

Clean Energy Australia

2024



**CLEAN
ENERGY
COUNCIL**

A high-speed sailboat is shown from a low angle on the deck, moving quickly across the water. The sails are partially visible, and the water is blurred due to motion. A large white square graphic element is positioned in the upper left quadrant, partially overlapping the text 'EXPLORE' and 'INVEST'.

EXPLORE

INVEST

ACCELERATE

Navigating the energy transition?
Harness the momentum with
MinterEllison: your end-to-end
renewable energy advisor.

MinterEllison.

ZEN
ENERGY

AUSTRALIA'S
FIRST 1.5°C
RETAILER

** In 2022, ZEN Energy became Australia's first electricity retailer to have a near-term science-based emissions reduction target in line with limiting global warming to 1.5°C.*

We respectfully acknowledge Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of the lands and waters on which we work and live. We commit to collaborate with First Nations communities, to promote sustainable practice, protect ancient sites and culture with equitable access to the benefits of clean energy. Sovereignty has never been ceded.

We acknowledge Elders, past and present, and their continuing culture and connection to Country.



← Cover image:
Liontown's Kathleen Valley Lithium Project Wind Farm
Northern Goldfields, WA
Tjiwarl Country
(Zenith Energy)

○ Rye Park Wind Farm
Rye Park, NSW
Wiradjuri Country
(Tilt Renewables)

Contents

Introduction

A message from our CEO	2
About us	4
2023 snapshot	9

Industry outlook

Small scale	15
Large scale	19

Politics

Federal politics	22
State targets and commitments	24
Renewables by state	26

Employment

29

Renewables for business

35

Electricity prices

40

Transmission

42

Energy reliability

46

International update

49

Tech profiles

Battery storage	55
Bioenergy	58
Hydro and pumped hydro	61
Hydrogen	64
Rooftop solar (including medium-scale)	67
Large-scale solar	79
Wind	85

Acknowledgements

91

INTRODUCTION

A message from our CEO



With a fantastic set of results for rooftop solar and record-breaking figures for investment in utility scale storage, 2023 was another strong year for renewable energy in Australia.

Meanwhile, we saw a wave of ambitious policy decisions at federal and state levels aimed at accelerating momentum for the sector, meaning 2024 and beyond will be pivotal years for clean energy.

Renewable energy provided 39.4 per cent of Australia's total energy generation in 2023, a 9.7 per cent increase from 35.9 per cent in 2022. That's a remarkable achievement given renewables represented just 17 per cent of Australia's electricity in 2017, when strong investment really took off.

Combined large and small-scale renewable capacity added reached approximately 5.9 GW in 2023, a figure that almost topped the 2021 record of 6.3 GW, and was significantly up from 5 GW in 2022. This was comprised of 2.8 GW from utility scale projects coming online, and 3.1 GW from rooftop solar. Utility-scale projects included 1.9 GW of large-scale solar capacity – up from 841 MW in 2022 – and 942 MW of wind capacity, down from 1.4 GW in 2022.

2023 was also a record-breaking year for new financial commitments to large-scale storage. In Q2, investment in big batteries broke the billion-dollar mark during a quarter for the first time, and by Q4 that record had been broken. Total investment in large-scale storage stood at \$4.9 billion by the end of 2023, up from \$1.9 billion in 2022 – a 157.9 per cent increase. The combined capacity of the large-scale storage projects reaching financial commitment in 2023 totalled 3,949 MW / 9,905 MWh.

5.9 GW

Renewable capacity added in 2023

(2022: 5 GW)

3.1 GW

Capacity added by rooftop solar in 2023

(2022: 2.7 GWh)

\$4.9 billion

New financial commitments to large-scale storage in 2023

(2022: \$1.9 billion)

Meanwhile, Australia's world-leading rooftop solar industry continued to flourish, driving Australia's clean energy transition forward with the largest contribution (3.1 GW) of any technology, significantly up from 2022 (2.7 GW). 337,498 solar systems were installed across Australia in 2023, up from 315,499 in 2022. These are terrific numbers, and demonstrate the value Australians see in rooftop solar, as well as the benefits it brings.

Unfortunately, 2023 saw a slowdown in new financial commitments to utility scale generation capacity at \$1.5 billion, significantly down on \$6.5 billion for 2022.

This reflects a more complex and challenging landscape for new investment decisions, which continue to include a constrained grid, slow planning and environmental assessment processes in some jurisdictions, higher costs and tighter markets for equipment and labour. The policy environment has also been uncertain, with a long-term Renewable Energy Target which is scheduled to wind-up at the end of 2030.


In its *Draft 2024 Integrated System Plan*, the Australian Energy Market Operator (AEMO) advised Australia will need to add at least 6 GW of utility scale generation to the National Electricity Market annually to meet the Federal Government's target of 82 per cent renewables by 2030. While 2.8 GW of new capacity across all of Australia in 2023 is a solid number, Australia clearly needs a rapid acceleration in investment and deployment.

The announcement of the Australian Government's expansion of the Capacity Investment Scheme, to support the addition of 23 GW of new renewable electricity generation capacity between 2024 and 2027 and a further 9 GW of dispatchable capacity, is intended to get large-scale investment back on track. There will however need to be urgent and careful policy design undertaken in the first half of 2024 to ensure the program realises its critical objective to turbocharge private investment in the coming years.

Australia's transition to a clean electricity system is closer than ever, and I believe we are now building the critical foundations that will deliver a transformative acceleration in renewables. Now is the time to ride the wave of policy ambition and turn Australia's huge pipeline of 'prospective' projects into 'built' projects. The Clean Energy Council, alongside our valued members, will be leading the charge for this clean energy future.

Kane Thornton
Chief Executive
Clean Energy Council



 Avonlie Solar Farm
Narrandera, NSW
Wiradjuri Country
(Beon Energy Solutions)



INTRODUCTION

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, emerging technologies and others.

We also manage leading industry compliance, certification and education programs to help drive best-practice standards in rooftop solar and batteries.

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 and promoting the clean energy 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**

Clean Energy Council members are companies who work in or support the clean energy sector. They join to receive various member benefits such as getting the latest industry updates, networking opportunities, contributing expertise to key industry discussions and having a central voice to represent the sector.

A special thank you must go to our sponsoring members. Our sponsoring members are industry leaders at the forefront of influence and innovation. They take an active role in the Clean Energy Council through policy and advocacy initiatives and have access to key industry engagement opportunities.

In 2023 we welcomed:

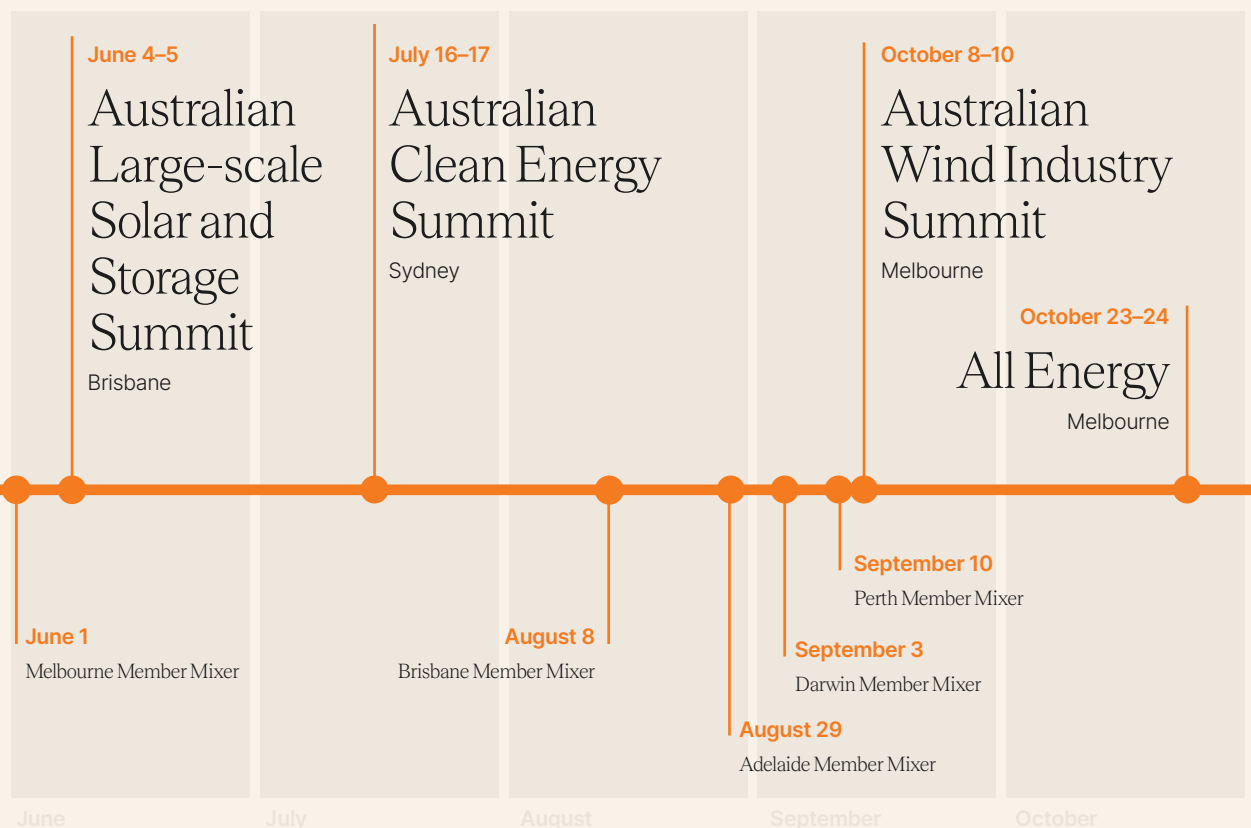
149

new members

65

event partners

2024 Events calendar



Clean Energy Council 2023 highlights

Advocated for distributed energy policy priorities to the Energy and Climate Ministerial Council, resulting in many priorities being addressed, including the establishment of a taskforce that will work on national standards and a distributed energy roadmap



JAN

FEB

MAR

APR

MAY

JUN

Campaigned for a response to the US Inflation Reduction act, resulting in government commitments for hydrogen, energy savings for households and businesses, and massive Federal Government support for new large-scale generation and storage capacity

Secured funding from the Victorian Government for the Victorian Clean Energy Required Training (V-CERT) project, to develop a training matrix and worker digital skills passport for Victorian clean energy projects

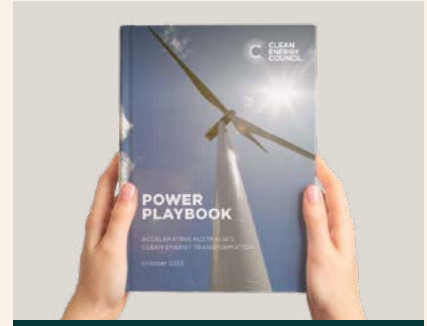
Published *Winding Up* report, on decommissioning and recycling of wind turbines



Biggest ever Australian Clean Energy Summit (ACES)



Launched inaugural Careers for Net Zero job fair promoting net zero jobs



Published *Power Playbook* report, with 45 recommendations for accelerating the clean energy transition

JUL

AUG

SEP

OCT

NOV

DEC



Announced plans to work with the NSW Anti-Slavery Commissioner to develop renewable energy Code of Practice

Campaigned against changes to Victoria's capital improved value assessment, which would have resulted in renewable energy assets paying a fire services property levy 20 times the current level. The campaign resulted in renewable energy being classified as a community benefit



Established the Australian Offshore Wind Taskforce to coordinate state and federal governments with offshore wind developers



INTRODUCTION

2023 Snapshot

It was a strong year for rooftop solar and utility scale storage in 2023, and overall figures for capacity added are up on 2022, though there has been a significant slowdown in new financial commitments to large-scale generation.

Renewable energy accounted for 39.4 per cent of Australia's total electricity generation in 2023, up from 35.9 per cent in 2022 and 32.5 per cent in 2021. While there is still a fair way to go to reach the Federal Government's target of 82 per cent renewables by 2030, there were nevertheless plenty of positives for the industry in 2023.

There were records broken in terms of new renewable capacity added, the rooftop solar sector continued to lead Australia's clean energy transition, and the utility scale storage sector had its strongest-ever year, offset by a significant slowdown in new financial commitments to large-scale generation projects.

A new-record 5.9 GW of renewable capacity was added to the grid in 2023, up from 5 GW in 2022. Of that 5.9 GW, 3.1 GW was provided by rooftop solar and 2.8 GW from utility scale generation. In 2022, rooftop solar provided 2.7 GW and utility scale provided 2.3 GW.

In its *Draft Integrated Systems Plan* released in late 2023, the Australian Energy Market Operator indicated Australia would need to bring on at least 6 GW of new utility scale capacity in the National Electricity Market each year in order to meet the Government's 82 per cent target. While 2.8 GW of new capacity in 2023 is a solid number, Australia clearly needs a rapid acceleration in investment and deployment.

39.4%

Australia's electricity generation from renewable sources, 2023
(2022: 35.9%)

24,985 GWh

NSW renewable energy generation, highest of Australian states
(2022: 21,765 GWh)

3.1 GW

Rooftop solar capacity added in 2023
(2022: 2.7 GW)

56

Large-scale generation projects under construction at the end of 2023
(2022: 72)

Rooftop solar leads the way

At 3.1 GW, rooftop solar was the largest contributor to Australia's renewables drive, accounting for 28.5 per cent of all renewable energy and 11.2 per cent of energy generation overall, up from 25.8 per cent and 9.3 per cent respectively in 2022. Approximately 3.7 million Australian households now have rooftop solar PV systems installed, up from approximately 3.4 million at end-of-year 2022.

The total number of new rooftop solar installations for 2023 was 337,498, up from 315,499 in 2022. The average size of systems installed continued to trend upwards, too, reaching 9.3 kW compared to 8.7 kW in 2022. The trend towards larger system sizes may begin to plateau as the years go by, as technological advancements allow for more efficient solar panels and inverters, and there is a growing emphasis on optimising the size of solar installations to match a household's energy needs. But that trend would represent effective optimisation and not be seen as a negative.

As the large-scale sector experiences something of a slowdown (see below), Australia's world-leading rooftop solar sector continues to demonstrate that it is the quiet achiever of the clean energy transition.

Meanwhile, household batteries continue to grow in uptake. According to SunWiz figures, roughly 56,000 household storage units were installed in 2023, up from around 43,000 in 2022 and 37,000 in 2021, as more and more Australians embrace energy independence.

Storage sensation

Speaking of batteries, it was a remarkable year for the utility scale storage sector, both in terms of new financial commitments and assets under construction.

Twenty-seven large-scale batteries were under construction at the end of 2023, up from 19 in 2022, for a combined capacity of 5 GW / 11 GWh, up from 1.4 GW / 2 GWh in 2022. The largest utility scale storage project currently under construction is the 850 MW / 1,680 MWh Waratah Super Battery in New South Wales, which is being delivered by the NSW Government through its EnergyCo authority. Construction is scheduled to complete in August 2025.

On the financial front, big batteries boomed in 2023. Q2 saw the two-billion-dollar mark for new large-scale storage investment broken in a quarter for the first time, and Q4 broke that record just a few months later, making 2023 the strongest ever year for new financial commitments in the large-scale storage space, at \$4.9 billion including hybrid projects with storage elements (\$4.7 billion for storage-only projects). By comparison, 2022 reached \$1.9 billion in new financial commitments to large-scale storage.

Mixed outlook for large-scale generation

The outlook for large-scale generation, meanwhile, is more mixed. While the year saw a solid number of large-scale projects commissioned, financial investment commitments – a lead indicator for future build – were at their lowest level since the Clean Energy Council began tracking investment data in 2017.

Utility scale solar was the biggest provider of new capacity in 2023, with 1.9 GW, up from 841 MW in 2022. That capacity came from 15 newly commissioned projects, up from 12 in 2022. The largest commissioned projects were Neoen's Western Downs Green Power Hub in Queensland, and ACEN Australia's New England Solar Farm Stage 1, in NSW. Both of those are 400 MW developments and are now the joint-largest solar farms in Australia.

The large-scale wind sector had a less successful year, with 942 MW of new capacity added, down on 1.4 GW in 2022. Of the seven wind farms commissioned in 2023, the largest was Squadron Energy's 244 MW Bango Wind Farm in NSW.

Despite a downturn in capacity added, wind power still accounts for the highest percentage of Australia's renewable energy generation at 33.9 per cent. As a proportion of Australia's overall energy generation, wind power stood at 13.4 per cent in 2023, up from 12.8 per cent in 2022.

There were 56 renewable energy generation projects under construction as of December 2023, down from 72 at the same point in 2022. The combined capacity of these projects is approximately 7.5 GW, significantly down on 9.5 GW at the end of 2022.

Of those 56 projects, 38 are large-scale solar projects and 13 are wind farms, both down from 2022, when there were 48 solar and 21 wind projects in development. There are currently three combined wind/solar projects in development (130 MW), and two biomass projects (61 MW).

