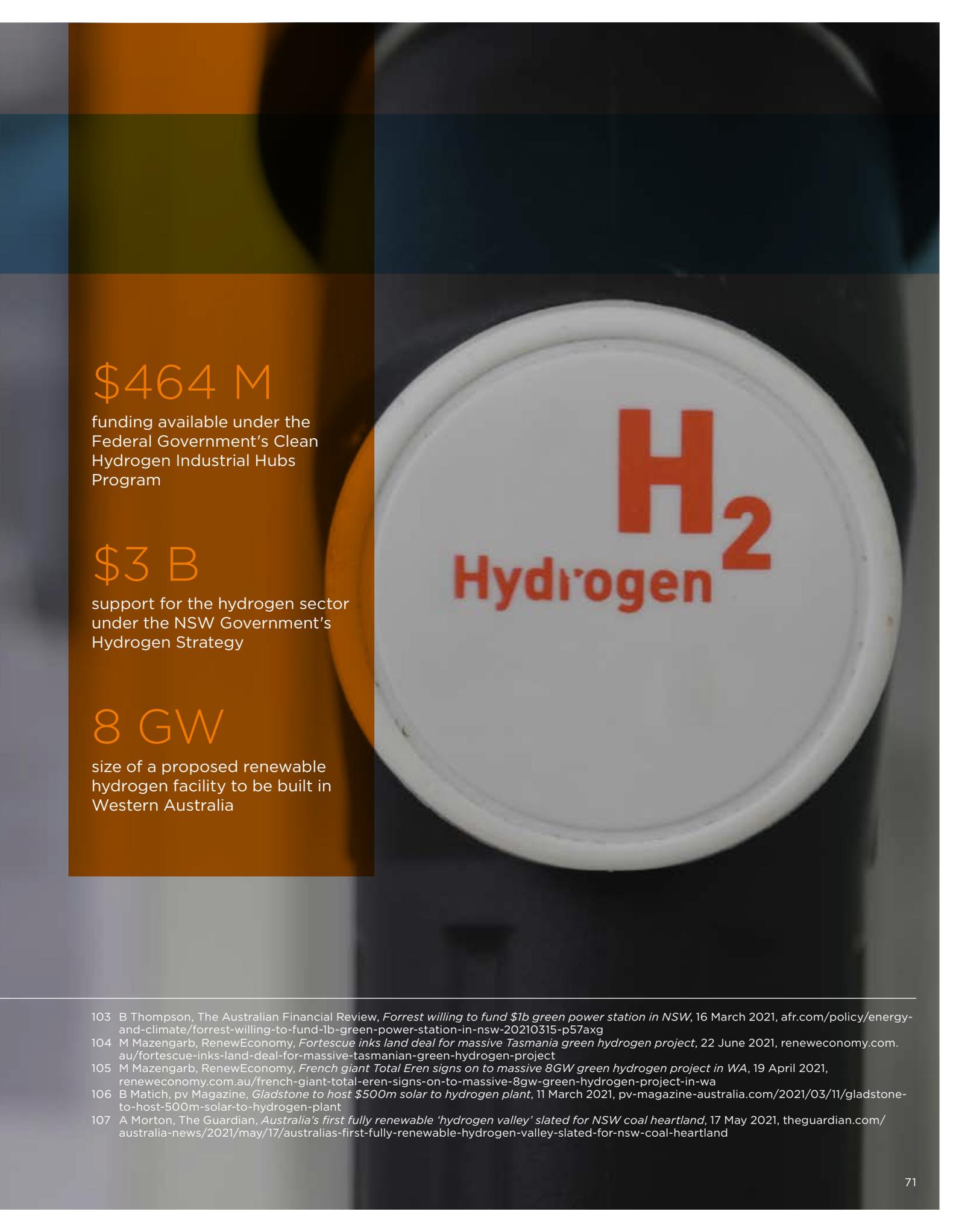
98 Clean Energy Finance Corporation, *CEFC hydrogen investment fuels world's heaviest fuel cell electric trucks*, 8 November 2021, [cefc.com.au/media/media-release/cefc-hydrogen-investment-fuels-world-s-heaviest-fuel-cell-electric-trucks/](https://www.cefc.com.au/media/media-release/cefc-hydrogen-investment-fuels-world-s-heaviest-fuel-cell-electric-trucks/)

99 NSW Department of Planning, Industry and Environment, *NSW Hydrogen Strategy: Making NSW a global hydrogen superpower*, October 2021, [energy.nsw.gov.au/sites/default/files/2021-10/govp1334-dpie-nsw-hydrogen-strategy-fa2_accessible_final.pdf](https://www.energy.nsw.gov.au/sites/default/files/2021-10/govp1334-dpie-nsw-hydrogen-strategy-fa2_accessible_final.pdf)

100 M Dennien, The Brisbane Times, *Queensland pours \$1.5b into energy fund to try to lower bills, hit emissions aim*, 10 June 2021, [brisbanetimes.com.au/national/queensland/queensland-pours-1-5b-into-energy-fund-to-try-to-lower-bills-hit-emissions-aim-20210610-p57zwo.html](https://www.brisbanetimes.com.au/national/queensland/queensland-pours-1-5b-into-energy-fund-to-try-to-lower-bills-hit-emissions-aim-20210610-p57zwo.html)

101 M Mazengarb, RenewEconomy, *WA tips \$118m into new green hydrogen hubs, wants Morrison to match funds*, 25 November 2021, [reneweconomy.com.au/wa-tips-118m-into-new-green-hydrogen-hubs-wants-morrison-to-match-funds](https://www.reneweconomy.com.au/wa-tips-118m-into-new-green-hydrogen-hubs-wants-morrison-to-match-funds)

102 J Fernyhough, RenewEconomy, *Fortescue puts aside \$400m for new hydrogen, wind and solar projects*, 18 February 2021, [reneweconomy.com.au/fortescue-puts-aside-400m-for-new-hydrogen-wind-and-solar-projects](https://www.reneweconomy.com.au/fortescue-puts-aside-400m-for-new-hydrogen-wind-and-solar-projects)



\$464 M

funding available under the Federal Government's Clean Hydrogen Industrial Hubs Program

\$3 B

support for the hydrogen sector under the NSW Government's Hydrogen Strategy

8 GW

size of a proposed renewable hydrogen facility to be built in Western Australia

- 103 B Thompson, The Australian Financial Review, *Forrest willing to fund \$1b green power station in NSW*, 16 March 2021, [afr.com/policy/energy-and-climate/forrest-willing-to-fund-1b-green-power-station-in-nsw-20210315-p57axg](https://www.afr.com/policy/energy-and-climate/forrest-willing-to-fund-1b-green-power-station-in-nsw-20210315-p57axg)
- 104 M Mazengarb, RenewEconomy, *Fortescue inks land deal for massive Tasmania green hydrogen project*, 22 June 2021, reneweconomy.com.au/fortescue-inks-land-deal-for-massive-tasmanian-green-hydrogen-project
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- 106 B Matich, pv Magazine, *Gladstone to host \$500m solar to hydrogen plant*, 11 March 2021, pv-magazine-australia.com/2021/03/11/gladstone-to-host-500m-solar-to-hydrogen-plant
- 107 A Morton, The Guardian, *Australia's first fully renewable 'hydrogen valley' slated for NSW coal heartland*, 17 May 2021, [theguardian.com/australia-news/2021/may/17/australias-first-fully-renewable-hydrogen-valley-slated-for-nsw-coal-heartland](https://www.theguardian.com/australia-news/2021/may/17/australias-first-fully-renewable-hydrogen-valley-slated-for-nsw-coal-heartland)



The rooftop solar sector chalked up its fifth-straight record-breaking year in 2021, passing 3 GW of new capacity for the first time. Rooftop solar now accounts for almost a quarter of Australia's total renewable generation, a remarkable achievement considering that it made up less than 11 per cent just eight years ago.

389,577

rooftop solar installations in 2021, a new record

3.3 GW

rooftop solar capacity added in 2021, a new record

3 M+

Australian households with rooftop solar

The rooftop solar industry continued its remarkable run in 2021, with the 389,577 systems and 3.3 GW of new capacity installed throughout the year both new records for the sector. Every state and territory besides the Northern Territory set new records for installed capacity in 2021, with NSW leading the way from Queensland and Victoria. The average rooftop solar system size increased again in 2021 to 8.51 kW, representing a more than threefold increase over the past decade. The industry also passed the milestone of 3 million homes with rooftop solar systems in 2021, meaning that more than one in three Australian households are now powered by the sun.

Rooftop solar accounted for 24.9 per cent of Australia's renewable energy generation and 8.1 per cent of total generation in 2021. However, the technology was responsible for meeting a significantly higher proportion of demand at certain times throughout the year, with rooftop solar accounting for 78.7 per cent of total demand in South Australia on 4 November and 64.5 per cent of total demand in Western Australia on 30 October.¹⁰⁸ The sector's impact was also seen on electricity prices, with rooftop solar sending average daytime prices in Victoria to just \$0.01/MWh throughout August and September.¹⁰⁹

While the rooftop solar revolution is having a positive impact on Australia's emissions and customers' electricity bills, the downside is that the electricity grid is struggling to keep up. As a result, authorities in some parts of Australia introduced measures such as export limits and remote disconnection in 2021 to ensure the stability of the network, while a proposal by the Australian Energy Market Commission has even suggested charging rooftop solar customers for exporting their excess electricity to the grid.

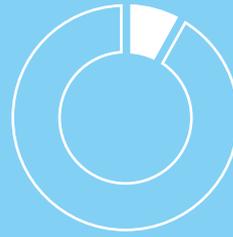
There are some signs that policies such as these and the steady decline of feed-in tariffs and electricity prices in recent years are beginning to impact the sector's growth. While the 3.3 GW of capacity installed was another phenomenal result, the 2021 growth rate was lower than in previous years and less than that forecast by some analysts. While this was partly due to the impact of the COVID-19 pandemic on supply chains and installations during lockdowns, time will tell whether this is just a blip or the first signs that the sector's breakneck growth of recent years is beginning to slow.

¹⁰⁸ G Parkinson, RenewEconomy, *Rooftop solar smashes output records in all Australian states*, 12 November 2021, reneweconomy.com.au/rooftop-solar-smashes-output-records-in-all-australian-states

¹⁰⁹ S Vorrath, RenewEconomy, *Rooftop solar sends Victorian power prices to zero every day for two months*, 22 October 2021, reneweconomy.com.au/rooftop-solar-sends-victorian-power-prices-to-zero-every-day-for-two-months

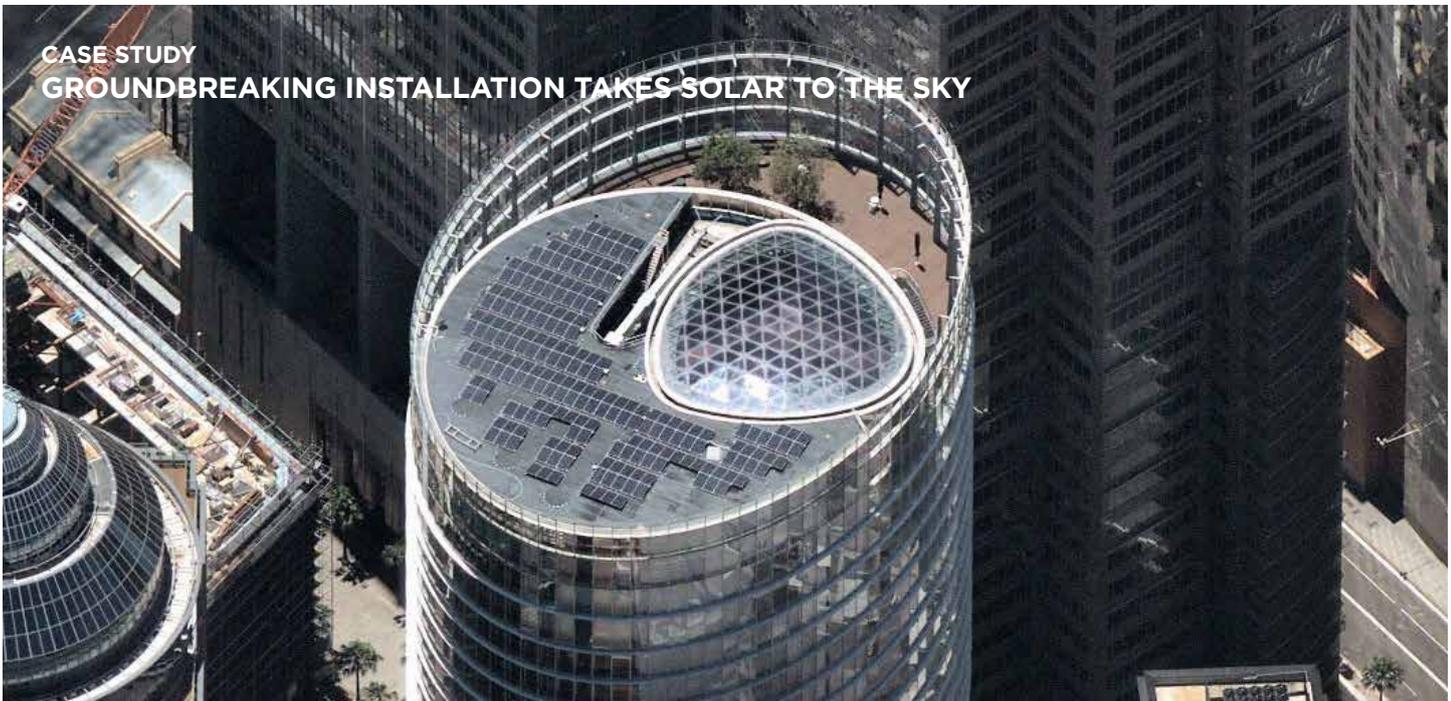


24.9%
of total clean energy
generated in Australia
in 2021



8.1%
of total Australian
electricity generated
in 2021

CASE STUDY GROUNDBREAKING INSTALLATION TAKES SOLAR TO THE SKY



Australia continues to lead the world for per capita solar installations thanks to the phenomenal growth of the small-scale solar industry. However, despite this overwhelming success, the industry has barely scratched the surface when it comes to Australia's total energy consumption.

A big part of this is the thousands of commercial rooftops that haven't yet joined the rooftop solar revolution. Installing rooftop solar on a business premises is often complicated by factors such as leasing arrangements, multiple tenancies and the roof's suitability for a rooftop solar installation, which is particularly the case on multistorey office buildings.

However, the installation of a 78 kW, 216-panel installation on a 139 m skyscraper in the Sydney CBD shows that this last challenge has now been solved, paving the way for many more commercial buildings to take advantage of the benefits offered by rooftop solar.

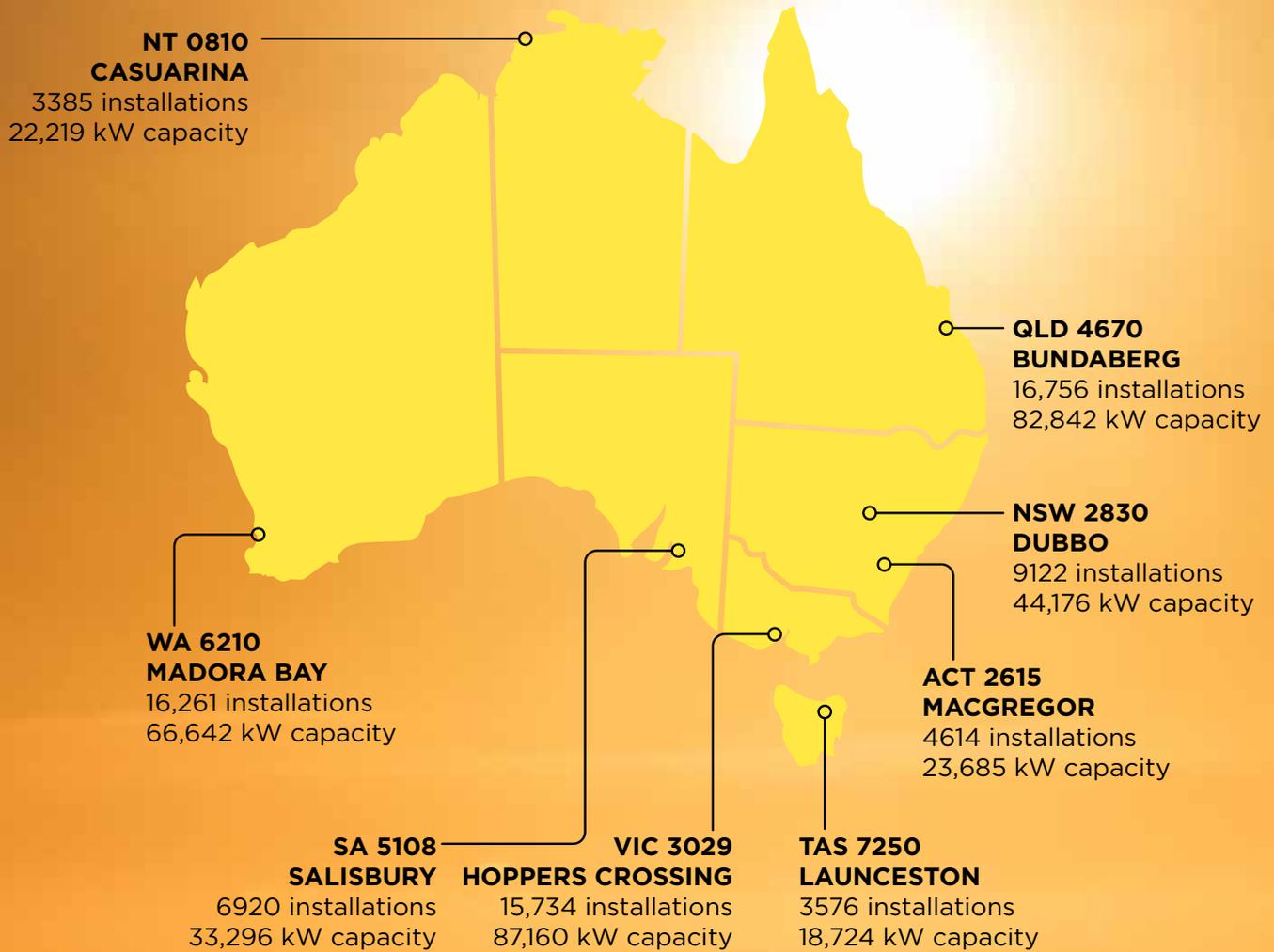
Using innovative design methods to overcome challenges associated with high winds and installing the system on a metal grate floor, the installation solved many of the problems that previously prevented rooftop solar systems on tall buildings to create an aesthetically pleasing and environmentally friendly system.

The installation serves as a fantastic example of the potential for rooftop

solar to be installed on many different types of buildings. When combined with the rapid development of virtual power plants and solar sharing solutions, these installation types will become more common, driving the next phase of the small-scale solar industry's development and further accelerating Australia's clean energy transition.