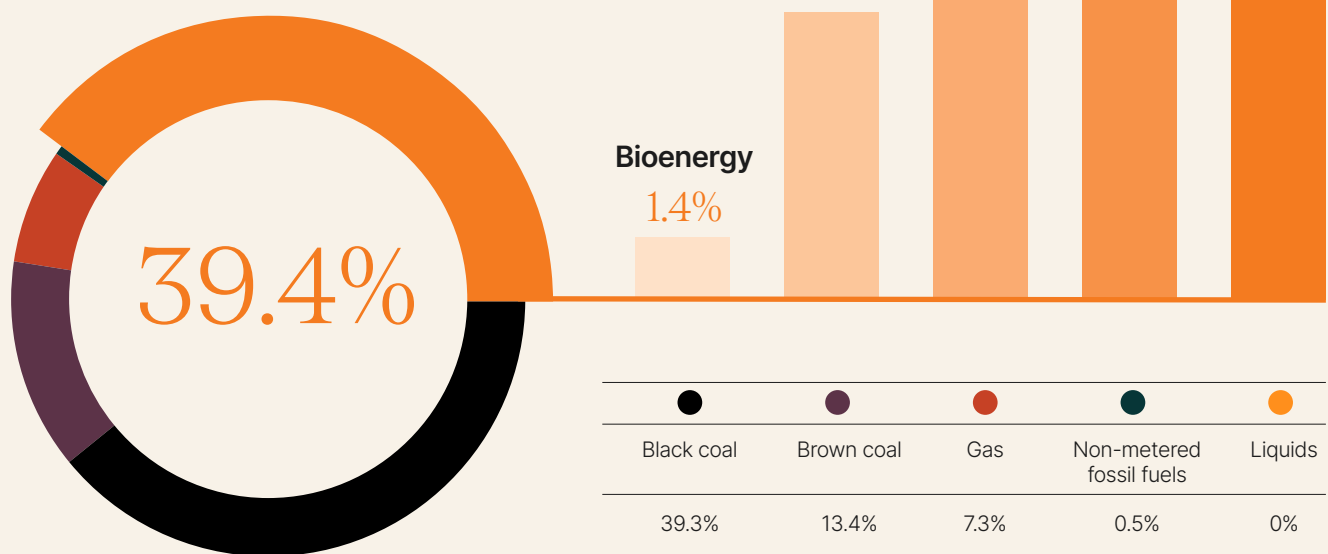
In 2022, the renewables industry in Australia commenced construction of over 5 GW of wind and solar farms, which was the highest year for new renewable construction commitments on record. The figure for 2023 stands at 2.7 GW-worth of wind and solar – a significant reduction and representative of the wider slowdown in the industry.

Investment slowdown

Despite there being some positives for large-scale renewables, 2023 was a particularly poor year for new investment in utility scale generation, which is usually a strong signifier of where the sector is headed.

Renewable electricity generation in 2023 (all sources)

Renewable energy provided 39.4% of Australia's electricity generation in 2023, up from 35.9% in 2022



New financial commitments to large-scale generation projects in 2023 stood at \$1.5 billion, substantially down on \$6.5 billion in 2022. Even factoring in the exceptional performance of the large-scale storage sector in 2023, overall investment figures remain down on 2022.

There were seven new financial commitments to solar projects in 2023 for a combined 921 MW, down from 10 projects and 1.5 GW in 2022. There were no new financial commitments to utility scale wind projects in 2023, compared to six in 2022.

The rolling 12-month quarterly average for investment on generation projects in Q4 2023 was the lowest it has been since the Clean Energy Council began collecting data in 2017, dipping below \$1 billion for only the third time since 2017.

The Federal Government's decision to expand its Capacity Investment Scheme in late 2023 is intended to arrest and reverse this trend. For more information on what the Government is doing to boost renewables in Australia, particularly in response to international policy movements such as the US's Inflation Reduction Act, see the rundown on federal politics on page 22.

For more information on the various sectors in Australian clean energy, check out the tech profiles from page 52 onwards.

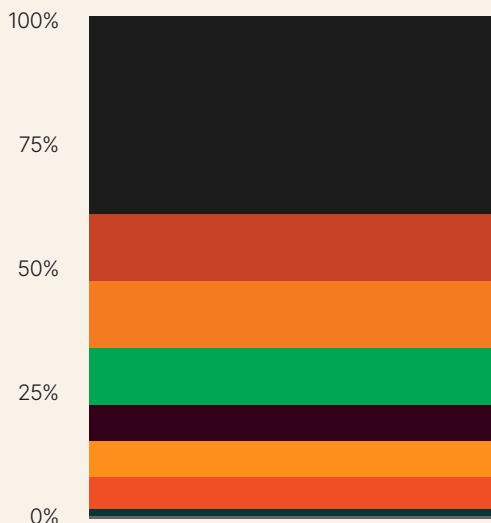
Fossil fuels and international renewables

The amount of coal in Australia's electricity system fell to 52.7 per cent in 2023, down from 54.6 per cent in 2022. Similarly, gas currently generates 7.3 per cent of energy, down from 8.9 per cent in 2022. These incremental reductions in fossil fuels are inevitable as more and more renewables are added to the grid, although uptake of renewables needs to be accelerated in order to bring down Australia's reliance on fossil fuels and usher in a clean economy in Australia.

According to the International Energy Agency's *Renewables 2023*¹ report, "global annual renewable capacity additions increased by almost 50 per cent to nearly 510 GW in 2023, the fastest growth rate in the past two decades". Meanwhile, according to BloombergNEF, global investment in the renewable energy transition hit a record USD \$1.8 trillion in 2023, up 17 per cent from a year earlier, with electrified

¹ International Energy Agency, *Renewables 2023*

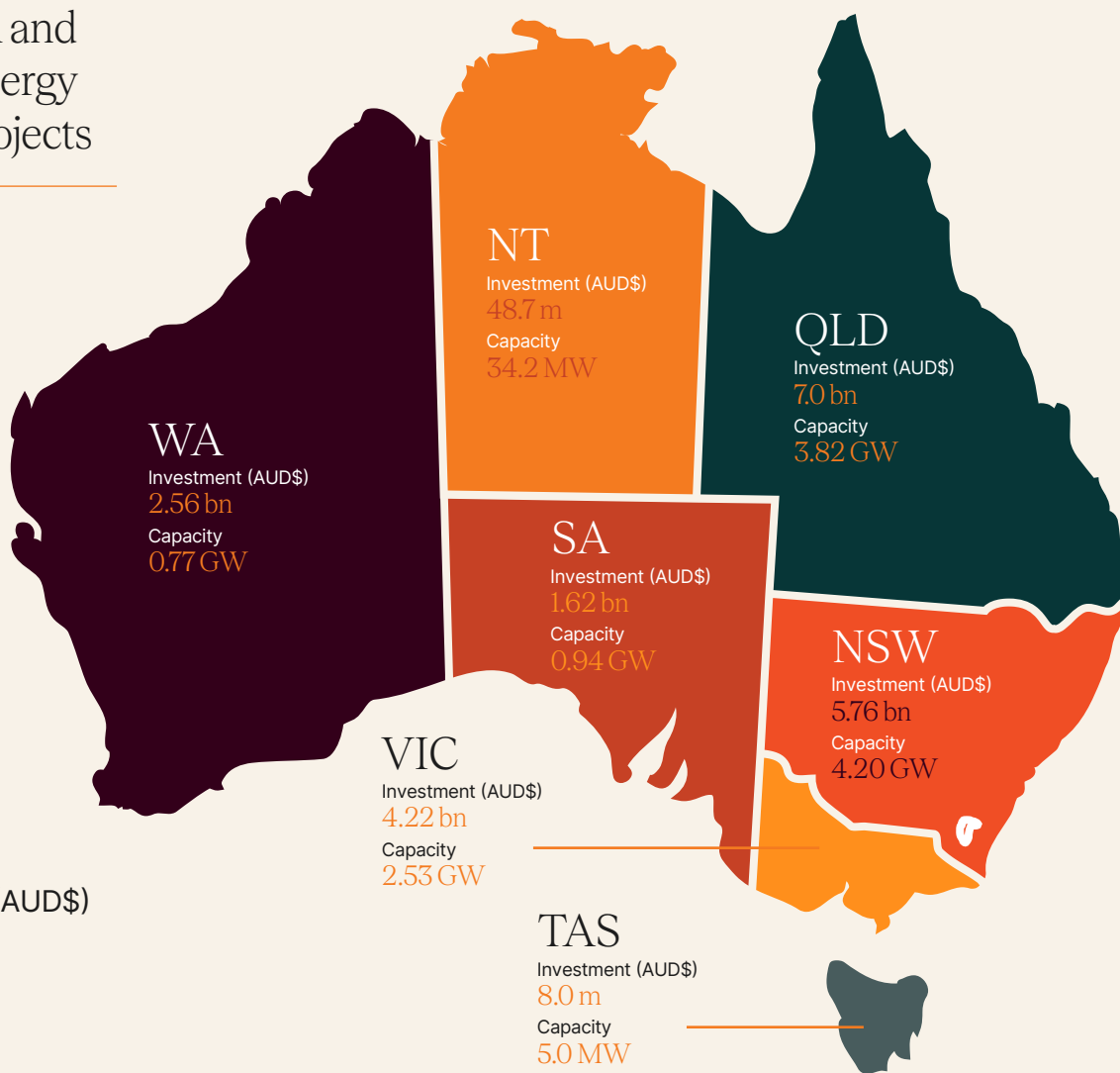
Australia's electricity generation mix in 2023 (fuel types by MWh)



Type of Fuel	Total MWh	MWh %
Black Coal	92,843,404	39.3%
Brown Coal	31,682,666	15.4%
Wind	31,559,920	13.4%
Rooftop solar	26,553,206	11.2%
Gas	17,267,583	7.3%
Solar	16,478,113	7.0%
Hydro	15,306,966	6.5%
Bioenergy	3,248,732	1.4%
Non-metered fossil	1,218,230	0.5%
Liquids	111,998	0.0%
Total	236,270,819	100.0%

Investment in and capacity of energy generation projects

Projects currently at financial commitment or under construction
(As at 31 December 2023)



Total investment (AUD\$)
21.23 bn
Total Capacity
12.29 GW

transport being the main driver of that growth. On a global level, electrified transport overtook renewable energy as the largest driver of spending, at USD \$634 billion, up 36 per cent year-on-year. Renewable energy investment rose 8 per cent to reach \$623 billion.

For more on international renewables in 2023, see page 48.

For a more detailed rundown of clean energy in Australia in 2023, visit the individual sections in this report.

Renewable energy projects completed in 2023

2.8 GW

Total capacity of large-scale renewable projects completed in 2023

Tech	State	Project	Lead Operator-Owner	Capacity (MW)
Solar	QLD	Western Downs Green Power Hub	Neoen Australia	400.0
Solar	NSW	New England Solar Farm Stage 1	ACEN Australia	400.0
Wind	VIC	Murra Warra Wind Farm Stage 2	Squadron Energy	209.0
Solar	VIC	Kiamal Solar Farm	Total Eren	200.0
Solar	NSW	Avonlie Solar Farm	Iberdrola Australia	200.0
Wind	QLD	Dulacca Wind Farm	Octopus Australia	180.0
Solar	QLD	Columboola Solar Farm	Hana Financial Investment	162.0
Wind	NSW	Bango Wind Farm 1	Squadron Energy	159.0
Wind	QLD	Kaban Wind Farm	Neoen Australia	157.0
Solar	QLD	Edenvale Solar Park	Eneos & Sojitz Corporation	146.0
Wind	VIC	Berrybank 2 Wind Farm	Global Power Generation	109.2
Solar	SA	Port Augusta Renewable Energy Park - Solar Farm	Iberdrola Australia	107.0
Solar	QLD	Mica Creek Solar Farm	APA Group	88.0
Wind	NSW	Bango Wind Farm 2	Squadron Energy	84.8
Solar	QLD	Warwick Solar Farm	The University of Queensland	64.0
Wind	QLD	Kennedy Energy Park Wind & Solar	Windlab	58.2
Solar	WA	Mt Keith Solar Farm	TransAlta	27.4
Solar	VIC	Cohuna Solar Farm	Enel Green Power	27.3
Solar	SA	Murray Bridge - Onkaparinga Pipeline Pump 2	South Australia Water Corporation	13.0
Solar	WA	Leinster Solar Farm	TransAlta	10.7
Solar	WA	Nova Nickel Mine Solar Upgrade	Zenith Energy	10.0
Solar	NSW	Wathagar Solar	Sundown Pastoral Company	8.7



INDUSTRY OUTLOOK

Small-scale renewable energy

Rooftop solar in Australia had another bumper year in 2023, with solar installations and capacity added both significantly up on 2022, while the uptake of household battery systems continues to increase.

In 2022, rooftop solar generated 9.3 per cent of Australia's electricity from all forms, and in 2023 this figure rose to 11.2 per cent, providing more than a tenth of Australia's total energy for the first time. This is another key milestone for the sector, and more proof that Australians are buying into the industry and looking to take more control of their energy costs. The year as a whole was a very positive one, with figures up across the board.

New capacity added from rooftop solar totalled 3.1 GW from 337,498 new rooftop solar installations. Both of those figures are significantly up on 2022, when 2.7 GW was added from 315,499 installations. The sector didn't quite reach the record levels seen in 2021, but wasn't far behind. According to SunWiz, November 2023 was the biggest ever month for rooftop capacity installed.¹

In 2023, the 3.1 GW of capacity added by rooftop solar comfortably surpassed that of the utility scale sector, which came in at 2.8 GW. The difference of 0.3 GW between rooftop and large-scale generation was similar to 0.4 GW in 2022. There are now approximately 3.7 million households with rooftop solar systems installed in Australia, up from 3.4 million at the end of 2022.

New South Wales led the way for installed capacity on a state level – as it did in 2022 – with just over 1 GW: the single-largest state-specific rise in installed rooftop capacity on record. Only WA and the NT recorded lower levels of rooftop solar capacity added than in

337,498

rooftop solar installations in 2023

(2022: 315,499)

3.1 GW

rooftop solar capacity added in 2023

(2022: 2.7 GW)

56,000+

household battery systems installed in 2023

(2022: 43,000+)

2022, and these dips were small: 276 MW versus 287 MW for WA, and 15.7 MW versus 19.3 MW for NT. The average size of solar systems installed also continued to trend upwards, reaching 9.3 kW compared to 8.7 kW in 2022.

In addition, Australian uptake of household batteries continues to grow. The Clean Energy Regulator

¹ S Vorrath, *RenewEconomy*, <https://reneweconomy.com.au/rooftop-solar-installs-smash-record-as-households-turn-to-bigger-systems-pu>

reported that to the end of September 2023, there had been more than 17,000 battery installations, a 14 per cent increase on the 15,000 reported in the same period in 2022. SunWiz figures for 2023 suggest the total number of storage units installed was approximately 56,000, up from 43,000 in 2022 and 37,000 in 2021, showing that more and more Australians are embracing energy independence.

For many years, the rooftop solar sector in Australia has been essential to the clean energy transition, and never was that more true than in 2023. While large-scale generation capacity added was not far behind that of rooftop solar, there was a significant slowdown in new financial commitments to renewable energy projects

“The importance of rooftop solar will only continue to grow as the large-scale industry works to overcome its investment slowdown”

in 2023, which may well reverberate in the market for some time. The importance of rooftop solar will only continue to grow as the large-scale industry works to overcome that slowdown. Additionally, with electricity prices rising year-on-year, more and more consumers are turning to solar and storage as a way to reduce their energy consumption from the grid and take control in reducing their bills.

Industry support

In February 2023, the Clean Energy Council, alongside a group of other peak and industry bodies, launched the New Energy Tech Consumer Code (NETCC). The NETCC superseded the Approved Solar Retailer (ASR) program to expand the coverage of consumer protections beyond just solar and storage, aiming to build on that program's success and ensure more Australian homes and businesses can access clean, affordable, new energy tech from trusted companies. The program is designed and governed by the NETCC Council and administered by the Clean Energy Council. Since the program launched, the Clean Energy Council has received 412 applications from businesses wishing to join the program, of which 356 have been approved. By the end of 2023, 1,572 companies were participating in the NETCC program.

The Clean Energy Council continued its rigorous compliance activity in 2023, opening 168 NETCC compliance cases against Approved Sellers, of which

29 resulted in compliance action. These actions were vital in maintaining the program's integrity and ensuring that Australian consumers purchased new energy tech products, systems and services from Sellers committed to good practice standards. To support Sellers in adapting to the NETCC program, the Clean Energy Council took a support-to-comply approach for compliance outcomes in the first six months of the NETCC's operation.

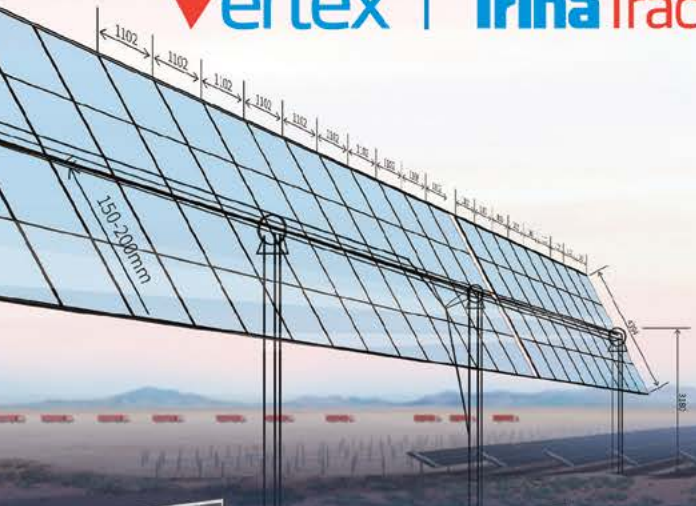
The Clean Energy Council also undertook compliance activities under the ASR program which came to an end in July 2023. The Clean Energy Council received 117 ASR complaints in 2023 and closed 177 ASR cases following investigation. Of the closed cases, 39 resulted in compliance action.