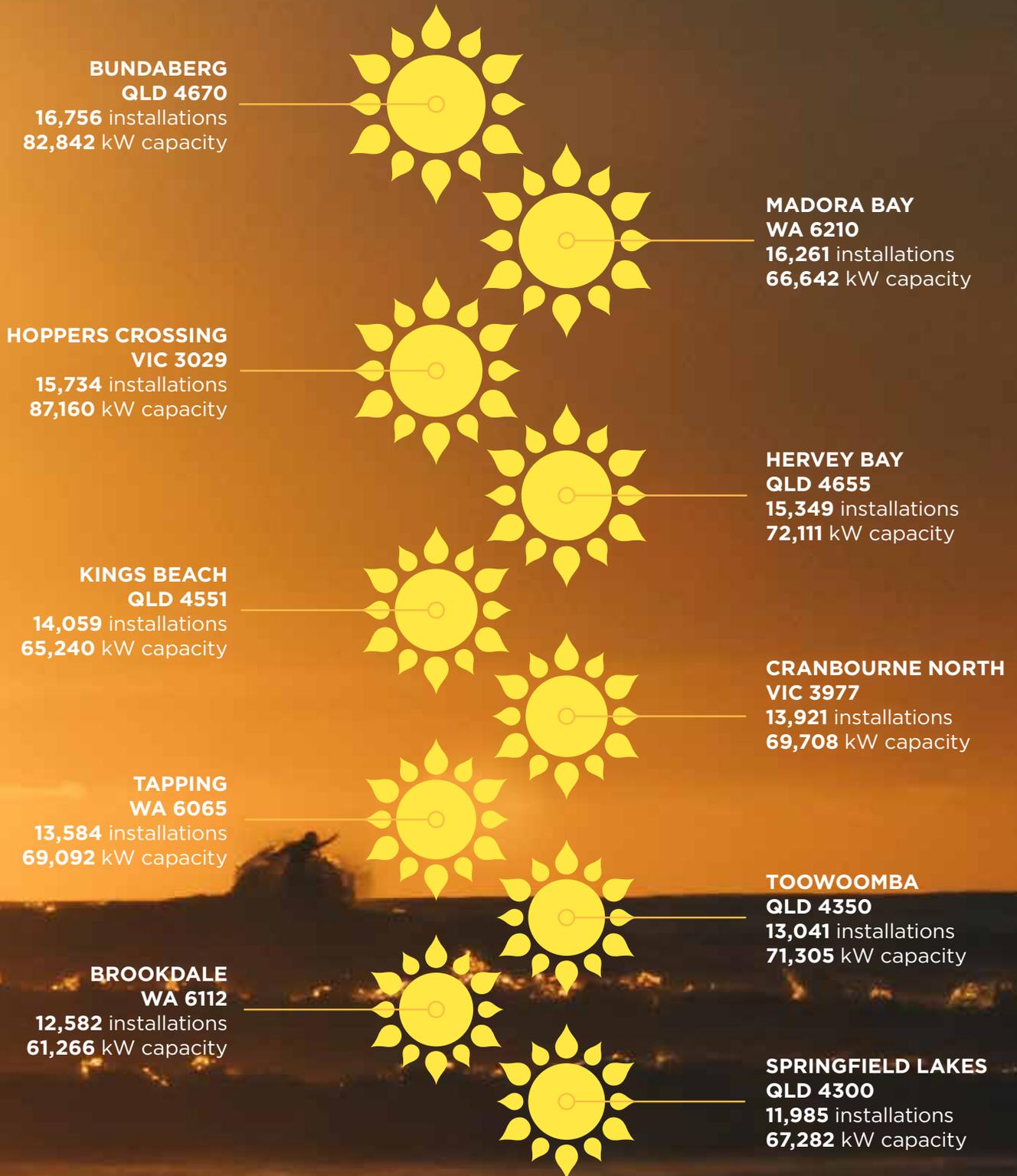
The project's groundbreaking design and innovative application earned Autonomous Energy's Matthew Linney and Jarrod Shepherd a 2021 Clean Energy Council Solar Design and Installation Award in the 30-240 kW category.

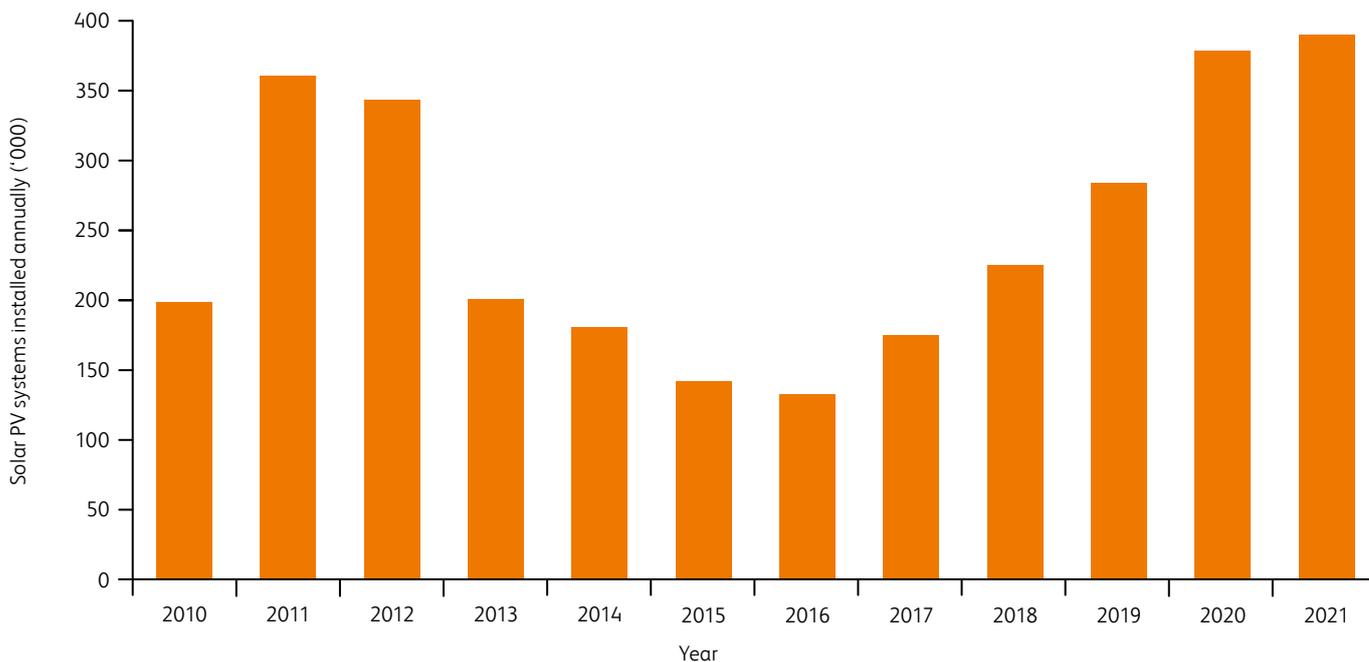
TOP SOLAR POSTCODE IN EACH STATE BY NUMBER OF INSTALLATIONS¹¹⁰



¹¹⁰ Clean Energy Regulator, Green Energy Markets

TOP TEN SOLAR POSTCODES IN AUSTRALIA BY NUMBER OF INSTALLATIONS¹¹⁰



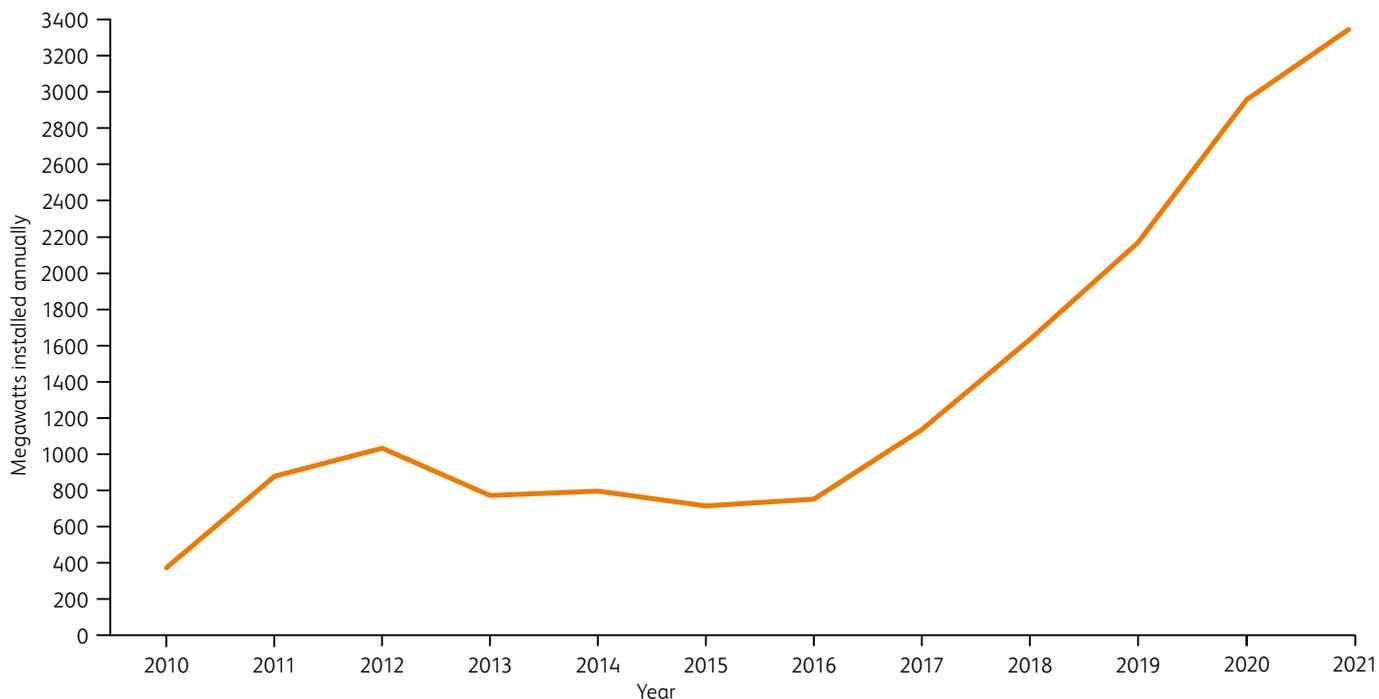
ANNUAL SOLAR PV INSTALLATIONS¹¹¹

INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
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	33,478	1197	39,507	12,081	2020	31,354	20,797	141,500
2016	1001	29,498	1745	34,423	12,604	2487	26,740	24,199	132,697
2017	1946	43,253	1950	46,448	16,190	2393	31,358	31,404	174,942
2018	3206	59,329	2365	55,087	21,894	2641	47,216	33,112	224,850
2019	3799	77,628	3505	70,710	27,089	2891	61,738	36,654	284,014
2020	5567	110,718	3241	88,371	36,341	3357	74,286	48,275	370,156
2021*	6234	114,975	1977	94,244	33,919	4206	82,946	51,078	389,579
TOTAL**	38,308	762,896	20,014	854,948	341,129	44,270	603,156	420,939	3,085,658

* 2021 numbers are based on STC creation up to 31 December 2021 and then adjusted for lags in audit invalidation and then upwards based on historical patterns that 7.77 per cent of installations only manage to create STCs in the subsequent year.

** Total includes solar systems installed before 2010.

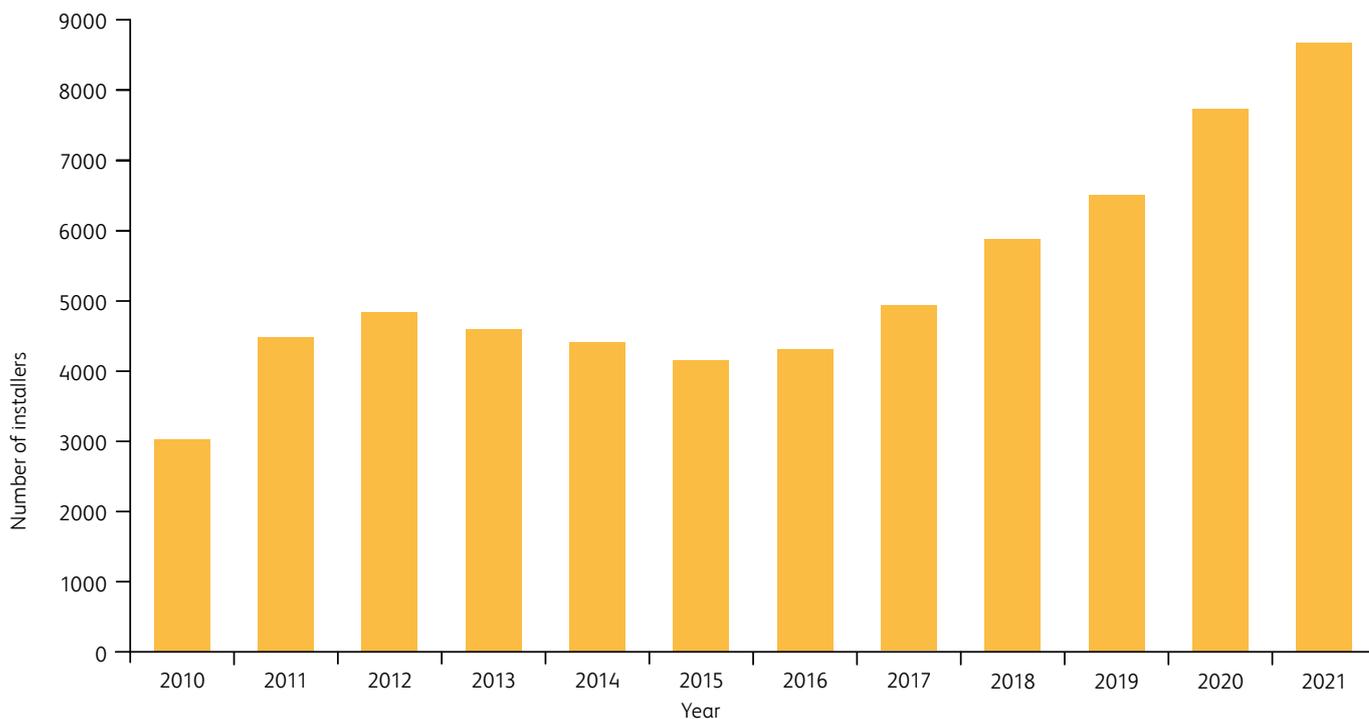
ANNUAL INSTALLED CAPACITY OF SOLAR PV (MW)¹¹²



INSTALLATION YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	NATIONAL
2010	4.7	153.9	1.5	92.4	33.2	3.0	59.0	42.1	389.7
2011	15.9	196.5	1.8	225.2	163.5	5.9	140.4	123.0	872.2
2012	4.6	145.0	2.3	418.4	138.0	20.3	207.6	99.5	1035.8
2013	9.8	134.4	5.0	268.9	141.4	31.5	131.6	69.6	792.2
2014	4.5	172.4	6.1	248.8	82.5	19.0	171.7	95.3	800.3
2015	5.1	177.1	8.6	192.8	66.6	9.5	150.0	96.2	705.9
2016	6.2	167.3	12.7	199.5	77.7	11.8	144.5	128.0	747.8
2017	11.0	262.9	15.3	306.1	115.2	14.5	205.2	186.2	1116.4
2018	21.9	426.2	20.1	407.2	174.4	18.9	337.4	210.0	1616.0
2019	28.3	597.4	27.4	587.6	226.2	21.0	449.2	253.7	2190.8
2020	46.5	895.2	27.7	753.2	303.7	26.8	573.9	335.8	2962.8
2021*	57.6	995.5	19.9	854.3	306.6	34.2	681.2	366.6	3316.0
TOTAL**	217.7	4347.2	149.4	4582.9	1846.5	218.4	3264.9	2023.4	16,650.4

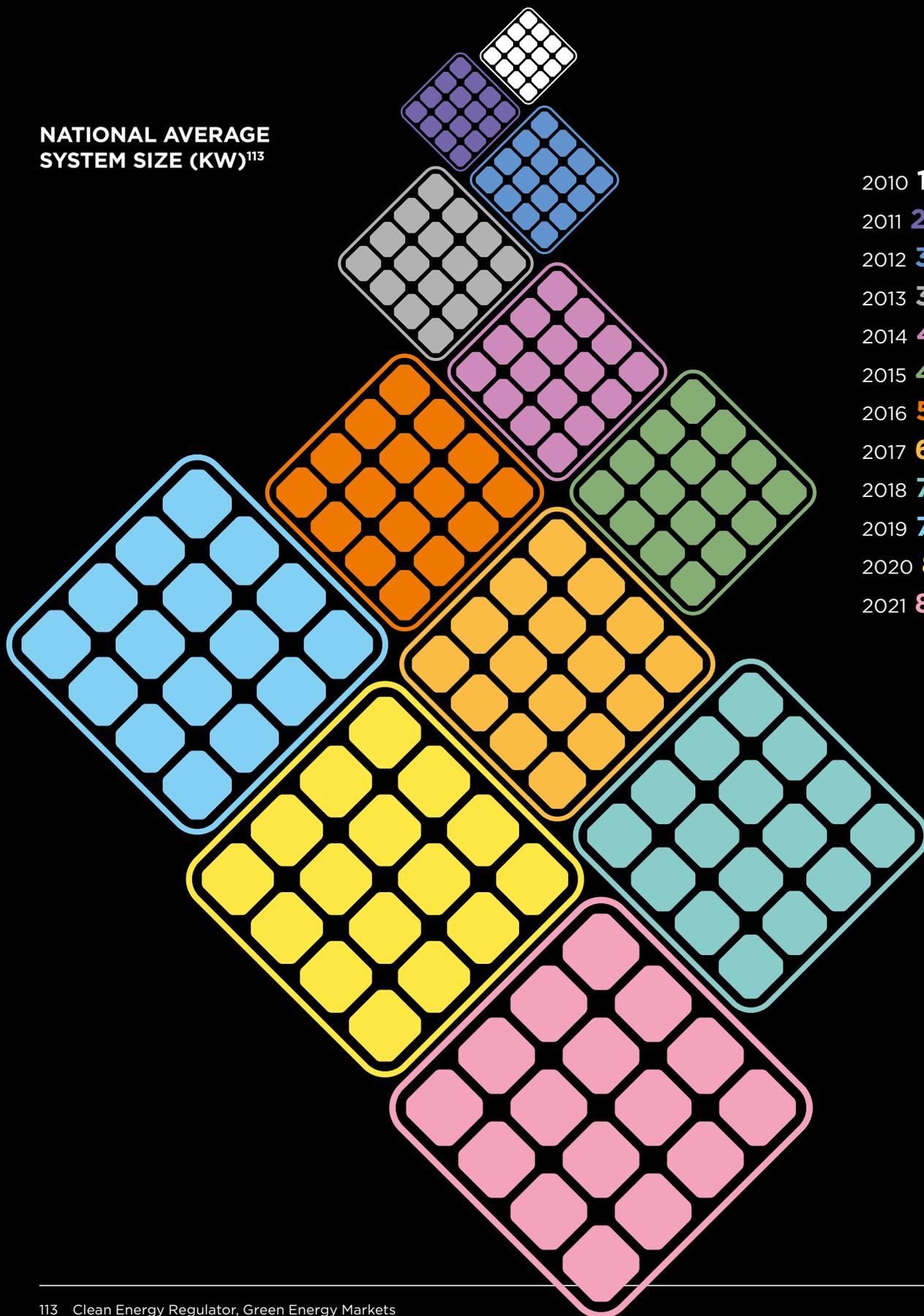
* 2021 numbers are based on STC creation up to 31 December 2021 and then adjusted for lags in audit invalidation and then upwards based on historical patterns that 8.61 per cent of capacity create STCs in the subsequent year to installation.