At the end of 2023, the number of Clean Energy Council accredited installers and designers was 9,262, up from 8,988 at the same point in 2022. The number increased in all states and territories except WA and NT, and there are now three international operations on the list, up from two in 2022. The total number of accredited installer and designers has risen consistently for eight years.

High Power Bifacial Module and Intelligent Tracker

The industry's only truly integrated power plant solution from Trina Solar that improves reliability, enhances project returns and lowers risk.

Vertex | TrinaTracker



585W

610W

675W

455W

505W

625W

645W

720W

Vertex

Vertex S⁺

Vertex N

Wide range of 210mm ultra-high power modules designed for all applications



For more information & videos

Join our upcoming events or watch the previous webinar in APAC region.

Trinasolar



INDUSTRY OUTLOOK

Large-scale renewable energy

The story of large-scale renewables in 2023 was a mixed one, with a strong figure for capacity added – 2.8 GW – but a considerable slowdown in new financial commitments to generation projects.

Large-scale renewable energy projects completed in 2023 totalled 2.8 GW of capacity across 22 completed projects. The number of projects is slightly up on 2022 (20), while capacity added is up from 2.3 GW.

Of the 22 projects completed in 2023, 15 were solar farms and seven were wind farms, with the two largest being Neoen's 400 MW Western Downs Green Power Hub solar farm in Queensland, and ACEN Australia's 400 MW New England Solar Farm Stage 1, in New South Wales.

The technology that added the most new large-scale capacity in 2023 was the large-scale solar sector, with 1.9 GW – up from 860 MW in 2022. That comes from 15 commissioned projects, up from 12 in 2022. This comes after three years in which the number of large-scale solar projects had fallen. As mentioned above, the two largest renewables projects to come online in 2023 were both 400 MW solar farms.

Large-scale solar contributed 15.9 per cent of Australia's renewable generation in 2023, up from 14 per cent in 2022, and accounts for 6.3 per cent of all electricity generation, up from 5 per cent in 2022.

The technology contributing the highest amount of utility scale generation capacity in Australia remains the wind sector, with 33.2 per cent of Australia's renewable generation and 13.2 per cent of electricity generation overall, although solar (when including large-, medium- and rooftop-scale systems), is of course the overall leader.

2.8 GW

of large-scale capacity added in 2023

(2022: 2.3 GW)

22

large-scale renewable energy projects completed in 2023

(2022: 20)

5 GW/ 11 GWh

approximate capacity of large-scale batteries under construction at end of 2023

(2022: 1.4 GW /2 GWh)

Seven new wind farms were commissioned in 2023, slightly down on eight in 2022. The figures for capacity added were more significantly down, with new wind farms providing 957 MW in 2023 compared with 1.4 GW in 2022. The largest wind farm commissioned in 2023 was Squadron Energy's 224 Bango Wind Farm, which is divided into two segments: Bango Wind Farm 1 at 159 MW, and Bango Wind Farm 2, at 84.8 MW, both of which commenced operations in 2023. Squadron also had the second-largest wind farm: the 209 MW Murra Warra Wind Farm Stage 2 in Victoria.

Dipping investment

There were 56 renewable energy projects under construction as of December 2023, down from 72 at the same point in 2022. The combined capacity of these projects is approximately 7.5 GW, significantly down on 9.5 GW at the end of 2022.

“2023 was the strongest ever year for new financial commitments in the large-scale storage space, at \$4.9 billion”

Of those 56 projects, 38 are large-scale solar projects and 13 are wind farms, both down from 2022, when there were 48 solar and 21 wind projects in development. There are currently three combined wind/solar projects in development (349 MW), and two biomass projects (61 MW).

But the more alarming statistic is the significant slowdown in new financial commitments to large-scale generation projects, which is usually a good signifier of the how the sector will perform in the years to come. New financial commitments stood at \$1.5 billion in 2023, substantially down on \$6.5 billion in 2022.

There were no new financial commitments to utility scale wind projects in 2023 (compared to six in 2022) – a disheartening situation that needs to be addressed – and seven new financial commitments to solar projects for a combined 912 MW, down from 10 projects and 1.5 GW in 2022.

Hopefully the Federal Government's move to attempt to incentivise new financial commitments to large-scale renewables projects – in the form of the expanded Capacity Investment Scheme, announced in late 2023 – will help reverse the current slowdown.

Storage takes centre stage

While it has been something of a chastening year for utility scale renewables in some respects, one area that has been storming ahead is the large-scale storage sector.

Twenty-seven large-scale batteries were under construction at the end of 2023, up from 19 in 2022, for a combined capacity of 5 GW / 11 GWh, up from 1.4 / 2 GWh in 2022. Those batteries will be spread around the National Electricity Market, too: three of the top five are to be located in New South Wales, one is in Victoria and one is in Queensland. The largest battery system currently under construction as at the end of 2023, is the 850 MW / 1,680 MWh Waratah Super Battery in NSW, which is being delivered by the NSW Government through its EnergyCo authority. Construction on that project is scheduled to be completed in August 2025. The largest utility scale battery storage project commissioned in 2023 was the 150 MW / 300 MWh Riverina Energy Storage System.

The large-scale storage sector has also been blazing a trail in terms of new financial commitments. Q2 2023 saw the billion-dollar mark for new large-scale storage investment broken in a quarter for the first time, and Q4 broke that record just a few months later, making 2023 the strongest ever year for new financial commitments in the large-scale storage space, at \$4.9 billion including hybrid projects with storage elements (\$4.7 billion for storage-only projects). By comparison, 2022 reached \$1.9 billion in new financial commitments to large-scale storage.

After a 2022 in which the story for large-scale storage was not overly positive, 2023 represented a welcome boost to the industry. Large scale batteries will be essential going forward to provide the firming capability the energy grid will need as more renewables are added and more fossil fuel generation is retired.

Other generation sources

2024 could be the year Australia gets its first new hydropower project in over 40 years, as Genex Power's 250 MW / 2,000 MWh Kidston Pumped Storage Hydro Project is scheduled to be operational before the year is out. Hydropower generation for 2023 totalled approximately 15,307 GWh, down on 16,537 GWh in 2022 – a 7.4 per cent decrease year-on-year. Statista predicts that the annual growth rate of hydropower in Australia will be 2.67 per cent from 2024-28, and that the hydropower market is projected to amount to 14.73 billion kWh in 2024.¹

Bioenergy provided 3.5 per cent of Australia's renewable energy generation in 2023, down from 3.8 per cent in 2022. The *Transitioning Australia's Liquid Fuel Sector: The Role of Renewable Fuels* Report by Bioenergy Australia and Deloitte, published in 2023, highlighted a number of decarbonisation opportunities for Australia, including that replacing just six per cent

¹ Statista, <https://www.statista.com/outlook/io/energy/renewable-energy/hydropower/australia>

of petrol with bioethanol, based on targets, would be the equivalent of taking 730,000 vehicles off the road, and that replacing just 10 per cent of jet fuel with sustainable aviation fuel, based on airline targets, could be the equivalent of around 220 million less kms flown annually by a Boeing 747.

As mentioned above, investment in large-scale battery storage projects was very high in 2023, but even factoring in that exceptional performance, overall investment (\$6.2 billion) was still down on 2022 (\$7.9 billion).

According to the Australian Energy Market Operator (AEMO), at the end of Q4 2023, “new capacity totalling

36 GW was progressing through the connection process from application to commissioning. During Q4 2023, AEMO approved applications for 6.5 GW of capacity across 28 projects, a notable increase from 1.7 GW across 11 projects in Q4 2022.”²

The pipeline is there for Australia to make significant strides in large-scale renewables, but in a year of highs and lows for the sector, it is key that the Federal Government’s expanded Capacity Investment Scheme is delivered in the right way to bring on the financial commitments the country needs to accelerate the deployment of large-scale renewables.

FOCUS ON

Connection reform initiative

The Clean Energy Council (CEC) continues to collaborate with the Australian Energy Market Operator (AEMO) and other National Electricity Market stakeholders to improve the process of connecting new renewable energy plants and storage to the grid. To do this, the Connection Reform Initiative (CRI) seeks to achieve three key objectives:

1. Developing a consistent and predictable connections process that delivers repeatable outcomes;
2. Reducing the amount of re-work and improving efficiency and quality of information to address information asymmetry; and
3. Creating a collaborative working model between industry, AEMO and the network service providers (NSP).

In 2023, the CEC led the effort to develop and submit a request to the Australian Energy Market Commission (AEMC) to update the National Electricity Rules so they provide better certainty for investors during the registration process for new generation plants and speed the connection process. Developing the rule change involved consulting with AEMO, NSPs, Clean Energy Council members, investors, and experts from KPMG.

Since submitting the rule change request in May 2023, the CEC has remained engaged with stakeholders through the public rule change process. This has included providing input during the AEMC’s public consultations, supporting AEMC staff in creating a technical working group (TWG) to understand the problems, and participating in TWG workshops.

The CEC also supported AEMO’s efforts to lead reviews of the rules for generating system alterations, for example when adding a battery or additional wind turbines to a generating system, or when modifications are required to new plants prior to connection to keep the grid reliable.

CRI work will continue in 2024, and the CEC will continue to engage with the investment certainty rule change, expecting it to become finalised. There will also be opportunities to engage with AEMO as it progresses its review of rules for generator system alterations. Likely this will include creating fact sheets, reviewing modelling requirements for older wind and solar farms, and submitting a rule change request to the AEMC.

² Australian Energy Market Operator, *Quarterly Energy Dynamics Q4 2023*

Federal politics

After a year of significant renewable energy records but also a slowdown in new financial commitments to utility scale generation, bold policy action was required to ensure Australia continues to build on its strong clean energy foundations.

Several clean energy records were broken in 2023, but we also saw a continued slowdown in new investment in large-scale generation, meaning 2023 was a year in which bold policy action was required.

Clean energy was a real winner in the May Federal Budget, with new funding commitments aimed at turbo-charging Australia's bid to become a clean energy superpower. Chief among those was a \$2 billion commitment in production incentives for the nascent renewable hydrogen industry, Australia's first serious policy mechanism aimed at keeping Australia competitive in the global renewables race, particularly in light of key international policies such as the US's Inflation Reduction Act, which are already beginning to Hoover up talent and investment. Some of the clean energy highlights from the May Budget are collected on the opposite page.

With the 33,000 GWh Renewable Energy Target achieved in 2020, and the scheme due to sunset in 2030, the Clean Energy Council campaigned strongly throughout the year for the Federal Government to commit to a long-term national policy mechanism to drive increased and sustained investment in large-scale renewable energy projects and support achievement of an 82 per cent renewable energy share by 2030.

The announcements in the Federal Budget were an excellent start, but the key policy enactment in this space came in November, when the Government announced an expansion of the Capacity Investment

Scheme, a significant commitment that is intended to put Australia back on track to achieve the government's target of 82 per cent renewables by 2030, replacing aging coal-fired generation with cheaper renewable energy and driving down power prices.

“The Federal Government announced an expansion of the Capacity Investment Scheme, a significant commitment that is intended to put Australia back on track to achieve the Government’s target of 82 per cent renewables by 2030”

Investment in large-scale scale projects has been in gradual decline since the highly successful Renewable Energy Target (a policy that had delivered substantial investment) was met in 2020. It is now up to the government, alongside industry, to ensure its bold new policy lives up to its intent. It is crucial that the new policy provides increased certainty to investors and can bring in the enormous private sector capital that will be required.

For state-specific highlights and trends, go to page 24.

\$2 bn

commitment in production incentives for **renewable hydrogen** industry

\$300 m

in funding to be matched by the states for a total of \$600 million to help provide **energy-efficiency upgrades for social housing**

\$1 bn

for the Clean Energy Finance Corporation to provide green finance for residential **home electrification and energy upgrades**, including provision for landlords to support rental housing.

\$38.2 m

for a **Guarantee of Origin** scheme to certify renewable energy and green hydrogen production

\$14.8 m

to establish the **Powering Australia Industry Growth Centre**, to help manufacturing, commercialisation of local ideas, and to bring First Nations advisory services

Funding for First Nations Community Engagement with **green hydrogen development on Country**

Significant new generation and storage through the **Capacity Investment Scheme**

Confirming budget commitments for the **Net Zero Authority** and the **Small Business Energy Incentive** program

State targets and commitments



Key initiatives, targets and updates for Australia's states and territories

New South Wales

- Halve emissions by 2030
- Net-zero by 2050
- NSW Electricity Strategy includes \$8 billion of new private investment over the next decade
- Almost 200 large-scale renewable energy projects totalling almost 35,400 MW in the NSW planning system, representing almost \$50 billion in investment
- Passage of NSW Climate Change (Net Zero Future) Bill in December 2023, enshrining the state's energy transition into law



Tasmania

- 150 per cent renewable electricity generation by 2030
- 200 per cent renewable electricity generation by 2040
- Net zero by 2030



Queensland

- Queensland Energy and Jobs Plan, released Sept 2022, targets 70 per cent renewable energy by 2032 and 80 per cent by 2035. Announced in 2023 it will be enshrined into law, along with state's renewable energy targets
- \$145 million Queensland Renewable Energy Zones initiative
- Investing \$22 million to investigate constructing a 2 GW pumped hydro energy storage facility at Borumba Dam
- QLD halfway to achieving 2030 renewable energy target¹

¹ QLD Government, <https://statements.qld.gov.au/statements/98416>



South Australia

- 100 per cent renewables by 2030
- Hydrogen Jobs Plan to lead construction of hydrogen power station, electrolyser and storage facility by end of 2025
- Hydrogen Action Plan: \$40 million in grants and loans to three megawatt-scale renewable hydrogen projects



Victoria

- 50 per cent renewable electricity generation by 2030, with an intention to increase this to 65 percent
- Stated ambition to legislate for 95 per cent renewable electricity generation by 2035
- At least 6.3 GW of energy storage by 2035
- By mid-2030s, electric vehicle use to increase by more than 1,600 per cent



Australian Capital Territory

- Aim to move completely away from gas usage by 2045
- Net-zero by 2045
- Integrated Energy Plan is in development to set out how ACT will move away from fossil fuels



Western Australia

- 80 per cent emissions reduction target by 2030
- Approx. \$3.8 billion to be invested in green power infrastructure
- \$22.5 million commitment to help streamline approvals for green energy proposals



Northern Territory

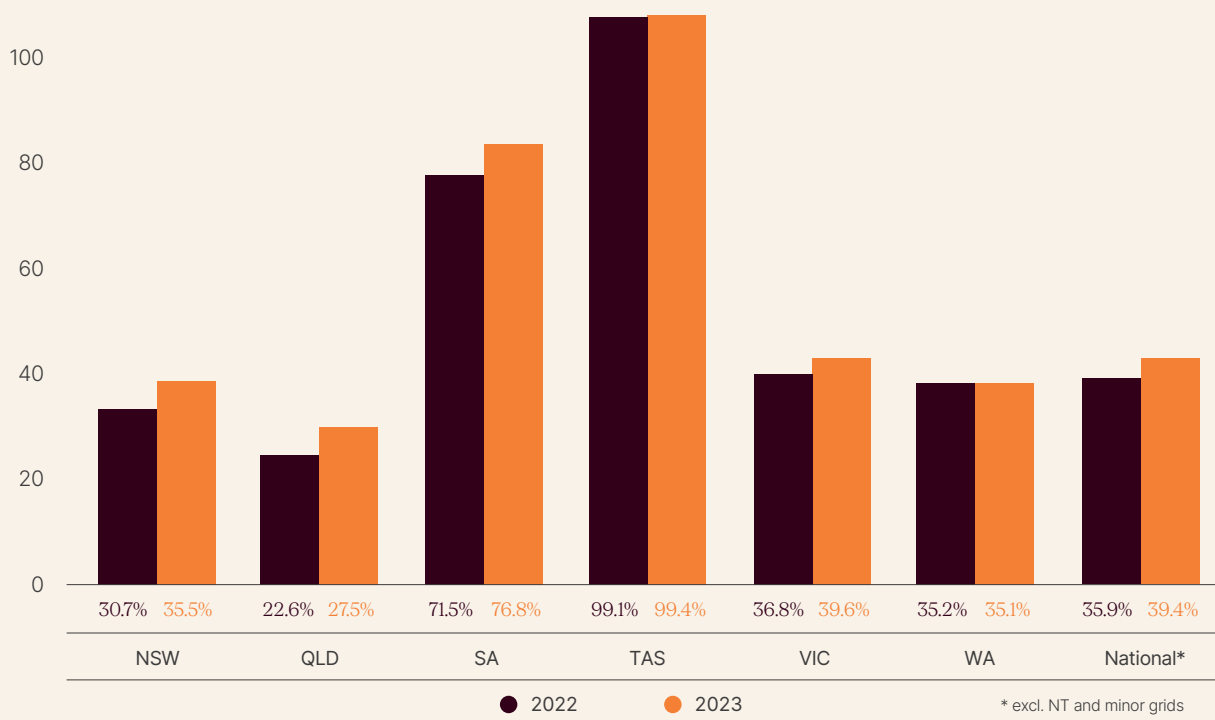
- 50 per cent renewable electricity generation by 2030
- Net-zero by 2050