** Total includes installed capacity before 2010.

TOTAL NUMBER OF ACCREDITED INSTALLERS AND DESIGNERS

YEAR	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Intl	TOTAL
2010	46	879	16	675	252	45	754	414	3	3084
2011	53	1034	22	1187	593	71	1004	531	2	4497
2012	48	948	28	1391	650	120	1122	514	3	4824
2013	44	894	41	1336	604	144	1093	439	6	4601
2014	44	908	47	1263	521	137	1075	401	8	4404
2015	44	916	51	1151	490	109	998	384	7	4150
2016	56	951	70	1188	500	101	974	465	7	4312
2017	66	1085	72	1354	552	112	1059	612	7	4919
2018	91	1323	81	1571	653	112	1316	712	5	5864
2019	103	1539	86	1797	694	116	1510	716	5	6566
2020	129	1905	117	2121	810	130	1707	793	1	7713
2021	171	2231	118	2407	846	130	1940	838	1	8682

**NATIONAL AVERAGE
SYSTEM SIZE (KW)¹¹³**



2010	1.97 kW
2011	2.42 kW
2012	3.02 kW
2013	3.95 kW
2014	4.44 kW
2015	4.99 kW
2016	5.64 kW
2017	6.38 kW
2018	7.19 kW
2019	7.71 kW
2020	8.00 kW
2021	8.51 kW

113 Clean Energy Regulator, Green Energy Markets

SOLAR MEDIUM SCALE: SYSTEMS BETWEEN 100 KW AND 5 MW



The COVID-19 pandemic had a noticeable impact on the performance of the medium-scale solar sector for the second-straight year in 2021. However, the 117 MW installed throughout the year was still the sector’s third-best year.

667 MW

total capacity of the medium-scale solar sector

117 MW

new medium-scale solar capacity added in 2021

Installed capacity in the medium-scale solar sector has fallen in each of the past two years as businesses have felt the effect of the COVID-19 pandemic. Yet despite the difficult economic conditions, 2021 was the fourth-straight year that the sector has seen more than 100 MW of new capacity installed, bringing the sector’s total capacity to 667 MW. Medium-scale solar was responsible for 1.1 per cent of Australia’s total renewable energy generation in 2021, which was slightly down on the 1.4 per cent it contributed in 2020.

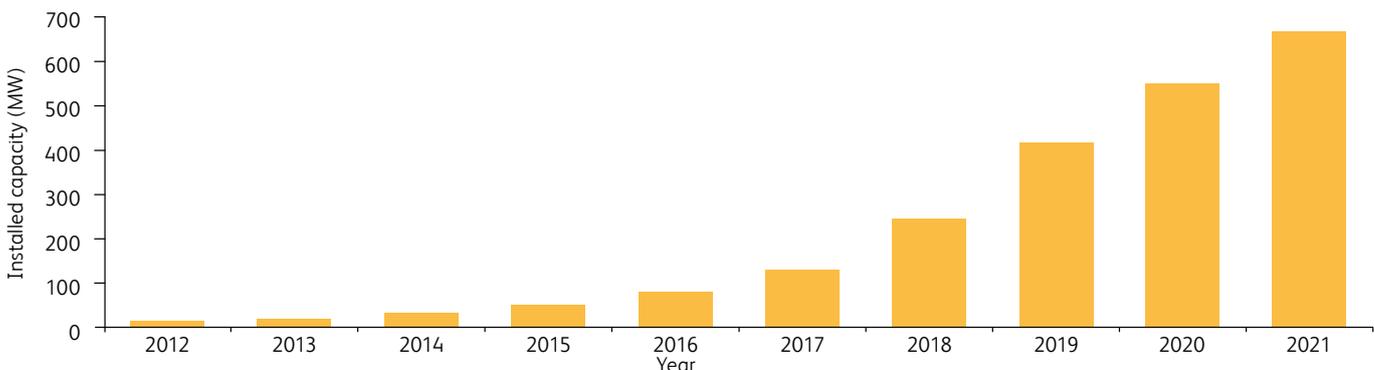
One of Australia’s leading proponents of commercial rooftop solar is retail property business

Vicinity Centres. Vicinity has set a target of generating 48,500 MWh of clean energy each year across its portfolio of shopping centres, with the majority of this coming from rooftop solar installations. The company added 3.6 MW of new capacity in 2021, including a 2.3 MW system on the Karratha City shopping centre that won a 2021 Solar Design and Installation Award in the Over 240 kW category. The company has now installed more than 25.2 MW of rooftop solar across 20 shopping centres around the country.¹¹⁴

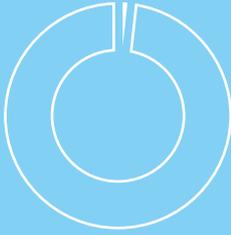
As more companies embrace commercial rooftop solar systems, a number of unique and innovative

business models have begun to emerge. One such example is international window furnishings supplier Hunter Douglas, which introduced a solution in 2021 that provides the excess electricity produced by its 800 kW solar system to employees. The solution uses Enosi’s Powertracer solar sharing technology to offer solar power to employees on weekends and after 4.00pm when the company’s factory is closed. The Australian-first solution offers the dual benefits of providing employees with significant discounts on their electricity bills while allowing Hunter Douglas to get the same return for the power as if it was sending it to the grid.¹¹⁵

CUMULATIVE INSTALLED CAPACITY OF MEDIUM-SCALE SOLAR SYSTEMS¹¹⁶



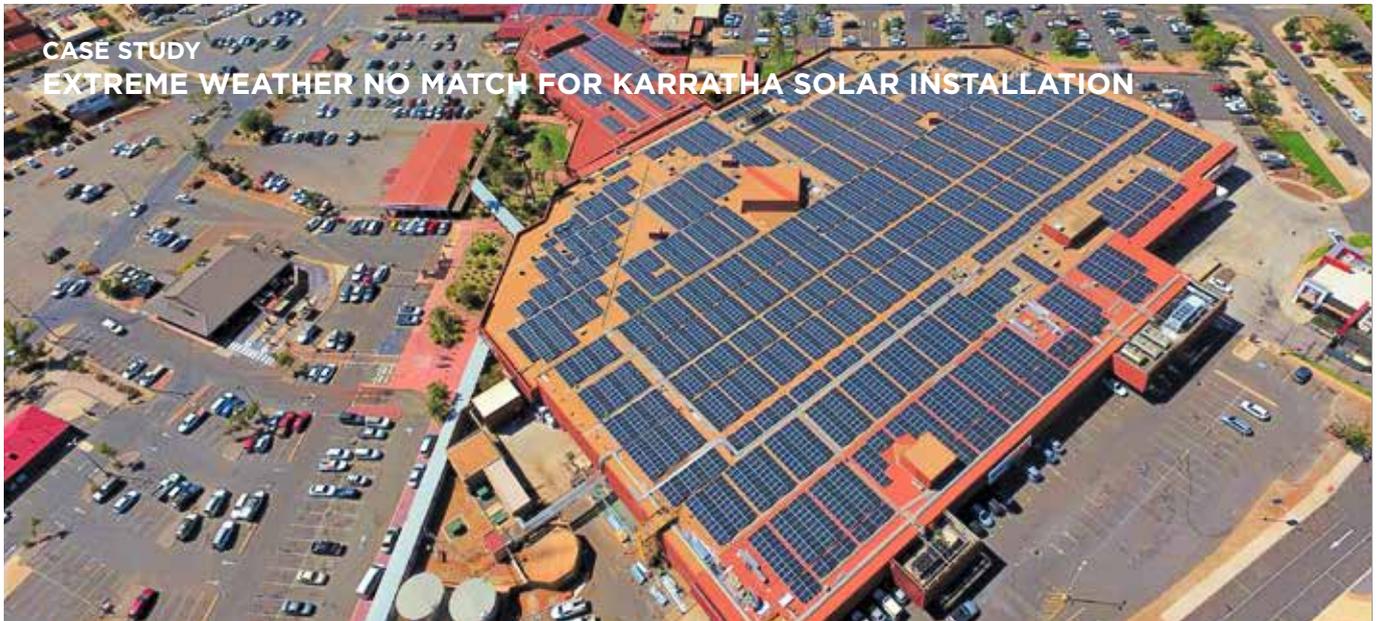
Note: The figure for 2021 is an estimate due to lags in Clean Energy Regulator accreditation data.



1.1%
of total clean energy
generated in Australia
in 2021



0.3%
of total Australian
electricity generated
in 2021



The outback city of Karratha, located in Western Australia’s Pilbara region, is one of the few places in Australia that experiences extreme heat, tropical cyclones and monsoonal rain at various times throughout the year.

As a result, installing a 2.3 MW rooftop solar installation on the Karratha Shopping Centre required all the expertise and ingenuity that the Australian rooftop solar industry has become known for. The system, encompassing more than 6000 solar panels, is built to ensure that it can withstand cyclonic winds with gusts

of up to 280 km/h. Strengthened by a custom-designed and fabricated mounting solution, the system has additional fixing points for the solar panels and added protection around edges and gaps to reduce extreme pressure differentials.

In addition to accounting for extreme weather, large renewable energy installations in remote locations such as Karratha have previously found it difficult to get connection approval due to their impact on the local grid. However, by working closely with the local distributed network

service provider, Horizon Power, the installation not only gained approval, but its successful integration into Karratha’s energy mix has shown that such systems are more viable than previously assumed.

This important project earned Ashley Funnel (working for AGF Electrical), Dylan Palmer (working for ACE Electrical) and Nelson Steer (working for Solgen Energy Group) a 2021 Clean Energy Council Solar Design and Installation Award in the Over 240 kW category.

114 D Carroll, pv Magazine, *Vicinity Centres continues rollout of rooftop PV across retail portfolio*, 20 May 2021, pv-magazine-australia.com/2021/05/20/vicinity-centres-continues-rollout-of-rooftop-pv-across-retail-portfolio

115 S Vorrath, *One Step Off the Grid, Sydney factory to share excess rooftop solar power with employees*, 1 April 2021, onestepoffthegrid.com.au/sydney-factory-to-share-rooftop-generated-solar-power-with-employees

116 Clean Energy Regulator, Green Energy Markets



The large-scale solar sector bounced back in 2021, adding more than 1.2 GW of new capacity throughout the year after falling below the 1 GW mark in 2020. This made 2021 the sector's second-best year and increased total large-scale solar capacity to more than 5.1 GW.

1209 MW

new large-scale solar capacity added in 2021

38%

increase in large-scale solar capacity in 2021

275 MW

size of the Darlington Point Solar Farm, Australia's largest

The large-scale solar sector saw 19 projects commissioned during 2021 with a cumulative capacity of 1209 MW. The number of new projects was slightly down on the 22 projects completed in 2020, but capacity increased by 38 per cent due to Australia's three largest solar farms all being commissioned during the year. The new projects were located right throughout the country, with Victoria, NSW and SA all adding four new projects, while Queensland and the NT both added three. Large-scale solar's contribution to Australia's renewable energy generation increased from 10.9 per cent in 2020 to 12.3 per cent in 2021, while it accounted for 4.0 per cent of Australia's total electricity generation.

The 275 MW Darlington Point Solar Farm became Australia's largest solar project in 2021, comfortably surpassing the 150 MW Coleambally and Daydream solar farms that previously shared the record.

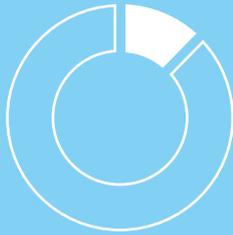
The Darlington Point project is located in western NSW and features almost 1 million solar panels and two synchronous condensers. The condensers will provide crucial system strength services in the West Murray zone, which will help to solve some of the grid strength issues that have plagued renewable energy projects in the region in recent years. Australia's second- and third-largest solar farms were also commissioned in 2021. The Kiamal Solar Farm in Victoria and the Wellington Solar Farm in NSW added 200 MW and 174 MW of new capacity respectively.

A further 42 large-scale solar farms were under construction or had reached financial close at the end of 2021, representing over 3.6 GW of new capacity. These new projects include the 400 MW Western Downs Green Power Hub in Queensland, which is expected to be completed in the first half of 2022, and the 400 MW New England Solar Farm in NSW, which

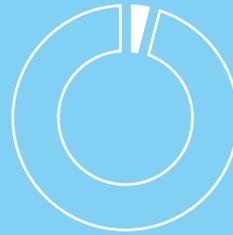
is scheduled to be fully operational in 2023. Upon completion, these two projects will share the mantle of Australia's largest solar farm.

Progress on the world's largest solar farm – the Sun Cable project in the Northern Territory – continued steadily throughout 2021. In September, Sun Cable announced that it had expanded the proposed size of the megaproject from 14 GW to 17-20 GW and the co-located battery storage system from 30 GWh to 36-42 GWh. This increased the value of the project to \$30 billion, which is expected to create more than 1500 construction jobs and 350 ongoing roles.¹¹⁷ The project also signed a project development agreement with the Northern Territory Government in 2021, was included on Infrastructure Australia's Infrastructure Priority Initiative List, and was granted a subsea survey permit and recommended transmission route by the Indonesian Government.

117 P Hannam, The Sydney Morning Herald, *Sun Cable scales up plans for world's biggest solar farm with Indonesian help*, 23 September 2021, [smh.com.au/environment/climate-change/sun-cable-scales-up-plans-for-world-s-biggest-solar-farm-with-indonesian-help-20210923-p58u5y.html](https://www.smh.com.au/environment/climate-change/sun-cable-scales-up-plans-for-world-s-biggest-solar-farm-with-indonesian-help-20210923-p58u5y.html)



12.3%
of total clean energy
generated in Australia
in 2021



4.0%
of total Australian
electricity generated
in 2021

CASE STUDY **AGRISOLAR A GROWING PRACTICE BENEFITTING BOTH FARMERS AND SOLAR FARMS**

One of the key arguments from those that oppose the large-scale solar industry is that solar farms are often built on prime agricultural land and thus prevent it from being used to graze animals or grow crops.

However, a report released by the Clean Energy Council in 2021, *The Australian Guide to Agrisolar for Large-scale Solar*, puts paid to this argument by demonstrating how agricultural activities can be integrated into solar farm projects (known as ‘agrisolar’), providing improved outcomes for both farmers and project owners.

In Australia, the dominant form of agrisolar is allowing sheep to graze in and around solar farms. This has been proven to have

significant benefits for farmers, including providing access to free agistment, solar panels protecting sheep from the elements and secure fencing providing safety from predators. Solar farm owners also benefit from the arrangement by reducing mowing costs and strengthening relationships with local communities.

In addition to sheep grazing, solar farm operators and farmers worldwide have joined forces to come up with several other innovative ways that solar can be combined with agriculture. This includes using elevated solar arrays that allow fruit trees to be grown underneath or machinery to be operated, locating beehives in and around solar farms and

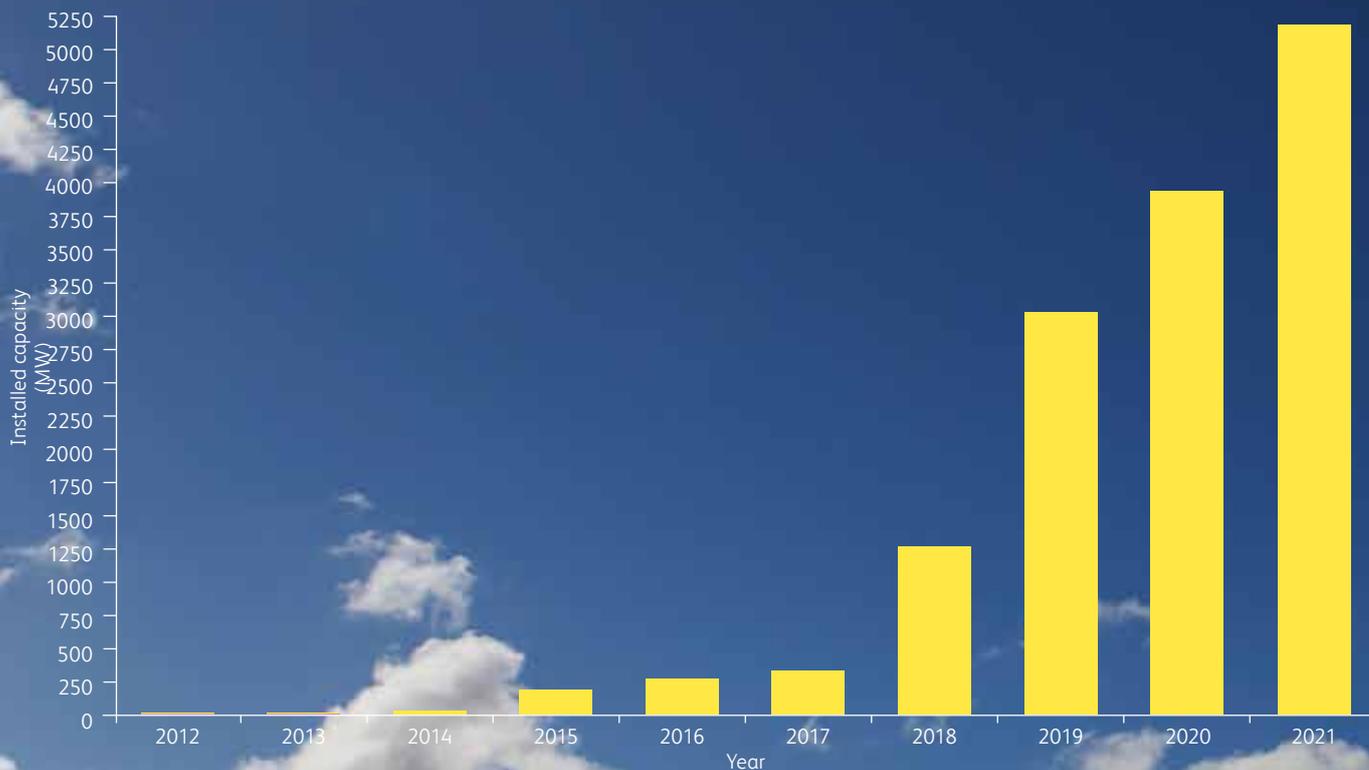
using solar panels on greenhouses growing flowers and vegetables to generate cheap renewable energy while protecting them from weather, climate and insects.

Cooperation between the large-scale solar and agriculture sectors will continue to grow in the coming years as farmers and project proponents work together to find new and innovative ways to integrate the two industries. Not only will this rebuff the industry’s critics, but it will also help solve the woolly problem of maintaining food and fibre production in a changing climate.