Renewables by state

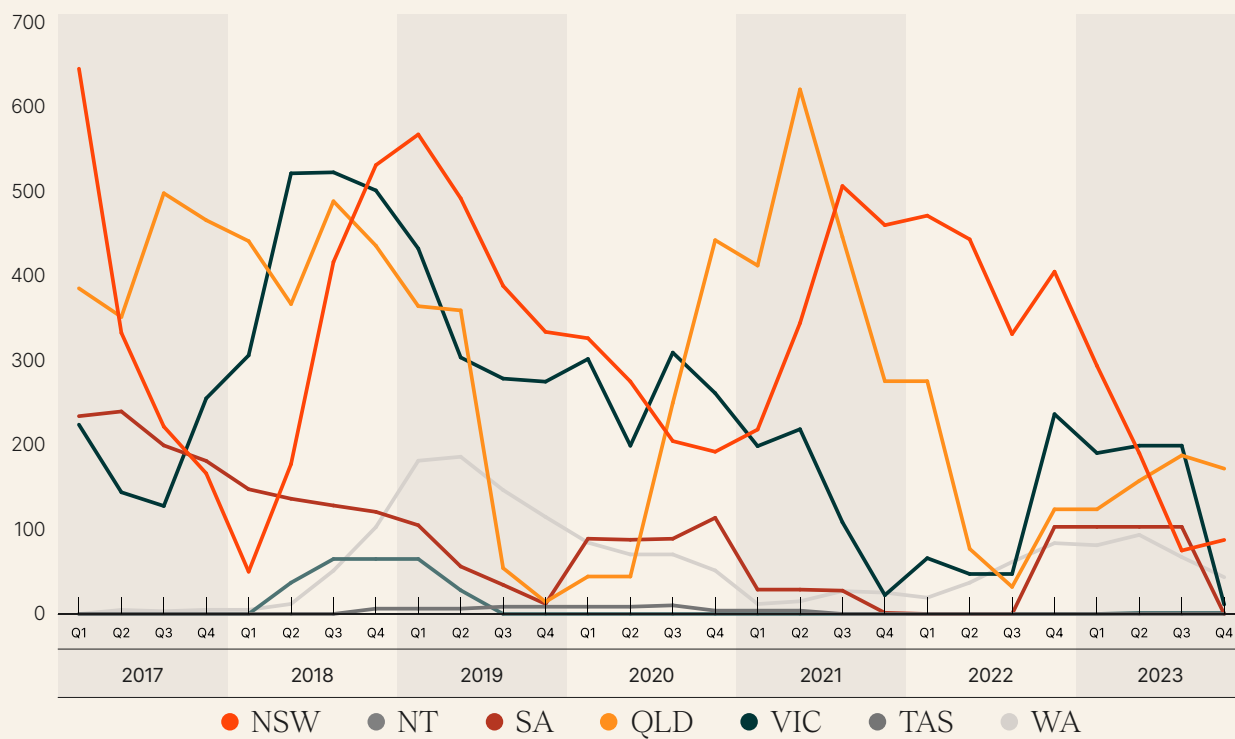
Renewable energy penetration by state, 2023

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
NSW	70,418	45,433	24,985	35.5%	32.5%
QLD	66,763	48,411	18,352	27.5%	28.8%
SA	13,761	3,186	10,575	76.8%	72.5%
TAS	10,652	63	10,588	99.4%	93.4%
VIC	53,698	32,408	21,290	39.6%	43.6%
WA	20,979	13,623	7,356	35.1%	35.1%
National (excl. NT and minor grids)	236,271	143,124	93,147	39.4%	39.4%

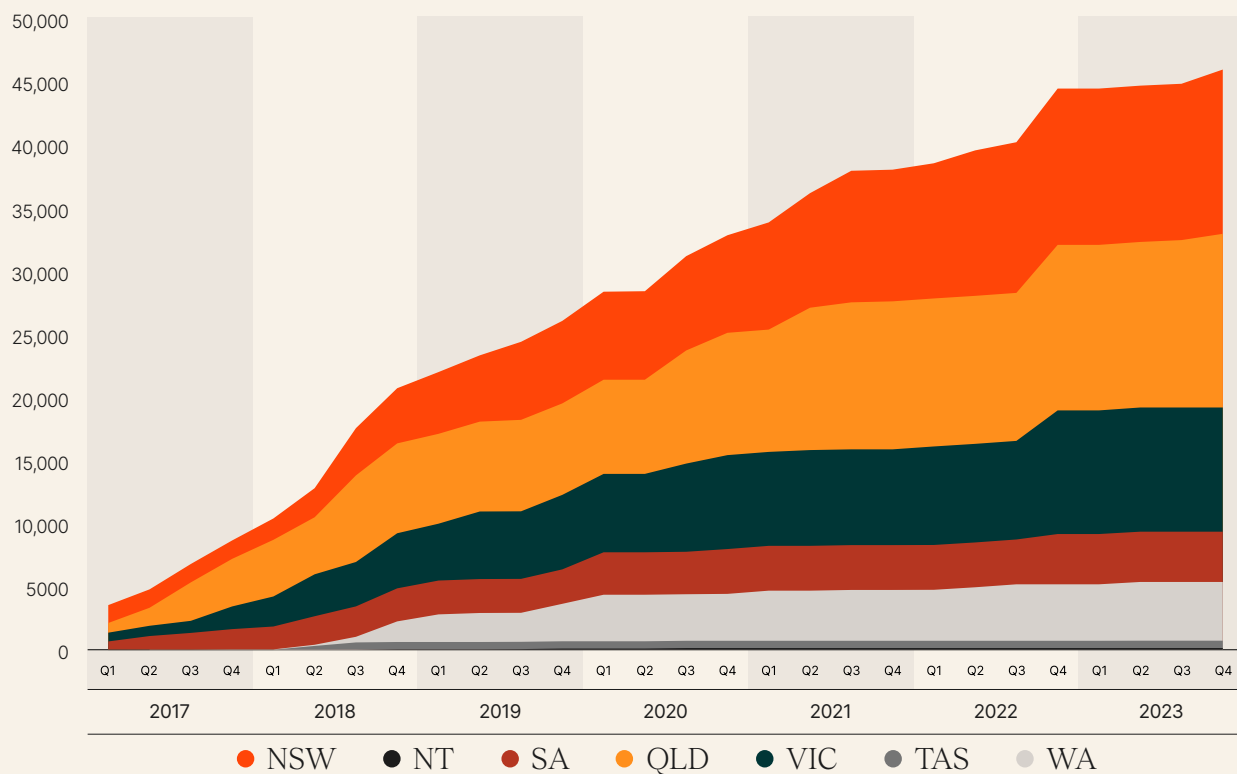
Renewable energy penetration by state as proportion of generation



Rolling 12-month average of installed capacity (MW) of generation projects by state



Cumulative investment in generation projects by state (\$M)





○ Jabiru Hybrid Renewable Power Station
Jabiru, NT
Mirarr Country
(EDL Energy)

Employment

Jobs and Skills Australia completed a landmark report in 2023, laying foundations to address structural workforce challenges experienced by the clean energy industry.

The clean energy industry experienced ongoing workforce challenges in 2023. Global competition for investment and workers continues to intensify due to state industrial policy, producing high costs across the supply chain. Tight conditions due to low unemployment and high participation endure throughout the broader workforce. Key occupations and skills are in persistent shortage across Australia, including the construction workforce, electricians, engineers, and major groups including Technician and Trades Workers and Professionals.

Despite existing skill shortages challenges, the industry has a growing project pipeline that will exacerbate these pressures if unaddressed. The Australian Energy Market Operator (AEMO)'s 2024 draft Integrated System Plan (ISP) expanded uptake of utility-scale wind, solar and batteries to 2030, reflecting increased state and federal ambition to rapidly decarbonise electricity generation. When compared with the 2022 ISP, this requires an additional 24,000 direct clean energy jobs by 2030, an 81 per cent increase on previous projections. Queensland introduced its Energy and Jobs Plan to Parliament, which will legislate renewable energy targets and defines a pathway to deliver 22 GW of new wind and solar projects by 2035. According to the government, this will support 64,000 direct and indirect jobs in construction and operations and maintenance, and 36,000 jobs in the supply chain. The scale and pace of workforce change required to 2030 is urgent and requires coordinated reforms.

This message, and the call for a planned response led by the federal government, has been a core focus of Clean Energy Council (CEC) advocacy for some time. In

response, the commonwealth commissioned the newly established Jobs and Skills Australia to undertake a capacity study of the current and future state of the clean energy workforce. The result was *The Clean Energy Generation* report, a landmark analysis of the problems facing a growing industry. The report defined the workforce for the first time and identified emerging skill gaps through whole-of-economy workforce projections. It also examined the barriers to participation from underrepresented cohorts including women, First Nations people and skilled migrants. The report found that while there are sufficient workers overall, there is a significant mismatch between projected demand for workers and available supply of vocationally trained occupations.

“Despite existing skill shortages challenges, the clean energy industry has a growing project pipeline that will exacerbate these pressures if unaddressed”

The report made 50 recommendations that echoed many of the Clean Energy Council's recommendations from the *Skilling the Energy Transition* report. They call for comprehensive reforms across multiple sectors to attract, train and retain workers. These included higher education, vocational education and training, skilled migration, industry, and government. It also addressed several key reforms across these sectors that were initiated in 2023, including a new National

Skills Agreement, a review of higher education leading towards a new Universities Accord, and the Australian Government's Migration Strategy. The recommendations will also inform the work of new bodies including the Net Zero Economy Agency, which was established to support regional fossil-fuel dependent communities in a just transition, and Powering Skills Organisation, the new Jobs and Skills Council for the energy sector.

In a context of tight workforce conditions, promoting diversity, equity and inclusion is essential to resolving skill shortages by enhancing attraction and retention of workers to the industry. This is an enduring challenge in clean energy, acknowledged by governments and industry, with many key occupations heavily male skewed. The Federal Government and the CEC have committed to Equal by 30, which aspires to deliver equal pay, equal leadership, and equal opportunities for women in the clean energy sector by 2030. The CEC also expanded its Women in Renewables (WiR) Program to include a Mentoring Program that facilitates connections and support for women in the industry as they progress their careers. The CEC's WiR program also includes:

- **Women in Renewables Scholarships**, including the Chloe Munro Scholarship for Transformational Leadership and the Australian Institute of Company Directors Scholarship. These enable professional development of women in the clean energy industry.
- The **Panel Pledge**, which commits signatories to only participate in forums and panels that embrace gender diversity.
- A **Speakers Guide**, which showcases the breadth, expertise and knowledge offered by women in the sector to event organisers.
- The **Career Launcher Program**, which enables member companies to sponsor a student or recent graduate who identifies as a woman to attend a major conference.

To address the visibility gap for young people seeking a career in clean energy, the Clean Energy Council and the Energy Efficiency Council jointly delivered the inaugural Careers for Net Zero Fair. The Fair launched the Careers for Net Zero campaign, which is designed to help fill Australia's skills gap and encourage job seekers to pursue a clean economy career. It showcases the many occupations needed to deliver the clean energy transition in Australia and information on pathways into the industry.

Diversity and inclusion in renewables

The Clean Energy Council 2021 report *Empowering Everyone* concluded that the clean energy industry had

significant opportunity – and obligation – to improve the representation of many traditionally underrepresented groups: women (particularly in leadership roles and the trades), Indigenous Australians, people with disabilities, and more.

The report, *The Clean Generation: Workforce needs for a net zero economy*, published in late 2023 by Jobs and Skills Australia, goes into detail on what the clean energy sector needs to work on.

Representation of women

The JAS concludes that little has been done to so far to counter the fact that the clean energy workforce is predominantly male, “especially amongst the critical occupations for clean energy supply and demand”. JSA analysis has shown that “the majority of occupations in shortage have a substantially gendered workforce, most of which are male dominated”.

First Nations

According to the JSA report, First Nations peoples are represented more strongly (3.4 per cent) in the traditional mining sector than they are in clean energy, where representation matches the labour force average of around 1.9 per cent. The JSA recommends expanding Indigenous Range and Caring for Country programs across the country; revising employment, training and educational targets for clean energy developments on First Nations land; and more.

People with disability

There is not enough understanding in key institutions of accessible careers options in clean energy for people with disability. “The Government [should] collaborate with clean energy employers and disability support organisations to identify suitable career options for people with disability” says the JSA.

Migrants

The qualifications of migrant workers tend to be undervalued, concludes the JSA, and “overseas-born engineers are significantly more likely to be unemployed or underemployed”. JSA analysis shows a high proportion of non-citizens with electrical engineer degrees are working in lower skilled jobs. The Diversity Council Australia also revealed that institutionalised racism remains a factor, with nearly nine in 10 respondents to its Racism at Work survey saw racism as a problem in their workplace.

The above statements and figures present a massive challenge for the clean energy industry, but also a massive opportunity. The industry needs so many more workers, in so many different areas, to build and maintain the energy transition, that there should and can be a place for everybody.



CASE STUDY

Powering and empowering: clean energy is for everyone

The transition to clean energy will be the most significant economic transformation since the industrial revolution. The mechanics of that transformation – the projects we need to build, the grid we need to re-shape, the policies we need to reform – tend to be the focus. But while those things are essential, so is ensuring that the clean energy industry is diverse and inclusive.

Workplaces should reflect and respect the ideals and perspectives of society and the employees who constitute them, primarily because that is simply the right thing to do, but also because research consistently shows that diverse and inclusive organisations are more likely to be effective, innovative and provide excellent customer service.

The Clean Energy Council spoke to Amanda White, then-Global Head of Diversity and Inclusion at RES Group (RES), to talk about diversity in the clean energy industry, the barriers we need to remove, and the pathways into the industry we need to build.

“According to a recent report by DCA (Diversity Council Australia), there are three million people looking for work in Australia, most of whom are from marginalised groups,” said White. “Too many candidates are being overlooked due to systemic barriers and processes that are open to bias and discrimination.

“Employment policies and processes need to be designed with inclusion in mind, demonstrating to people that your organisation is welcoming and safe. Things like gender-neutral parental leave, LGBTQ+ allyship training, domestic family violence support, cultural holiday swap and gender affirmation policies help to signal safety as well as inclusion.

“To get more people into clean energy, we need to amplify the range of roles within renewables, partner with organisations to reach diverse talent, and demonstrate safety and inclusion throughout our entire talent lifecycle processes.”

View this case study in full at the Clean Energy Council website.

Chloe Monroe Scholarship for Transformational Leadership 2023 recipients

In recognition of the enormous legacy of the late Chloe Munro AO, the Clean Energy Council and a coalition of organisations established the Chloe Munro Scholarship for Transformational Leadership. The scholarship honours Chloe's legacy and supports the next wave of women leaders. Building on the success of the inaugural 2021 scholarship, there were 11 recipients in 2023, each of whom is doing fantastic work in our industry.

The scholarship is open to emerging and mid-level women leaders in the fields of renewable energy, energy management and carbon abatement. Successful applicants will receive a fully funded scholarship to undertake one of two courses offered by education provider, Women & Leadership Australia.



Catherine Featherstonhaugh
Head of Commercial Asset Management, RES



Maiken Hansen
Commercial Manager, Green Energy Partners



Gemma Harrison
Hydrogen Business Development Manager, Ampol Australia



Jessica Holt
Generation Technician, Hydro Tasmania



Manuela Londono Ferro
Business Development Lead, Raygen



Alice Moore
Principal Policy Officer, DEECA



Lara Panjkov
Growth and Market Development Senior Manager, Fluence



Sera Tarpis
Engineer, Australia Energy Market Operator



Dr Madeline Taylor
Senior Lecturer, Macquarie University



Sharon Tissai-Krishna
Associate Technical Director, Ampyr Energy



Claire Whiteway
National Development Lead E&P, Aurecon



○ Tyronne Garstone talking with Kimberley locals Broome, WA Yawuru Country (Pollination)

CASE STUDY

Energy sharing: clean energy on Country

Community engagement and collaboration is essential to a just energy transition, particularly with the Traditional Owners of the lands on which many renewable infrastructure projects will be built. The Clean Energy Council spoke to the leaders of the Aboriginal Clean Energy Partnership, which is working with Traditional Owners as equal shareholders in its East Kimberley Clean Energy Project in Western Australia.

The project is being built around a partnership in which the Traditional Owners of the land, represented by MG Corporation and Balangarra Aboriginal Corporation, will join the Kimberley Land Council and climate change investment and advisory firm Pollination as equal shareholders.

“We know that in Australia, around 48 per cent of the renewables we are going to need to get to net zero will have to be located on land that is subject to some kind of native title or traditional ownership. It’s not just a case of us wanting this model to work; we say it must work. This is by far the most inclusive, most commercially astute and least risky way of building the future infrastructure that is going to be needed,” said Rob Grant, Head of Projects at Pollination.

The project has moved through the scoping phase and is currently at the stage of project feasibility and design, alongside approvals applications. When completed, it will consist of a 2000-hectare solar farm developed on MG Corporation freehold land near Kununurra. The solar farm will produce approximately 1 GW of energy, which will be combined with fresh water from Lake Kununurra and hydro energy from the Ord Hydro Power Plant at Lake Argyle to produce green hydrogen.