Image: Gatton Solar Research Facility, Queensland

CUMULATIVE INSTALLED LARGE-SCALE SOLAR CAPACITY¹¹⁸



ANNUAL INSTALLED LARGE-SCALE SOLAR CAPACITY (MW)¹¹⁸

YEAR	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
ANNUAL INSTALLED CAPACITY	10	0	20	155	79	61	935	1760	908	1249

TOP FIVE SOLAR FARMS BY SIZE

DARLINGTON POINT, NSW

Owner: Edify and Fern Trading Development

Commissioned: 2021

275 MW

KIAMAL, VIC

Owner: Total Eren

Commissioned: 2021

200 MW

WELLINGTON, NSW

Owner: Lightsource BP

Commissioned: 2021

174 MW

COLEAMBALLY, NSW

Owner: Neoen

Commissioned: 2018

150 MW

DAYDREAM, QLD

Owner: Edify Energy

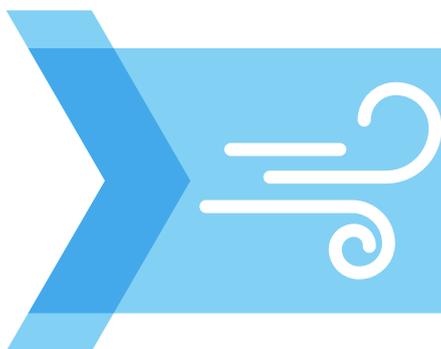
Commissioned: 2019

150 MW

LARGE-SCALE SOLAR PLANTS COMMISSIONED IN 2021¹¹⁸

STATE	PROJECT	OWNER	CAPACITY (MW)
NSW	Darlington Point Solar Farm	Edify and Fern Trading Development	275
VIC	Kiamal Solar Farm	Total Eren	200
NSW	Wellington Solar Farm	Lightsource BP	174
VIC	Glenrowan West Solar Farm	Wirtgen Invest	130
VIC	Winton Solar Farm	Fotowatio Renewable Ventures	85
VIC	Yatpool Solar Farm	BayWa r.e.	81
WA	Chichester Solar Farm	Alinta Energy	60
NSW	Jemalong Solar Project	Genex Power	50
QLD	Maryborough Solar Farm	Sentient Impact Group	35
QLD	Middlemount Solar Farm	SUSI Partners	34
NSW	Molong Solar Farm	AMP Energy	25
NT	Batchelor Solar Power Station	ENI Australia	10
NT	Manton Dam Solar Power Station	ENI Australia	10
NT	Batchelor 2 Solar Farm	Merricks Capital	10
SA	Morgan to Whyalla Pump Station 3	SA Water	8
SA	Morgan to Whyalla Pump Station 1	SA Water	6
SA	Morgan to Whyalla Pump Station 2	SA Water	6
SA	Morgan to Whyalla Pump Station 4	SA Water	6
QLD	Robina Town Centre Solar System	QIC	5

Image: Gannawarra Solar Farm, Victoria



The wind sector continued to lead Australia's clean energy transition in 2021, adding 1.7 GW of new capacity throughout the year. This made 2021 the sector's third record-breaking year in a row and brought Australia's total installed wind capacity to more than 9.1 GW.

1746 MW

new wind capacity added in 2021, a new record

Eight new wind farms were commissioned around Australia in 2021, representing 1746 MW of new capacity. Despite the number of projects commissioned being slightly less than the 10 that began operation in 2020, the installed capacity was far higher than the previous year's record of 1100 MW. This was primarily due to the commissioning of two of Australia's three largest wind farms in 2021, the 453 MW Coopers Gap Wind Farm in Queensland – Australia's largest – and the 336 MW Dundonnell Wind Farm in Victoria. Half of the new wind farms were installed in Victoria, followed by NSW with two projects and Queensland and WA with one each. Victoria extended its lead as Australia's leading wind jurisdiction in 2021, accounting for almost a third of total wind generation across Australia. It was followed by SA and NSW, which accounted for 21.4 per cent and 20.1 per cent of wind generation respectively.

8

wind farms commissioned in 2021

For the second-straight year, the wind sector was responsible for 35.9 per cent of Australia's total renewable energy generation. However, wind's percentage of total electricity generation increased from 9.9 per cent in 2020 to 11.7 per cent in 2021, highlighting the continued growth of all renewable energy technologies at the expense of coal- and gas-fired electricity.

Australia's largest wind farm was fully commissioned in 2021, the 453 MW Coopers Gap Wind Farm. Located in the Western Downs and South Burnett region of Queensland, construction of the wind farm was completed in April 2020, but several faults detected during the commissioning process meant that the project didn't come fully online until 2021.¹¹⁹ Another significant wind project to reach completion in 2021 was the 336 MW Dundonnell Wind Farm in Victoria, which became Australia's third-largest wind farm.

The prospects for the wind sector continue to look bright, with a further

453 MW

capacity of the Cooper's Gap Wind Farm in Queensland

19 wind farms under construction or financially committed at the end of 2021 representing more than 3.2 GW of new capacity. This project pipeline includes the Stockyard Hill Wind Farm in Victoria, which at 532 MW will be Australia's largest when completed.

The offshore wind sector was given a significant boost in 2021 when legislation creating a regulatory framework for offshore electricity infrastructure projects finally passed Parliament.¹²⁰ The new legislation will open the door to at least 12 offshore wind farms currently in the early planning stages, with the 2.2 GW Star of the South off Victoria's Gippsland coast the most advanced. Construction on Star of the South could begin as early as 2025, with the project expected to be completed towards the end of the decade.

¹¹⁹ G Parkinson, RenewEconomy, *Australia's biggest wind farm at Coopers Gap to undergo major repairs*, 4 November 2020, reneweconomy.com.au/australias-biggest-wind-farm-at-coopers-gap-to-undergo-major-repairs-16117

¹²⁰ Clean Energy Council, *Long-awaited offshore wind legislation should be followed with swift industry consultation*, 26 November 2021, cleanenergycouncil.org.au/news/long-awaited-offshore-wind-legislation-should-be-followed-with-swift-industry-consultation



35.9%
of total clean energy
generated in Australia
in 2021



11.7%
of total Australian
electricity generated
in 2021

WIND FARMS COMMISSIONED IN 2021¹²¹

STATE	PROJECT	OWNER	CAPACITY (MW)
QLD	Coopers Gap Wind Farm	PowAR/Tilt Renewables	453
VIC	Dundonnell Wind Farm	PowAR/Tilt Renewables	336
NSW	Collector Wind Farm	RATCH Australia	227
WA	Yandin Wind Farm	Alinta Energy	214
VIC	Bulgana Green Power Hub	Neoen	194
VIC	Berrybank Stage 1 Wind Farm	Global Power Generation	180
NSW	Crudine Ridge Wind Farm	CWP Renewables	134
VIC	Ferguson South Wind Farm	BayWa r.e.	7

TOP FIVE PLANTS BY SIZE

COOPERS GAP, QLD

Owner: PowAR/
Tilt Renewables

Commissioned:
2021

453 MW

MACARTHUR, VIC

Owner: HRL
Morrison/Malakoff
Corporation

Commissioned:
2012

420 MW

DUNDONNELL, VIC

Owner: PowAR/
Tilt Renewables

Commissioned:
2021

336 MW

SNOWTOWN 2, SA

Owner: Palisade
Investment
Partners

Commissioned:
2014

270 MW

SAPPHIRE, NSW

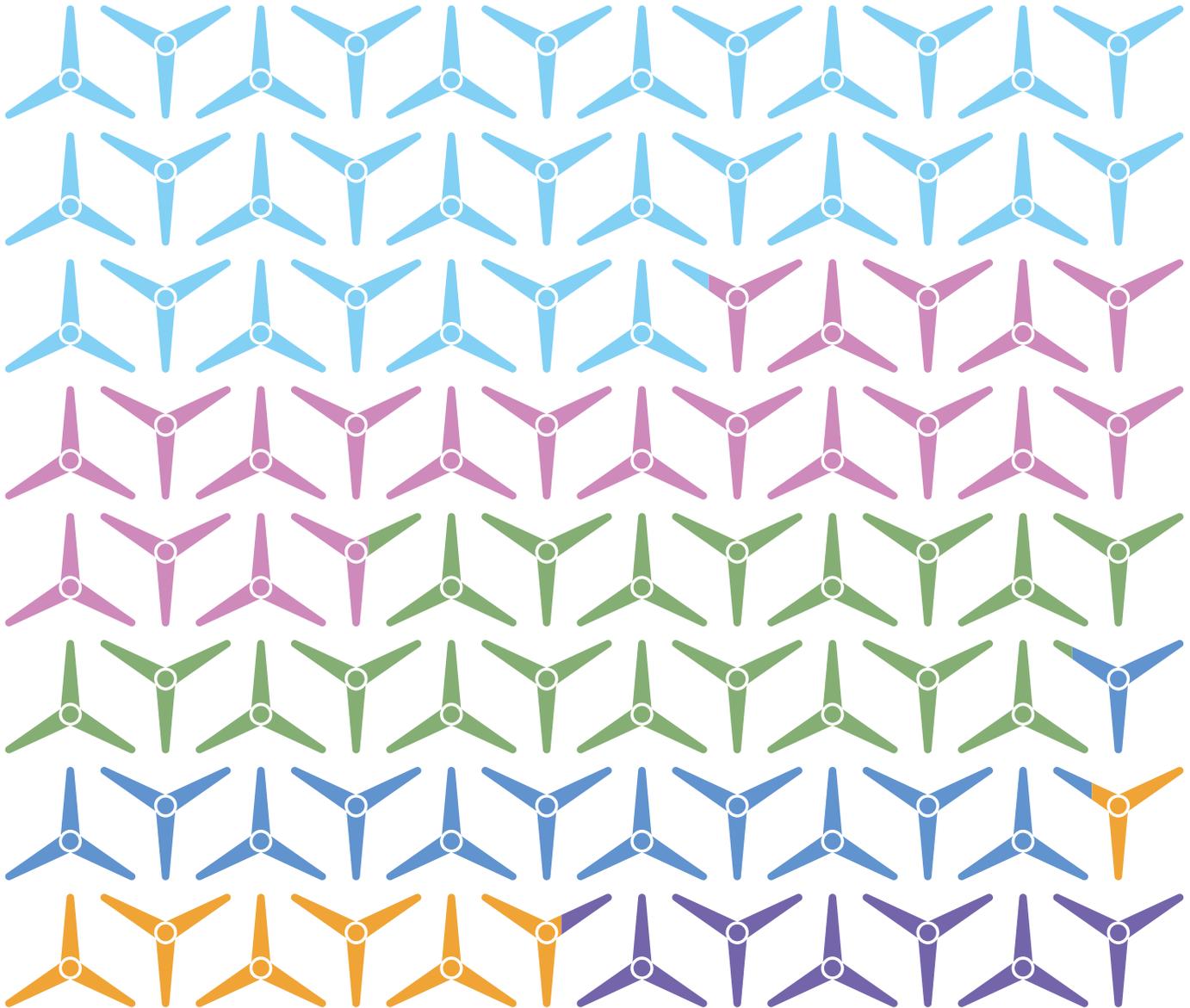
Owner: Partners
Group/CWP
Renewables

Commissioned:
2018

270 MW

TECHNOLOGY PROFILES
WIND POWER (CONTINUED)

PERCENTAGE OF WIND GENERATION BY STATE¹²²



VIC
32.3%
8655 GWh

SA
21.4%
5727 GWh

NSW
20.1%
5384 GWh

WA
12.7%
3407 GWh

TAS
6.9%
1859 GWh

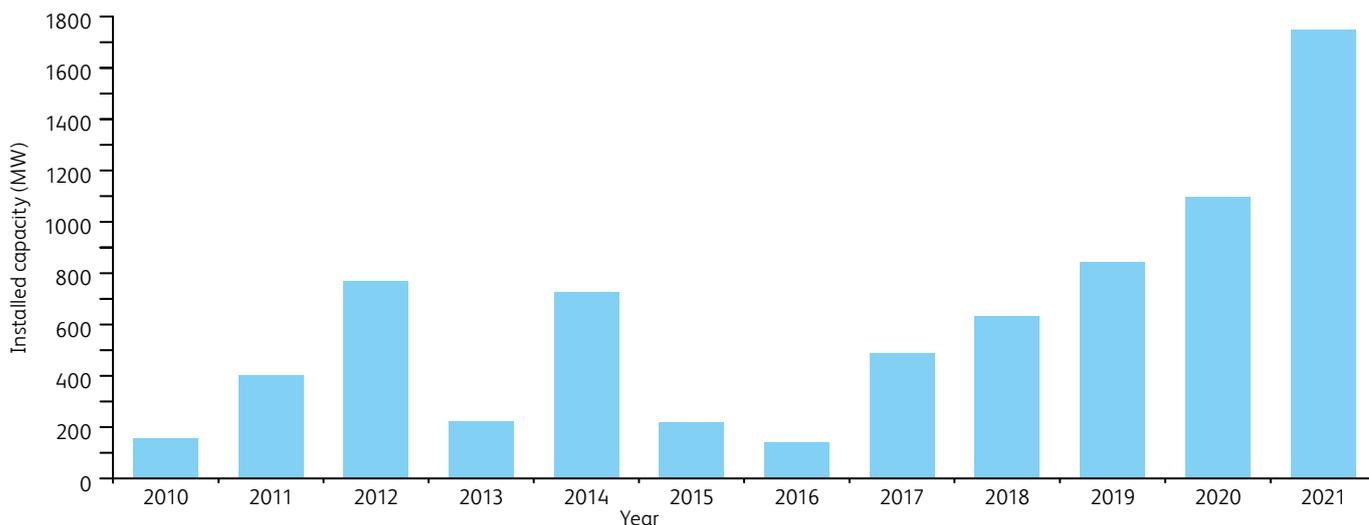
QLD
6.6%
1772 GWh

WIND FARMS UNDER CONSTRUCTION AND COMMITTED AT END OF 2021¹²²

STATE	PROJECT	OWNER	CAPACITY (MW)
VIC	Stockyard Hill Wind Farm	Goldwind Australia	532
NSW	Rye Park Wind Farm	PowAR/Tilt Renewables	396
VIC	Moorabool Wind Farm	Goldwind Australia	312
VIC	Ryan Corner Wind Farm	Global Power Generation	218
SA	Port Augusta Renewable Energy Park	Iberdola Australia	210
VIC	Murra Warra Wind Farm Stage 2	Partners Group	209
QLD	Dulacca Renewable Energy Hub	Octopus Australia	180
NSW	Bango Wind Farm 1	Partners Group/CWP Renewables	159
VIC	Mortlake South Wind Farm	ACCIONA	158
QLD	Kaban Green Power Hub	Neoen	157
VIC	Yendon Wind Farm	Northleaf Capital/InfraRed Capital Patners/Macquarie Capital	144
NSW	Biala Wind Farm	BJCE Australia	110
VIC	Berrybank Wind Farm Stage 2	Global Power Generation	109
VIC	Hawkesdale Wind Farm	Global Power Generation	97
SA	Lincoln Gap Wind Farm Stage 2	Nexif Energy	86
NSW	Bango Wind Farm 2	Partners Group/CWP Renewables	85
NSW	Crookwell 3 Wind Farm	Global Power Generation	58
VIC	Diapur Wind Farm	BayWa r.e.	8
SA	Bolivar Treatment Plant Solar Farm	SA Water	8

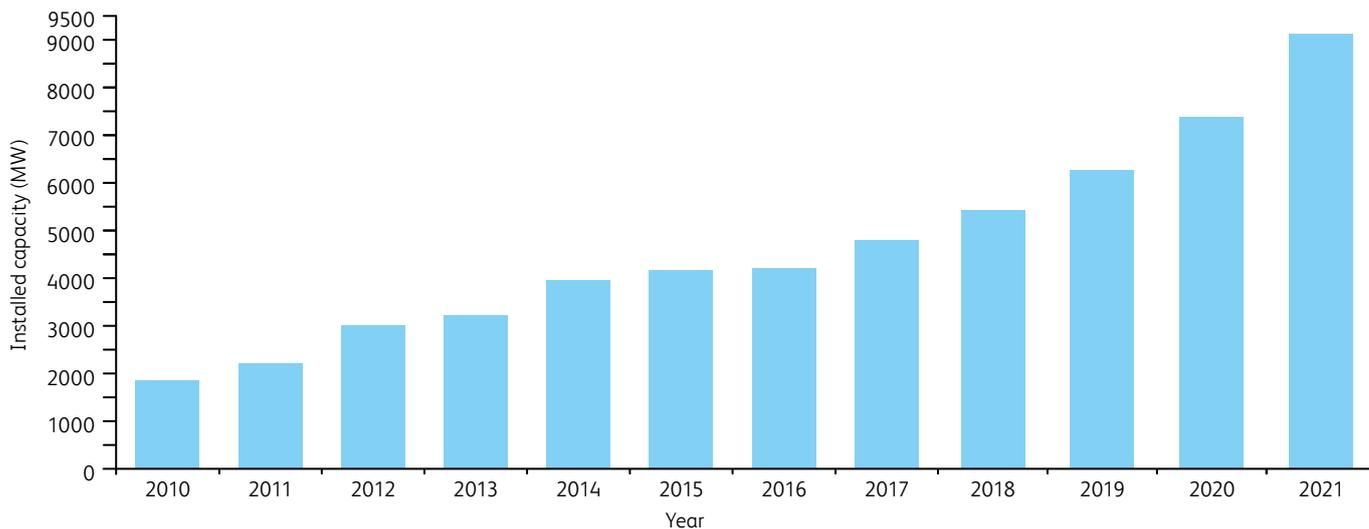
TECHNOLOGY PROFILES
WIND POWER (CONTINUED)

ANNUAL INSTALLED WIND CAPACITY IN AUSTRALIA¹²³



YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
ANNUAL INSTALLED CAPACITY (MW)	159	401	769	225	728	220	41	590	631	837	1100	1746

CUMULATIVE INSTALLED WIND CAPACITY IN AUSTRALIA¹²³



YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CUMULATIVE INSTALLED CAPACITY (MW)	1841	2241	3010	3235	3963	4183	4223	4813	5444	6281	7380	9126

123 Green Energy Markets



Image: IdentiFlight system at Cattle Hill Wind Farm, Tasmania

CASE STUDY INNOVATIVE BIRD DETECTION ANOTHER FEATHER IN THE CAP FOR THE WIND INDUSTRY

The wind industry has had an overwhelmingly positive impact on the Australian environment, drastically reducing carbon emissions and atmospheric pollution. However, even the cleanest energy sources have their downsides, with a significant issue for wind farms the possibility of birds being hit by wind turbine blades. While the danger of wind farms to birds is far less than other factors, such as domestic cats and the built environment, the industry goes to great lengths to ensure as few bird strikes as possible.

These efforts took a significant leap forward in 2021 with the installation of IdentiFlight at Goldwind Australia's

Cattle Hill Wind Farm in Tasmania, an Australian-first system designed to autonomously identify and prevent collisions with endangered Tasmanian Wedge-tailed Eagles.

The system uses 16 high precision optical sensors to detect incoming flying objects. This information is then fed into a computer algorithm that utilises machine learning and artificial intelligence (AI) to identify whether the object is an eagle and if its speed and trajectory could potentially result in a collision. If a collision is possible, the system automatically shuts down one or more wind turbines until the eagle has safely passed through the area.

The implementation of IdentiFlight at the Cattle Hill Wind Farm has significantly reduced the risk to eagles, and the system's highly advanced AI means that it can be easily adapted to other bird species. This will allow for IdentiFlight to be deployed at other wind farms around Australia, significantly reducing the prevalence of bird strikes and reinforcing the Australian wind industry's positive impact on the environment.

The deployment of IdentiFlight by Goldwind Australia at the Cattle Hill Wind Farm was recognised with the Innovation Award at the 2021 Clean Energy Council Awards.



Image: Agnew Hybrid Renewable Microgrid Solar and Wind Farm, Western Australia

The Clean Energy Council would like to thank the Business Renewables Centre Australia and Bioenergy Australia for their contributions to this year's report and the following members and industry stakeholders for providing photographs:

- ACE Electrical
- AGF Electrical
- Astronergy
- Autonomous Energy
- Beon Energy Solutions
- Canadian Solar
- Chint Solar
- CWP Renewables
- Edify Energy
- EDL
- Flow Power
- GE Renewable Energy
- Goldwind Australia
- Hydro Tasmania
- Neoen
- Pacific Hydro
- Powering Australian Renewables
- RATCH-Australia
- Solgen Energy Group
- Spark Renewables
- Star of the South Wind Farm
- Suzlon Energy Australia
- Tilt Renewables
- University of Queensland
- WIRSOL Energy
- X-Elio



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