Building renewable energy projects on First Nations land need not represent a clash of values. “We’ve seen the impacts of what the dirty energy revolution has done not only to our own country but more broadly to the world,” said Tyronne Garstone, CEO of Kimberley Land Council. “The clean energy movement is aligned to Traditional Owners’ values and core responsibility to look after Country.”

To learn more, visit the Aboriginal Clean Energy Partnership website, or find the full case study at the Clean Energy Council website.



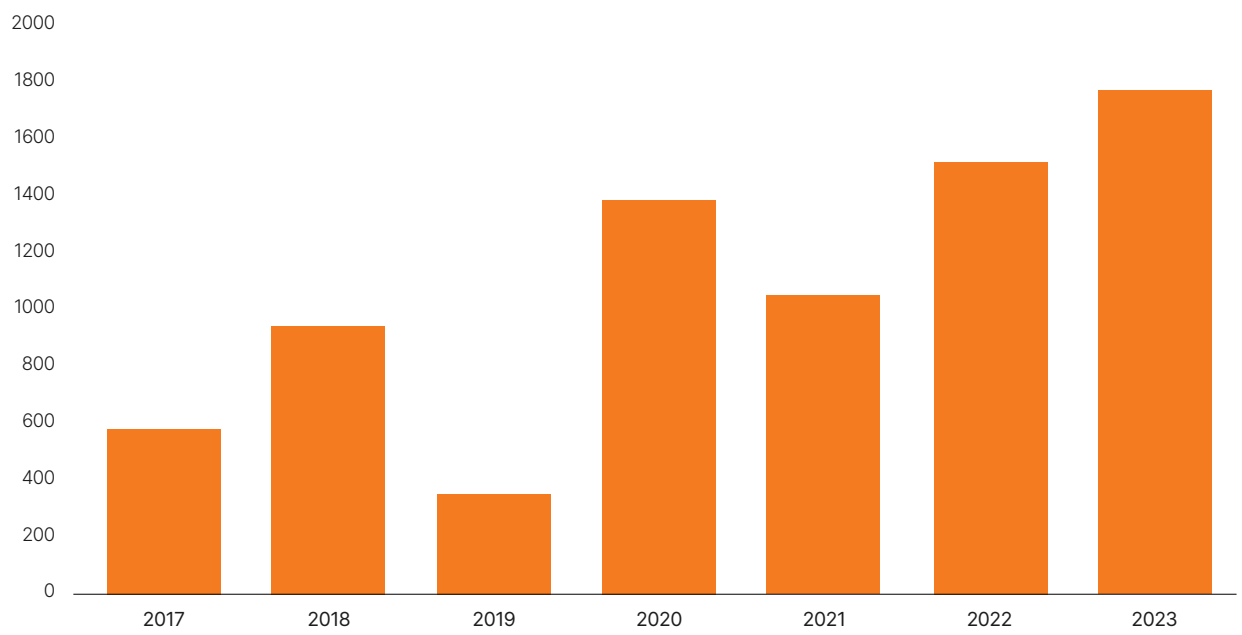
○ Western Downs Green Power Hub
Western Downs, QLD
Barunggam Country
(Neoen)

Renewables for business

Corporate Renewable Power Purchase Agreements (PPAs) had another record-breaking year in 2023. For the second year running, deal volume hit a new record – just over 1,700 MW, up from around 1,500 MW last year.

Many participants described the Australian corporate renewables PPA market in 2023 as a 'sellers' market' with an excess of demand for PPAs relative to supply. Buyer demand, underpinned by net zero and sustainability targets, remains high while various factors such as transmission constraints slowed the development of new renewable energy projects. There were various manifestations of a sellers' market, including reports of developers conducting quasi-auctions among buyers instead of the more usual buyer tenders.

Capacity contracted (MW)



Content and data supplied by Business Renewables Centre Australia

In a more challenging market, it was notable that many of the deals were signed by experienced, high-profile corporates that had already signed PPAs:

- BHP: 6th PPA (203 MW, MacIntyre Wind Farm, Western Downs Green Power Hub & Kaban Wind Farm & storage, Qld)
- Ikea: 1st PPA (195 MW, Golden Plains Wind Farm, Vic), 2nd PPA (13 MW, Peak Hill & Trundle Solar Farms, NSW) and 3rd PPA (152 MW, Tilbuster Solar Farm, NSW).
- Telstra: 5th PPA (60 MW, Munna Creek Solar Farm, Qld) and 6th PPA (70 MW, Bundaberg Solar Farm, Qld)
- Woolworths: 3rd PPA (205 MW, Bango Wind Farm and Darlington Point Solar Farm, NSW).
- NBN: 2nd (29 MW, Macarthur Wind Farm, Vic) and 3rd PPA (27 MW, Munna Creek Solar Farm, QLD).
- Lion Brewery: 2nd PPA (71 MW, Woolooga Solar Farm, QLD).

Fortescue Metals signed the first 'hydrogen PPA' in Australia (a trend also observed in Europe), a 338 MW PPA with Bulli Creek solar farm (and battery). Consequently, there was a notable shift towards larger deals (>100 MW) and fewer small deals (<20 MW) in 2023.

As with past years, public sector organisations were also prominent, notably regional local government buyer groups. There were also some household names who were first-time PPA buyers: Arnott's, Asahi, Boral and Optus.

Ups and downs and continuity

For the past four years, Business Renewables Centre Australia (BRC-A) has conducted an annual survey of buyers, advisers and developers – which for the most part has found continuity on the drivers for PPA buyers. The great electricity market crisis of 2022 had only a limited impact on Corporate PPAs – if anything, most buyers, advisers and developers reported the market volatility in 2022 had a positive impact on demand for PPAs, and most consider it didn't ultimately have a major impact.

The PPA market continues to be driven by buyers with sustainability targets: BRC-A's annual survey has year after year found around two thirds of buyers nominate sustainability targets or policies as the major catalyst for pursuing a PPA ahead of price or financial considerations. The growth in organisations with net zero targets continues to underpin demand for Corporate PPA.

Financial risk, price and developers are the top-line considerations for buyers assessing PPAs – but community and environmental issues are rated higher than developers think: once buyers go through the

process and are evaluating PPA offers, the top three issues have consistently been financial risk, price and developer reputation (in that order), but buyers have also consistently ranked the second tier of issues (community support, benefits, environment and biodiversity) higher than developers expect.

PPAs are still hard to do – but may be getting a little easier. Fewer buyers have reported it took longer than 18 months to negotiate PPAs in the past couple of years and more buyers rank the difficulty as a '3' or '4' than a '5'. Buyers report the key barriers are securing internal support and the challenge of finding the right PPA model to fit their organisation – but it appears they are a bit quicker and easier than earlier years.

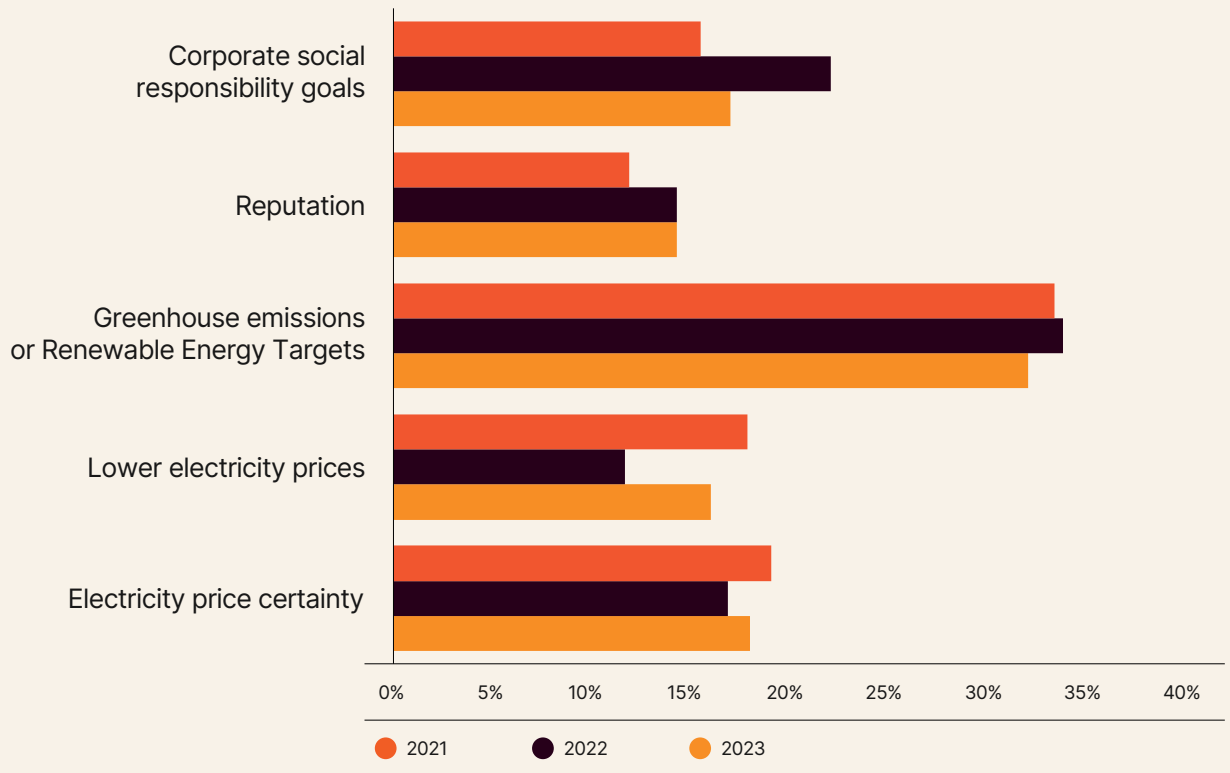
In 2022, there were virtually no PPAs with new projects. This year, deal volumes were evenly split between PPAs with new projects (28 per cent), 'committed' projects that had secured finance (33 per cent) and operational projects (39 per cent). The year was headlined by a new PPA by Fortescue Metals. NBN, Telstra and off-grid miner Bellevue Gold also negotiated new PPAs.

“Business Renewables Centre Australia’s annual survey has year after year found around two thirds of buyers nominate sustainability targets or policies as the major catalyst for pursuing a PPA ahead of price or financial considerations”

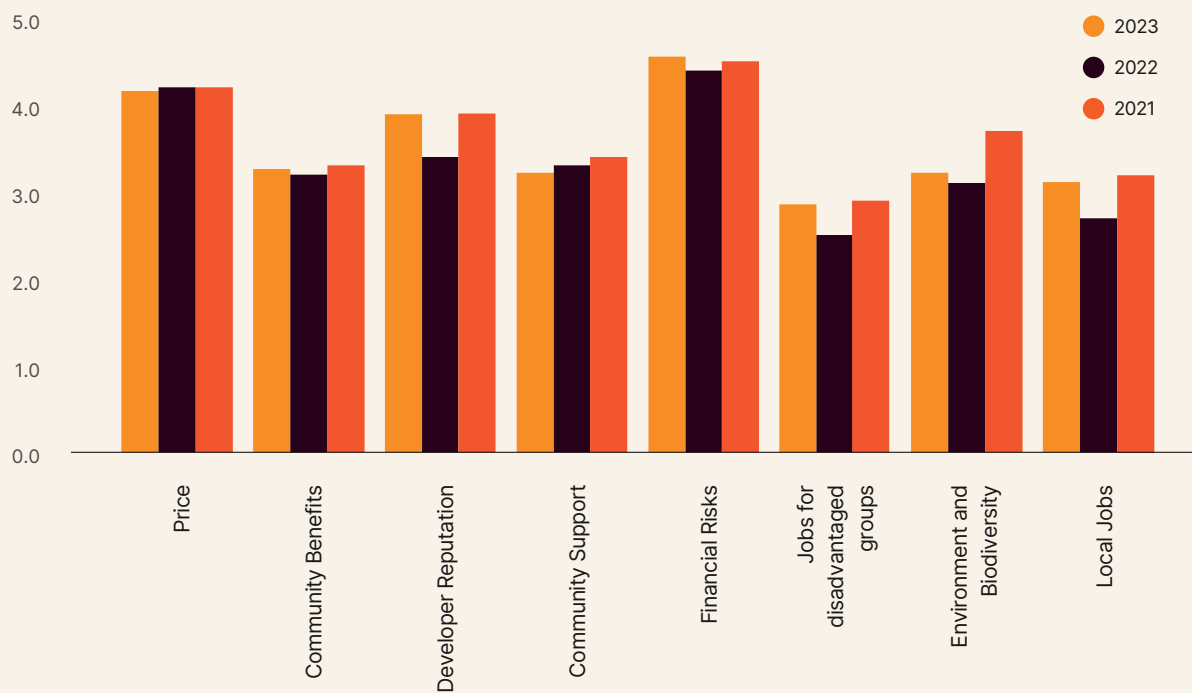
In general, there has been a lower volume of PPAs with new projects in recent years, which reflects the slowdown in supply and increased risks associated with contracting with new projects for Corporate PPA buyers and the now-established retailer market for PPAs with operating projects.

Content and data supplied by Business Renewables Centre Australia

What is the primary driver for your interest in Corporate Renewable PPAs?



Key factors for PPA buyers evaluating offers, average rating, 2021-23



Content and data supplied by Business Renewables Centre Australia

What is the future role of corporate PPAs?

The Corporate PPA market continues to evolve and reflect the wider dynamics of the energy transition. In the first phase (2016-20), Corporate PPAs were primarily developed by large corporates to leverage greater financial value and environmental impact from their renewable energy purchases through wholesale PPAs negotiated directly with new projects. In the second phase (2020-23), Corporate PPAs (partly) filled the void left by the decline in PPAs from major retailers after the achievement of the 2020 RET target, and the market expanded to a wider diversity of buyers via de-risked PPAs with operational projects brokered by retailers.

Corporate PPAs may now be entering a third-phase as the post-RET policy architecture is established, through the Renewable Energy Guarantee of Origin scheme, Capacity Investment Scheme (CIS) and Renewable Energy Zones. In late 2023, the Federal Government announced an expansion of the Capacity Investment Scheme, which has major implications for Corporate PPAs. From April/May 2024, competitive tenders will be held every six months until 2027 to contract 23 GW of renewable energy and 9 GW of dispatchable resources (e.g. battery storage). Although the scheme design is not yet established, it appears the CIS will be a variation on the NSW Long-Term Energy Supply Agreement (LTESA) auction model.

What are the implications for Corporate PPAs? Some participants and analysts have for some time projected that Corporate PPAs are a passing trend which will fade out as traditional parties re-enter the market for renewable energy. Certainly, one scenario is that Corporate PPAs will be crowded out as projects focus on bidding for contracts under the CIS. This is possible and may well be part of how the market changes, but it is unlikely that Corporate PPAs will fade out in our view. Demand for Corporate PPAs is underpinned by emissions reduction, ESG and reputational drivers that will continue.

However, the CIS in particular will certainly impact on the dynamics of the Corporate PPA market. The experiences of NSW and Queensland provide some indications on the potential implications. In Queensland, state-owned utilities with mandates to sign PPAs have emerged as the dominant entities for contracting with new projects. Most (but not all) corporate PPAs have been retail PPAs signed with solar and wind farms that are in commissioning or operational after one of the state-owned utilities have signed a PPA to underwrite construction. A similar dynamic could emerge as the CIS scales up.

Under the NSW LTESA model, tender criteria rate bids with alternative contracts such as Corporate PPAs higher because the aim is not to displace conventional market contracting. One of the weaknesses of earlier government auction processes was they effectively

removed projects from the contracting market with impacts on liquidity and generator behaviour.

Brad Hopkins of Australian Energy Market Operator (AEMO) Services noted after the announcement of the second round of LTESAs (November 2023): "Previously, people needed a 15-year PPA with a credit worthy utility in order to get a project built. They're showing up to our tenders, and they're saying, we need enough financial support from the LTESAs to pay our debt. But they say we're happy and we've got a five-year contract with a medium-sized company or a large corporate or a new entrant retailer. And our equity investors are happy to take the risk that we get another contract in another five years."¹

It may be that the role and composition of Corporate PPAs changes more than the volume. Corporate PPAs may be part of bids through the CIS auctions for new projects but remain the minority as in recent years because only larger parties would be attractive to enhance bids for the CIS – and the role of PPAs increasingly centres on revenue certainty through commissioning and operational phases.

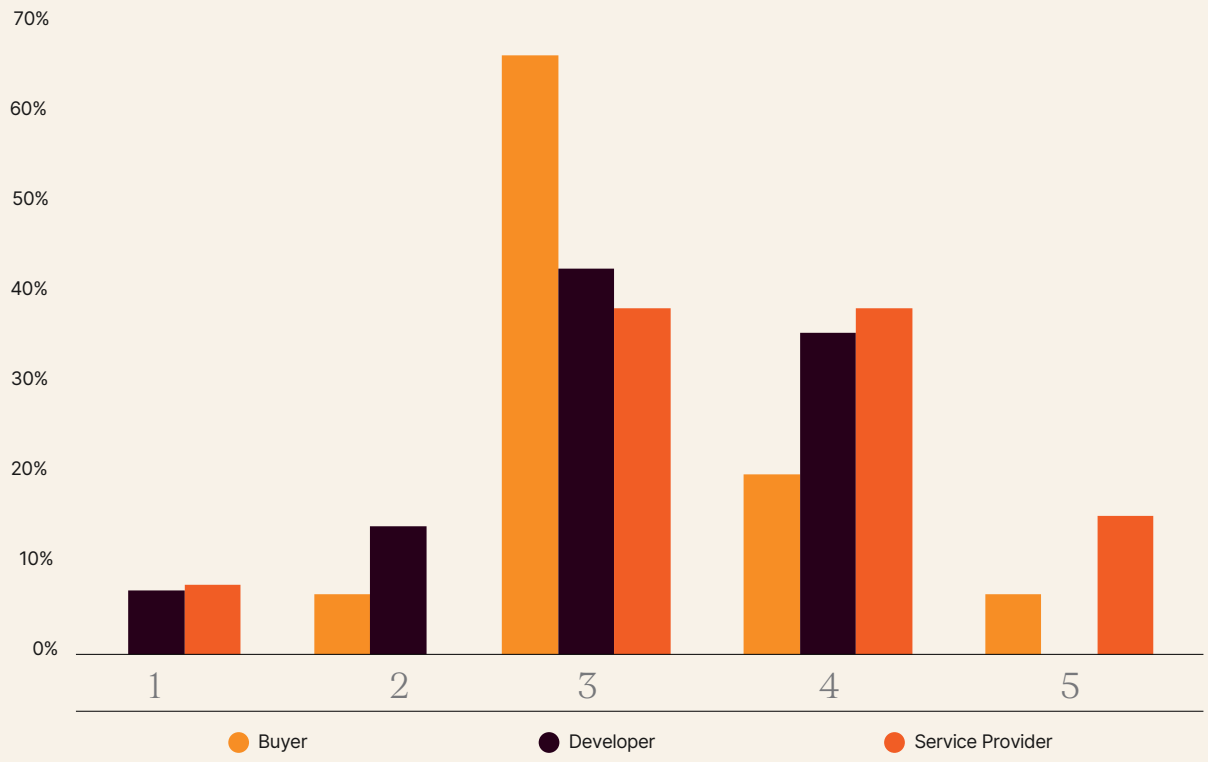
The shift towards more PPAs signed with commissioned and operating PPAs could be consolidated as the big retailers re-enter the market and negotiate deals after securing a contract through the CIS. The scale of investment required to achieve the government's 82 per cent renewables target – 6 GW per annum by AEMO's estimate – adds confidence that offtake demand from corporate PPA buyers will continue to have a role but it will evolve as the CIS gets into gear.

This summary is drawn from the annual State of the Market report produced by the Business Renewables Centre – Australia on Corporate PPAs. BRC-A is a national not-for-profit initiative established to facilitate the growth of renewable energy procurement by Australian companies. The initiative was originally established with seed funding from the NSW Government, Victorian Government, Queensland Government and ARENA. For more information see <https://businessrenewables.org.au>.

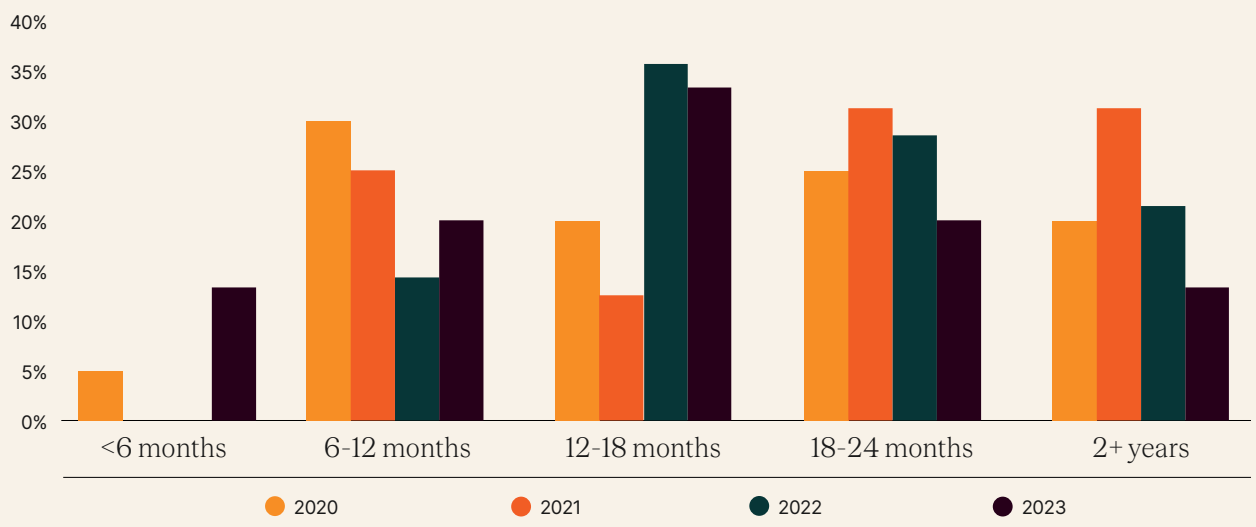


¹ G.Parkinson, *RenewEconomy*, <https://reneweconomy.com.au/bowen-capacity-plan-means-a-power-shift-from-big-utilities-but-will-there-be-enough-wind/>

How high are the transaction costs for Corporate PPAs?



Corporate PPAs, process duration



Content and data supplied by Business Renewables Centre Australia

Electricity prices

The extreme ups and downs of 2022 have mostly levelled out, and while energy prices year-on-year are still up, a downward trend may be on the way.

Energy wholesale prices continued to rise in early 2023 as a result of gas and coal input market conditions caused by Russia's war in Ukraine, but the latter half of 2023 saw wholesale prices stabilise and begin to fall, supported in part by an ongoing increase in the availability of new renewable generation capacity. Given that changes in wholesale markets prices flow through gradually into retail prices, we should see lower retail prices in 2024.

However, many of the vulnerabilities observed in 2022 remain (primarily: delays in new renewable investment and fossil fuel price shocks), and according to the Australian Energy Regulator, the general rise in prices since the war began is now a backdrop to the broader economic cost-of-living crisis. "Heightened wholesale electricity prices exerted major upward pressure on retail prices for 2023-24. This has occurred in economic conditions where consumers are not well-placed to absorb bill increases due to broader increases in costs of living."¹

However, in the final quarter of 2023, the Australian Energy Market Operator (AEMO) reported that wholesale spot electricity prices across the NEM averaged \$48 per megawatt-hour in Q4 2023, a 48 per cent drop from the same period in 2022, and that all states enjoyed wholesale price reductions as a result. These drops were likely due in part to thermal coal generators not spiking prices as much as they were, and increased penetration of renewables in the grid overall.

There were significant differences in those price reductions, however, with prices in Queensland (\$68/MWh) more than double those of Victoria (\$26/MWh). AEMO puts this disparity down to differing levels of operational demand and ongoing network congestion in northward flows on the Victoria-New South Wales Interconnector.²

AEMO wrote in its final quarterly report of 2023 that "record generation from grid-scale renewables and rooftop solar is triggering wholesale energy prices and greenhouse gas emissions to fall", a noteworthy point that reinforces just how important renewables are, from a climate and an economic perspective.

“Consumers are not well-placed to absorb bill increases due to broader increases in costs of living”

Meanwhile, all regions in the NEM saw an increase in negative price occurrences in 2023,³ reflecting the increased level of renewables supply. If Australia can bring on increased levels of storage and sure up the reliability of the grid, the benefits of low-cost clean energy could be shared with all consumers, and hopefully retail energy prices would reduce even further.

Consumer price pressures

While consumer electricity prices have not experienced the extreme highs seen in previous years, and are hopefully approaching a downward trajectory, they are nevertheless on the rise year-on-year. The Australian Bureau of Statistics (ABS) reports that electricity prices rose 10.7 per cent in the 12 months

¹ Australian Energy Regulator, *State of the Energy Market 2023*

² Australian Energy Market Operator, *Quarterly Energy Dynamics Q3 and Q4 reports*

³ G Parkinson, *RenewEconomy*, <https://reneweconomy.com.au/negative-pricing-events-hit-record-levels-and-are-worse-in-coal-fired-grids/>

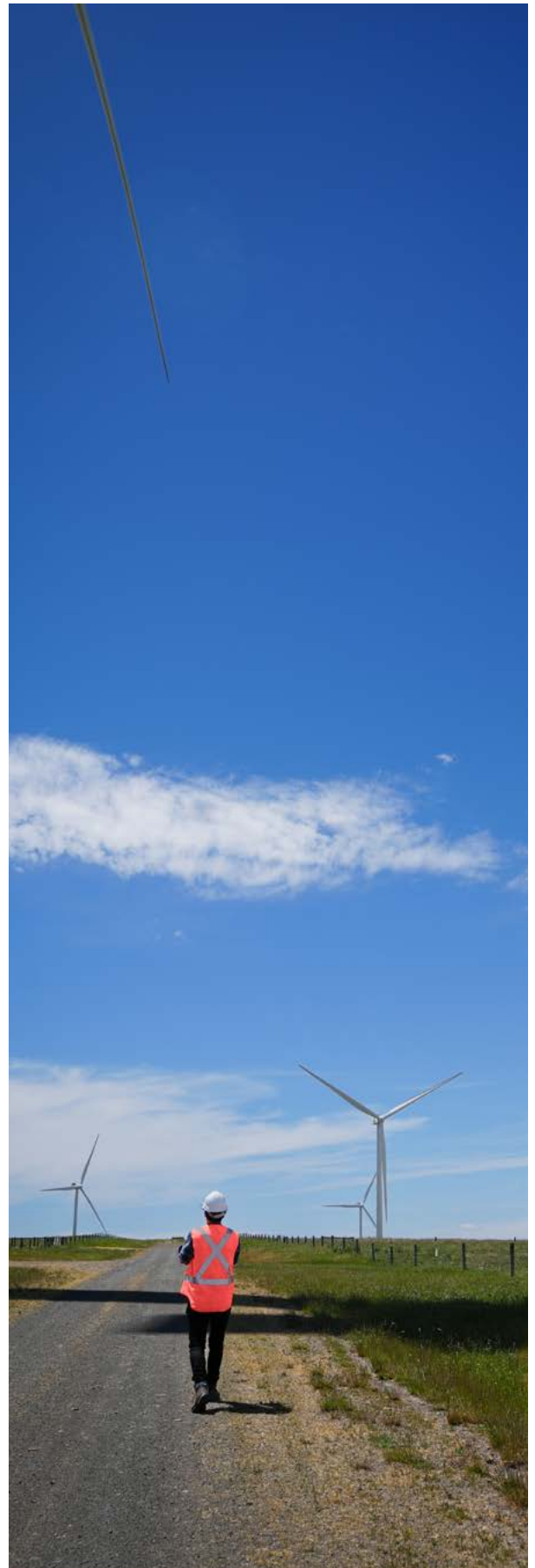
to November 2023. The Federal Government's Energy Bill Relief Fund became active in July 2023, offering bill-relief payments to eligible households and small businesses; and in April, the Government extended its wholesale gas price cap to at least mid-2025 in an additional effort to keep energy bills from escalating.⁴ In November 2023, ABS reported that electricity prices had risen 8.8 per cent since June 2023. Excluding Energy Bill Relief Fund rebates, prices would have increased by 19 per cent over this period.

Fluctuations and volatility

According to Rystad Energy in October 2023, "Australia's NEM power market is now the most volatile in the world".⁵ The key metric Rystad used to reach this conclusion was the average difference between the highest and lowest price during a given hour, with domestic price spreads for Queensland and South Australia seeing the widest spreads of all markets Rystad investigated. Rystad concludes that among the measures for handling these fluctuations, increased storage capacity is required. Indeed, that seems to be something that is on the way. See page 55 for more on a record-breaking year for battery storage.

The Australian Energy Market Commission (AEMC) will be changing its reporting methods for residential electricity price trends, with a 10-year forecast to be published in late 2024. The AEMC believes this approach will provide greater insight into the drivers of consumer electricity costs over a longer period of time.

→ Lal Lal Wind Farm
Yendon, VIC
Wadawurrung Country
(Clean Energy Council)



⁴ P Hannam, *The Guardian*, <https://www.theguardian.com/australia-news/2023/apr/26/labor-extends-gas-price-cap-to-2025-to-protect-power-bills>

⁵ Rystad Energy, <https://www.rystadenergy.com/news/australia-electricity-market-most-volatile-in-the-wor>

Transmission

With lots of new transmission needed to support the clean energy transition, and plenty of ageing transmission infrastructure to be upgraded or replaced, there was plenty happening in 2023 in terms of regulation and new technological solutions.

In late December 2023, the Australian Energy Market Operator (AEMO) published the 2024 Draft Integrated System Plan (ISP). Broadly, transmission buildout remains the same as the 2022 ISP, with no major changes to the timing of projects. Both AEMO's Step Change and Progressive Change scenarios require 5,000 km of transmission in the next decade, and 10,000 by 2050.

The only change is the inclusion of two new actionable transmission projects, Gladstone grid reinforcement and Queensland Supergrid South. Both of these

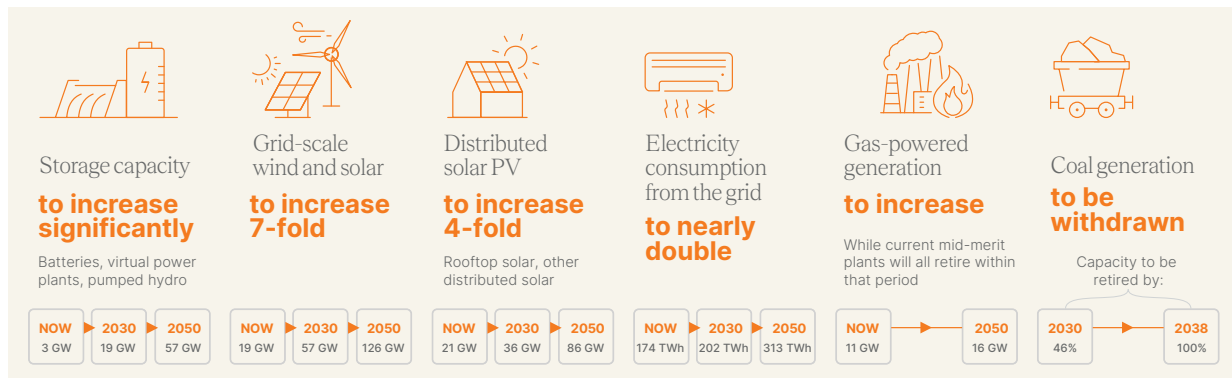
projects aim to increase the hosting capacity of the transmission network as significant new renewable generation has been announced in Queensland.¹

The energy transition requires significant investment to deliver on a seven-fold increase in utility scale renewable generation, supported by a 19-fold increase in storage capacity. The majority of generation and dispatchable capacity will be coordinated in renewable energy zones (REZs).² The transmission projects underway will support the expected growth in generation and increase in electricity consumption, particularly from emerging loads such as data centres and electrolyzers.

Renewable energy zones

In New South Wales, the Illawarra REZ was declared on 27 February 2023. It has 1 GW intended network capacity with the potential to support a future Commonwealth Offshore Wind Zone. The Hunter Transmission Project (HTP) will unlock generation from the Central West Orana and New England REZs to deliver an additional 5 GW of network capacity, which could be increase to as much as 8 GW.³

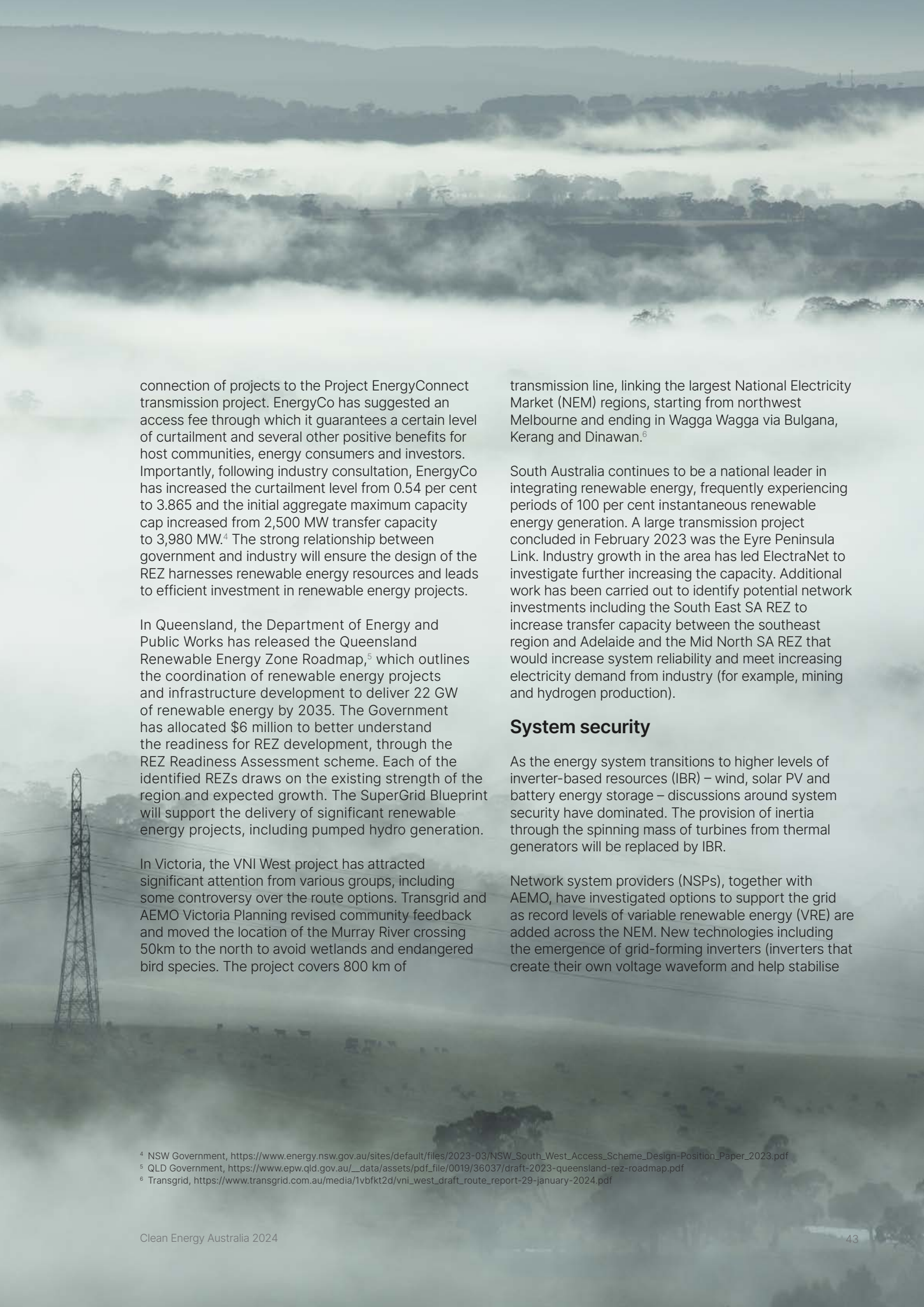
South West REZ has progressed to the access scheme declaration, which is a measure to control the



¹ Australian Energy Market Operator, *Draft Integrated System Plan 2024*

² Australian Energy Market Operator, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/draft-2024-isp-consultation/draft-2024-isp---overview.pdf?la=en

³ EnergyCo, <https://www.energyco.nsw.gov.au/sites/default/files/2023-11/htp-project-overview-public-exhibition-nov-2023.pdf>



connection of projects to the Project EnergyConnect transmission project. EnergyCo has suggested an access fee through which it guarantees a certain level of curtailment and several other positive benefits for host communities, energy consumers and investors. Importantly, following industry consultation, EnergyCo has increased the curtailment level from 0.54 per cent to 3.865 and the initial aggregate maximum capacity cap increased from 2,500 MW transfer capacity to 3,980 MW.⁴ The strong relationship between government and industry will ensure the design of the REZ harnesses renewable energy resources and leads to efficient investment in renewable energy projects.

In Queensland, the Department of Energy and Public Works has released the Queensland Renewable Energy Zone Roadmap,⁵ which outlines the coordination of renewable energy projects and infrastructure development to deliver 22 GW of renewable energy by 2035. The Government has allocated \$6 million to better understand the readiness for REZ development, through the REZ Readiness Assessment scheme. Each of the identified REZs draws on the existing strength of the region and expected growth. The SuperGrid Blueprint will support the delivery of significant renewable energy projects, including pumped hydro generation.

In Victoria, the VNI West project has attracted significant attention from various groups, including some controversy over the route options. Transgrid and AEMO Victoria Planning revised community feedback and moved the location of the Murray River crossing 50km to the north to avoid wetlands and endangered bird species. The project covers 800 km of

transmission line, linking the largest National Electricity Market (NEM) regions, starting from northwest Melbourne and ending in Wagga Wagga via Bulgana, Kerang and Dinawan.⁶

South Australia continues to be a national leader in integrating renewable energy, frequently experiencing periods of 100 per cent instantaneous renewable energy generation. A large transmission project concluded in February 2023 was the Eyre Peninsula Link. Industry growth in the area has led ElectraNet to investigate further increasing the capacity. Additional work has been carried out to identify potential network investments including the South East SA REZ to increase transfer capacity between the southeast region and Adelaide and the Mid North SA REZ that would increase system reliability and meet increasing electricity demand from industry (for example, mining and hydrogen production).

System security

As the energy system transitions to higher levels of inverter-based resources (IBR) – wind, solar PV and battery energy storage – discussions around system security have dominated. The provision of inertia through the spinning mass of turbines from thermal generators will be replaced by IBR.

Network system providers (NSPs), together with AEMO, have investigated options to support the grid as record levels of variable renewable energy (VRE) are added across the NEM. New technologies including the emergence of grid-forming inverters (inverters that create their own voltage waveform and help stabilise

⁴ NSW Government, https://www.energy.nsw.gov.au/sites/default/files/2023-03/NSW_South_West_Access_Scheme_Design-Position_Paper_2023.pdf

⁵ QLD Government, https://www.epw.qld.gov.au/_data/assets/pdf_file/0019/36037/draft-2023-queensland-rez-roadmap.pdf

⁶ Transgrid, https://www.transgrid.com.au/media/1vbfkt2d/vni_west_draft_route_report-29-january-2024.pdf

the grid in case of a fault) and synchronous condensers are offering new options to manage inertia and stability in the grid as more IBR connects. The System Strength Framework sets out the nodes across the NEM where the provision of system strength is required. This is determined through a methodology by the System Strength Service Provider (SSSP) represented by the local NSPs or jurisdictional planning body. The SSSP must meet the new requirements by 2 December 2025. Strong industry collaboration has led to significant improvements to the framework, including how prices are calculated. These changes have material benefits to the industry since renewable energy developers pay less to connect.

Another development has been the elevation of non-network solutions as a viable means of avoiding network augmentation. Non-network solutions are services provided by asset owners rather than owned by NSPs that can help accelerate project timeframes, unlock network capacity and lead to improved consumer benefits. Largely, these projects are energy storage solutions. Several projects have been proposed or progressed through the regulatory process to support NSPs including Hydrostor, the Broken Hill compressed air energy storage facility, and various battery energy storage projects in New South Wales procured to offer dynamic reactive support. The suite of options explored to unlock network capacity has sent strong signals as to the viability of multiple technologies deployed to support the grid.

On the regulatory front, the Australian Energy Market Commission has released a draft determination to address the challenges faced by NSPs in raising finance to proceed with actionable ISP transmission projects.⁷ The rule change initiated by the Honourable Chris Bowen MP, Commonwealth Minister for Climate Change and Energy and Energy Networks Australia, acknowledges that transmission is a critical enabler for the transition to net zero. Delayed investment in transmission infrastructure would likely come at a cost to consumers, ultimately delaying renewable energy generation. The rule change allows NSPs and the funding body to choose the mechanism best-suited to sharing benefits with consumers, sets out minimum information requirements the NSP needs to provide to the Australian Energy Regulator and clarifies how concessional finance benefits are treated in the economic assessment of project options during the development of the ISP and Regulatory Investment Tests.

Related to system strength, two rule changes, the system strength quantity⁸ and Powerlink reset system strength unit prices,⁹ have been fast tracked to incorporate clarification and corrections to the framework. This underscored extensive engagement with industry and recognition by market bodies of the urgency to rectify initial design choices.

⁷ Australian Energy Market Commission, <https://www.aemc.gov.au/sites/default/files/2023-12/Draft%20determination.pdf>

⁸ Australian Energy Market Commission, <https://www.aemc.gov.au/rule-changes/calculation-system-strength-quantity>

⁹ Australian Energy Market Commission, <https://www.aemc.gov.au/rule-changes/resetting-powerlinks-system-strength-unit-prices>



Energy reliability

By accelerating uptake of renewables and storage, Australia has an opportunity to gain total energy security and remove the prospect of reliability issues.

According to the Australian Energy Market Operator's (AEMO) 2023 Electricity Statement of Opportunities report, "with up to 62 per cent of its coal fleet expected to close before 2033, Australia's National Electricity Market (NEM) is perched on the edge of one of the largest transformations since the market formed".

AEMO's report (published in August 2023) forecast larger reliability gaps than its previous report in Feb 2023, and highlighted the need for Australia to meet "an imminent and growing need for firm capacity, new forms of energy production, and significant consumer energy investments"¹. In the conservative scenario that AEMO is required to follow under current regulations, reliability risks in electricity supply are forecast in Victoria from as early as 2024, and New South Wales from 2025-26, which other states following.

However, more realistic scenarios, which account for the additional generation and storage investment that is very likely to proceed, paint a different picture. AEMO reports that if these additional measures for building renewable capacity and storage proceed on schedule, the market is forecast to "remain within the reliability standard in all regions except Victoria in 2028-29".

This outlook tallies with Rystad Energy's analysis that Australia's electricity market is the most volatile in the world.² The key metric Rystad used to reach this conclusion was the average difference between the highest and lowest wholesale electricity prices during a given hour, with domestic wholesale price

spreads for Queensland and South Australia seeing the widest spreads of all markets Rystad investigated. It also factored in unexpected losses of supply from unplanned coal generation outages and transmission line issues.

It is important to note that while wholesale prices may be volatile, this doesn't necessarily mean consumers will experience the same volatility. Retailers enter into contracts with energy suppliers to manage this volatility and smooth retail prices.

Rystad concluded that strong investment in rapid, dispatchable storage assets – like batteries – is among the measures that can best manage fluctuations

“If the building of renewable capacity and storage proceed on schedule, the market is forecast to remain with the reliability standard in all regions except Victoria in 2028-29”

in wholesale prices. Thankfully, that seems to be something that is on the way. See page 55 for more on a record-breaking year for battery storage.

Risks and solutions

2023 demonstrated once again that severe weather events, often difficult to predict, can cause real harm to communities, including by causing power outages. The

¹ Australian Energy Market Operator, *Electricity Statement of Opportunities 2023*

² Rystad Energy, <https://www.rystadenergy.com/news/australia-electricity-market-most-volatile-in-the-wor>

summer storms along Australia's east coast were a harsh reminder of that,³ leaving thousands of residents temporarily without power.

As Russia's ongoing war in Ukraine has demonstrated, energy independence is of vital importance. An overreliance on a single source of energy can lead to shortfalls and inflated prices, and energy reliability will always be higher when reliance on external supplies is reduced. Bringing more renewables into the mix, alongside transmission investment and the dispatchable storage needed to firm the power system, will reduce volatility and bring security to everybodies electricity supply.

Crucially, AEMO's report highlights the great opportunity Australia has to take control of the reliability of its energy grid and provide security. "Federal and state government initiatives," said AEMO CEO Daniel Westerman in a press release, "including transmission projects and mechanisms for delivering firming capacity, can address many of the identified [reliability] risks, if delivered to schedule."

○ Western Downs Green Power Hub
Western Downs, QLD
Barunggam Country
(Neoen)

³ L Waterson, *ABC News*, <https://www.abc.net.au/news/2023-12-27/how-to-stay-comfortable-and-safe-during-a-power-outage/103267436>



○ Dulacca Wind Farm
Western Downs, QLD
Barunggam Country
(RES)

Vestas®

International update

Significant policy mechanisms such as the US's Inflation Reduction Act continue to affect global investment, trade flows and supply chains. While figures for renewable capacity added and investment worldwide are up, there is more work to do to accelerate clean energy and meet decarbonisation goals.

“China commissioned as much solar PV in 2023 as the entire world did in 2022”

According to the International Energy Agency's (IEA) *Renewables 2023*¹ report, “global annual renewable capacity additions increased by almost 50 per cent to nearly 510 GW in 2023, the fastest growth rate in the past two decades”. This follows the International Renewable Energy Agency's announcement at the beginning of last year that 2022 had seen the largest increase in global energy capacity to date.

According to BloombergNEF,² global investment in the energy transition hit a record USD \$1.8 trillion in 2023, up 17 per cent from a year earlier, with electrified transport being the main driver of that growth. On a global level, electrified transport overtook renewable energy as the largest driver of spending, at USD \$634

¹ International Energy Agency, *Renewables 2023*

² BloombergNEF, *Energy Transition Investment Trends 2024*

510 GW

Approximate renewable capacity added worldwide in 2023

(2022: approx. 295 GW)

\$623 bn (USD)

Global investment in renewable energy 2023

(+8% year-on-year)

\$634 bn (USD)

Global investment in electrified transport 2023

(+36% year-on-year)

billion, up 36 per cent year-on-year. Renewable energy investment rose 8 per cent to reach \$623 billion.

China contributed the most to the global spending total, with USD \$676 billion, the US was in second place with \$303 billion, and the 27 members of the European Union (EU) contributed a combined USD \$340 billion in investment.

China continues to lead the way in terms of new renewable capacity added, commissioning as much solar PV in 2023 as the entire world did in 2022. In total, China accounts for almost 60 per cent of the new renewable capacity the IEA expects to become operational globally by 2028.

These impressive numbers are a reminder of how much the clean energy transition is taking hold globally, and of the amount of work that remains to be done. For instance, the *Renewables 2023* report also claims that while the next five years will continue to see tremendous growth in renewables, lack of financing for emerging and developing economies is a key issue that remains to be adequately solved, and of course many of those nations are likely to be hit most prominently by the effects of climate change. BloombergNEF also assessment, which would have results in members paying a Fires Service Levy 20 times the current level. The campaign resulted in renewable still requires nearly three times the level of investment we are currently seeing.

International policy

Last year we flagged the passing of the US's Inflation Reduction Act (IRA) as a momentous moment for renewables on the international stage, not just because of what it would do for the energy transition in the US, but how it would affect global investment, trade flows and supply chains.

Following the passing of the IRA in August 2022, there has been a virtual tidal wave of investment announcements in the US, with the American Clean Power Association reporting in early 2024, that new clean energy announcements amounted to over USD \$420 billion in capital investments, 282 GW of new clean energy project capacity, and almost 42,000 new manufacturing jobs.³ Goldman Sachs estimates that clean energy spending by the Biden administration could reach up to USD \$1.2 trillion, but that public spending could in turn unleash USD \$3 trillion in clean energy and low-emissions investments across the economy.

The full effect of the IRA on international markets is still playing out, but many other countries and regions – including Canada and Europe – have been quick to detail their own policy and funding prescriptions to protect existing markets and manufacturing or stake their claims in new clean energy trade.

The Australian Government sees strong opportunities to leverage the new IRA incentives for electric vehicle

uptake to support investment in Australia's critical mineral supply chain – as a US free-trade partner – with President Biden and Prime Minister Albanese signing a new 'Climate, Critical Minerals and Clean Energy Compact' in May 2023.⁴

The Australian Government also unveiled \$2 billion for a new Hydrogen Headstart contract-for-difference scheme, to accelerate the development of large-scale renewable hydrogen projects in Australia – designed to maintain competitiveness with the new US hydrogen production credit.

Other significant global policies included China's 14th Five-Year Plan, the EU's REPowerEU and Fit for 55 plans, Canada's 'Made In Canada', and India's recently announced Carbon Credit Trading Scheme.

Interestingly, according to S&P Global,⁵ international policies may be having unintended consequences for global markets: "governments might not have expected the market response to be so heavily tilted towards investments in generating assets". S&P reports that between August 2022 and June 2023, private capital energy transition investment in renewable energy production totalled USD \$59.5 billion, while the figures for industrial decarbonisation (USD \$9.7 billion) and energy storage (USD \$8.1 billion), for example, are significantly lower, suggesting that the types of policy mechanisms in place around the world may be skewing investment into some areas more than others, perhaps because "generating assets (particularly solar PV)... [have] become bankable: proven [technologies]... generating steady returns". It will be interesting to see the cumulative effect this has in the years to come.

Meanwhile, energy prices for fossil fuels around the world continue to be affected and to some extent driven by Russia's ongoing war in Ukraine, which by the time of publication will be two years old. We are still seeing price fluctuations for all forms of fossil fuels, with the World Economic Forum predicting in February 2023 that since the beginning of the conflict, energy costs for households have increased by "at least 63 per cent and possibly as much as 113 per cent, [contributing] to an increase in global household expenditure of between 2.7 and 4.8 per cent." This is having a huge effect on household bills across the world, and again highlights that embracing renewables can lower bills and increase energy independence, all while contributing to the mass decarbonisation we need.

At COP28 in Dubai in December 2023, there was a welcome commitment signed by 198 nations to triple global renewable energy capacity by 2030, which was a win for the global renewables movement and a direct acknowledgement by parties that rapid renewable energy deployment will be fundamental to addressing the climate crisis. The challenging task will now be for governments and industry to scale-up international efforts to deliver on this ambitious goal.

³ American Clean Power, <https://cleanpower.org/investing-in-america/>

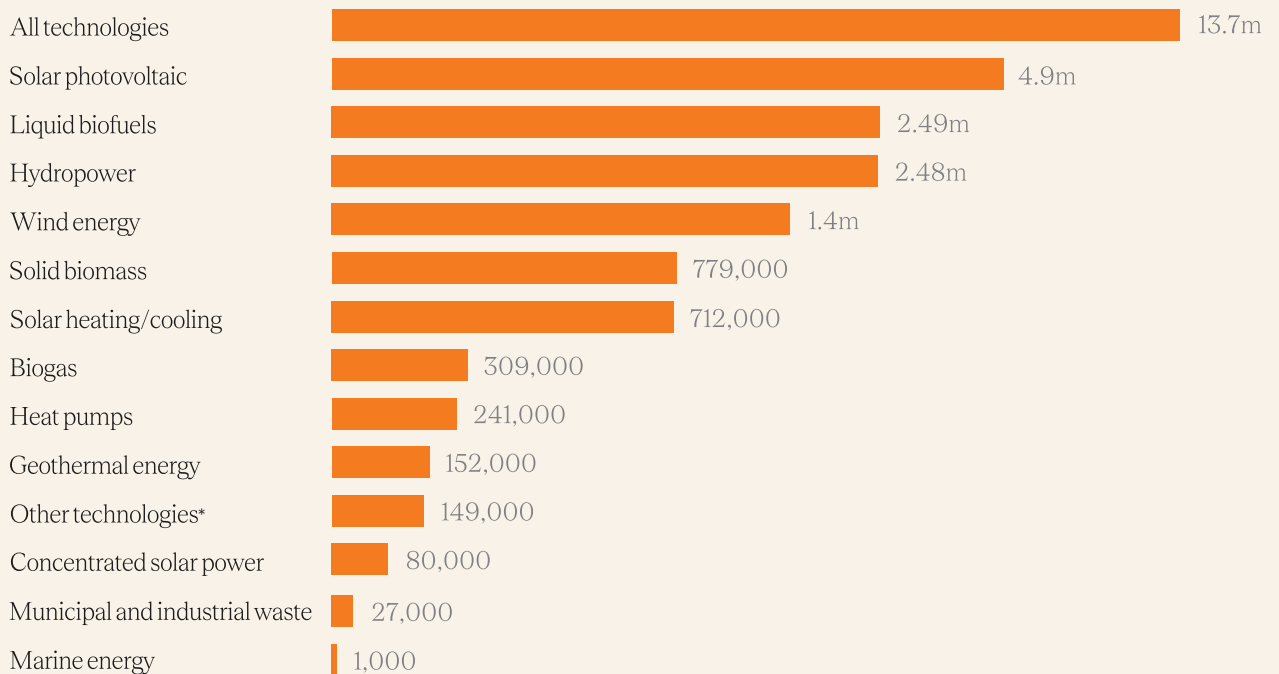
⁴ Federal Government, <https://www.pm.gov.au/media/australia-united-states-climate-critical-minerals-and-clean-energy-transformation-compact>

⁵ S&P Global, *Renewable Energy Funding in 2023: A 'Capital Transition' Unleashed*



○ COP 28
 Dubai, UAE
 (cop28.com.au)

Global renewable energy employment by technology, 2022 (millions)



*Other technologies includes jobs not broken down by individual energy technologies

Source: International Renewable Energy Agency



○ Kaban Green Power Hub
Atherton Tablelands, QLD
Jirrbal Country
(Neoen)

Technology Profiles

Battery storage	55
Bioenergy	58
Hydro and pumped hydro	61
Hydrogen	64
Rooftop solar (including medium-scale)	67
Large-scale solar	79
Wind	85



○ Victorian Big Battery
Moorabool, VIC
Wadawurrung Country
(Neoen)

TECHNOLOGY PROFILE

Battery storage

It was a record-breaking year for large-scale battery storage, with projects under construction significantly up on 2022 and massive levels of new investment.

Last year we reported that data suggested government measures would help spur an uptick in newly proposed and committed battery storage projects, and 2023 numbers suggest that has been the case. Q2 2023 saw the two-billion-dollar mark for new large-scale storage investment broken in a quarter for the first time, and Q4 broke matched that record just a few months later, making 2023 the strongest ever year for new financial commitments in the large-scale storage space, at \$4.9 billion including hybrid projects with storage elements (\$4.7 billion for storage-only projects). By comparison, 2022 reached \$1.9 billion in new financial commitments to large-scale storage.

Twenty-seven large-scale batteries were under construction at the end of 2023, totalling approximately 5 GW / 11 GWh, which is a significant increase on the equivalent figures from 2022: 19 batteries under construction totalling approximately 1.4 GW / 2 GWh. Whichever way you look at the figures, it has been a bumper year for large-scale storage. The largest batteries are spread around the National Electricity Market: three of the top-five largest batteries systems under construction are located in NSW, one is in VIC and one in QLD.

The largest utility scale battery system currently under construction is the 850 MW / 1,680 MWh Waratah Super Battery in NSW, which being delivered by the NSW Government through its EnergyCo authority, and built by Akaysha Energy, which began construction in May 2023 and expects to conclude construction in August 2025. Second-largest is the 600 MW / 1,600 MWh Melbourne Renewable Energy Hub in VIC, which was approved by the Federal Government in October 2023.

27

large-scale batteries under construction at end of 2023

(2022: 19)

5 GW / 11 GWh

approximate combined capacity of large-scale batteries under construction at end of 2023

(2022: 1.4 GW / 2 GWh)

\$4.9 billion

New financial commitments in large-scale storage

(2022: \$1.9 billion)

December 2023 saw a final investment decision being reached on AGL Energy's battery project at the Hunter Energy Hub in NSW, the site of the Liddell coal-fired power station which closed in April 2023.¹ The 500 MW / 1,000 MWh grid-scale battery has begun construction as of the very end of 2023, with commencement of operations targeted for mid-2026. Total construction cost is estimated to be in the region of \$750 million and will be supported by a \$35 million grant awarded by the Australian Renewable Energy Agency, as well as a Long-Term Energy Service Agreement (LTESA).

The largest utility scale battery storage project commissioned in 2023 was the 150 MW / 300 MWh Riverina Energy Storage System. NSW's largest battery system finished construction in May 2023 and went live into the grid in October. Designed and developed by Edify, the project "provides critical stabilising services to the transmission grid due to [its] advanced Tesla Megapack systems" and its output is "sufficient to supply 240,000 homes with two hours of electricity at peak times".²

Modelling published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in March 2023 predicted that "across the NEM, an additional 11–14 GW/59–69 GWh of storage capacity will be required by 2030"³ and while there is still a long way to go, it looks as if Australia is on a strong path to meet that requirement.

Expanding storage

In terms of policy, the current positive period for utility scale storage looks set to continue, with the Federal Government's expansion of the Capacity Investment Scheme (CIS) in November 2023. Of the capacity targets set out in that scheme (32 GW by 2030), the government's target is to bring on 9 GW of "clean, dispatchable energy [in addition to] the 1.1 GW already in progress through the first stage of the CIS".

Hopefully, incentives such as the CIS will see the continued growth of large-scale storage as Australia aims to accelerate construction to meet the government's ambitious renewable energy targets.

According to Wood Mackenzie's APAC Power & Renewables team, writing in *Forbes*, part of the reason for the growth of storage systems in Australia is that the country is one of the most attractive markets for battery energy storage systems (BESS).⁴ They argue that "the presence of daily spot markets for power and system frequency control services offer diverse revenue streams, which is crucial for the viability of BESS." They also suggest that the falling price of lithium carbonate, which is required for battery production, could have had a significant impact of willingness of investors to commit to storage projects. Wood Mackenzie believes BESS system costs could fall in Australia by 18 per cent over the next decade.

Five biggest large-scale battery systems under construction at end of 2023

State	Project Name	Project owner	Locality	Size of system
NSW	Waratah Super	Akaysha Energy	Colongra	850 MW / 1,680 MWh
VIC	Melbourne Renewable Energy Hub - Phase 1	Equis Australia	Melton	600 MW / 1,600 MWh
NSW	Liddell Power Station	AGL Energy	Muswellbrook	500 MW / 1,000 MWh
NSW	Eraring Battery - Stage 1	Origin Energy	Eraring	460 MW / 920 MWh
QLD	Western Downs Green Power Hub	Neeon Australia	Hopeland	270 MW / 540 MWh

¹ Australian Renewable Energy Agency, <https://arena.gov.au/news/green-light-for-australias-largest-grid-forming-battery/>

² Edify Energy, <https://edifyenergy.com/energy-storage-systems/dawn-of-a-new-era-in-energy-transition-as-nsws-largest-battery-system-goes-live/>

³ CSIRO, *Renewable Energy Storage Roadmap*

⁴ Wood Mackenzie's Power & Renewables team in *Forbes*, <https://www.forbes.com/sites/woodmackenzie/2023/07/11/australias-energy-revolution-the-promise-of-battery-storage-and-hydrogen/?sh=21cfd854ee7>

Other forms of long-duration energy storage are growing in Australia, too, for example HydroStor's Silver City project in the mining town of Broken Hill in the far west of New South Wales. It will be a compressed air storage project and is intended to replace ageing diesel generators and provide backup power to the town. The facility will be a 200 MW / 1,600 MWh storage facility in the Potosi mine.⁵

In November 2023, it was confirmed that an Australian Renewable Energy Agency (ARENA) programme to put \$120 million towards community storage received applications for more than 10 times that amount. This was the first round of funding for the Federal Government's Community Batteries Funding Program.⁶ According to *Energy Storage News*, the Department of Climate Change, Energy, the Environment and Water is "delivering 58 community battery installs across the country, with some already commissioned".

Batteries charging up

Meanwhile, Australian uptake of household batteries continues to grow. The Clean Energy Regulator (CER) reported that in Q3 2023, 7 per cent of systems were installed with a battery – noting that this data is voluntarily reported to the CER and the real proportion is likely higher. To the end of September 2023, the CER reported there had been more than 17,000 battery installations, a 14 per cent increase on the 15,000 reported in the same period in 2022.

SunWiz figures for 2023 suggest the total number of storage units installed was approximately 56,000, continuing a clear upward trend from roughly 43,000 systems in 2022 and 37,000 in 2021, as more and more Australians embrace energy independence. For more information on the rooftop solar sector, see our rundown on pages 67.

○ Blyth Battery
Blyth, SA
Karna Country
(Neoen)

⁵ G Parkinson, *RenewEconomy*, <https://reneweconomy.com.au/air-storage-pioneer-inks-first-of-its-kind-deal-to-keep-lights-on-in-australias-silver-city/>

⁶ A Colthorpe, *Energy Storage News*, <https://www.energy-storage.news/arena-receives-applications-to-fund-au1-3-billion-of-community-battery-storage-in-australia/>

Bioenergy

The policy landscape for bioenergy brightened in 2023, with state and federal governments and private industry heralding support and investment in biogas and biofuels.

Accelerating international momentum to meet decarbonisation goals and higher fossil fuel prices is driving market demand for alternatives to fossil fuels. Bioenergy will have a role to play in the broader energy transition to net zero particularly in the harder-to-abate sectors including industrial manufacturing, aviation, agriculture, and marine sectors.

While global investment in the bioenergy sector is beginning to grow in response to incentives and mandates in the European Union and the United States, cost competitiveness and scalability remain challenging for the Australian bioenergy sector.

However, 2023 saw a number of policy and funding developments aimed at creating more supportive conditions for renewable gas, including biogas, biomethane and other biogenic fuels.

GreenPower launched its voluntary Renewable Gas Certification Pilot scheme, to support the establishment of a voluntary market for biogas, biomethane and renewable hydrogen. The scheme will enable commercial and industrial gas customers to match their gas use with renewable gas certificates, and the pilot is now supporting the creation of certificates for biomethane injection on the gas network at Jemena's new Malabar Biomethane Injection Plant in NSW.

While the scheme is operating as a pilot at present, renewable gases may be included in the Australian Government's Guarantee of Origin scheme in the future.

At a state government level, the NSW Office of Energy and Climate Change released a consultation paper

seeking feedback on the extension of its legislated Renewable Fuel Scheme from 2025 to cover biogenic fuels in addition to its original focus on renewable hydrogen. The NSW Government is also considering the expansion of the scheme to mining operators and liquid fuel users, in addition to large gas users.

The Tasmanian Government released the Tasmanian Future Gas Strategy which outlined the state government's intention to establish the hydrogen and bioenergy industries to decarbonise its economy for fossil fuel replacement in heat generation and the production of transport fuels.

Sustainable aviation fuels ('SAF') is one of the leading opportunities for biofuels, and Australia's lead science agency, CSIRO, together with Boeing developed a Sustainable Aviation Fuel Roadmap, which estimated that Australian jet fuel demand would increase by a staggering 75 per cent between 2023 to 2050.

The roadmap identified sufficient feedstock to supply approximately 5 billion litres of SAF for the domestic market, enough fuel to power 640,000 return flights between Melbourne and Sydney on a Boeing 737, and projects that Australia will have enough feedstocks by 2025 to produce 60 per cent of domestic jet fuel demand, growing to 90 per cent by 2050.

The report highlighted the urgent need to deliver a viable, affordable and domestically made SAF product to propel the sector's decarbonisation efforts, and the Australian Government announced the establishment of the Jet Zero Council in 2023. The Council will give a platform for leading feedstock providers, global sustainable aviation fuel producers, airlines, airports and industry to collaborate with government on building a foundation for a viable domestic SAF industry, and on accelerating deployment.

In signs of the growing momentum of the domestic SAF industry, 2023 also saw Qantas and Airbus announce a \$200 million Sustainable Aviation Fuel Partnership, and the Australian Renewable Energy Agency announced \$30 million in grant funding to support development of domestic SAF production from agricultural feedstocks.


Bioenergy generation in 2023



3.5%

**of total clean
electricity generated
in Australia in 2023**

(2022: 3.8%)



1.4%

**of total electricity
generation in Australia
in 2023**

(2022: 1.4%)



○ Lake Cethana and dam, the site for Hydro Tasmania's proposed 750MW pumped hydro project Cethana, TAS Moomalremener Country (Hydro Tasmania)

Hydro and pumped hydro

Construction is progressing well on the Kidston Pumped Hydro Storage Project, which in 2024 could become Australia’s first pumped hydro development in over 40 years.

Hydropower provided 15,307 GWh of generation in 2023, down from 16,537 GWh in 2022, ending a three-year run of increased generation. Its total contribution to Australia’s renewable generation stood at 16.4 per cent, down from 19.7 per cent in 2022.

Genex Power’s 250 MW / 2,000 MWh Kidston Pumped Storage Hydro Project, which will be the first pumped hydro project to be built in Australia in over 40 years, is progressing well in its construction, and looks to be on track to be operational in 2024.¹ The pumped hydro project is part of the Kidston Clean Energy Hub, which already houses an operational 50 MW solar farm and 258 MW of wind power. When complete, Kidston Pumped Storage Hydro Project will be only the fourth pumped hydro project in Australia to reach commercial operation.

We reported last year about the ongoing difficulties facing the Snowy 2.0 pumped-hydro battery project in the Kosciusko National Park, which was originally scheduled to be completed in 2021 but has faced numerous delays and budget difficulties. In August 2023, the Federal Government announced that it was ‘resetting’ the project and renegotiating its agreement with Snowy 2.0’s leading contractor.² The project is now expected to cost \$12 billion, six times more than originally forecast, but the Albanese Government believes the project is still worth pursuing given its potentially enormous value in providing security to the energy grid, particularly as more coal-fired power stations are scheduled to close.

15,307 GWh

hydropower generation

(2022: 16,537 GWh)

-7.4%

annual decrease in hydropower generation

(2022: +2.5%)

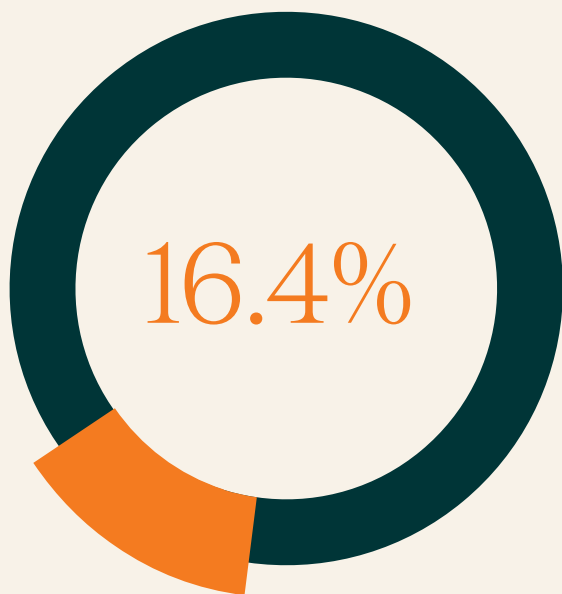
Meanwhile, the Marinus Link project, which will enable the flow of electricity in both directions between Tasmania and Victoria, took another step forwards when in September 2023 a deal between the Tasmanian and Australia Governments was announced. However, while the deal ensures the project is likely to progress, it also halves the proposed capacity of the project (to balance increased construction costs), which will now comprise one 750 MW sub-sea link to the mainland, as opposed to the two initially proposed. The Australian Energy Market Operator (AEMO) included Marinus Link in its list of five “already actionable” projects Australia must have to realise AEMO’s optimal development pathway,³ and in December 2023 the Australian Energy Regulator published a determination deeming the project’s revenue proposal “prudent and efficient”, suggesting there is significant support from industry bodies and the project is likely to forge ahead.

¹ D Carroll, *PV Magazine*, <https://www.pv-magazine-australia.com/2023/08/16/genex-reaches-construction-milestone-on-2-gwh-pumped-hydro-project/>

² T Lowrey, *ABC News*, <https://www.abc.net.au/news/2023-08-31/snowy-hydro-reset-project-to-cost-12-billion/102797650>

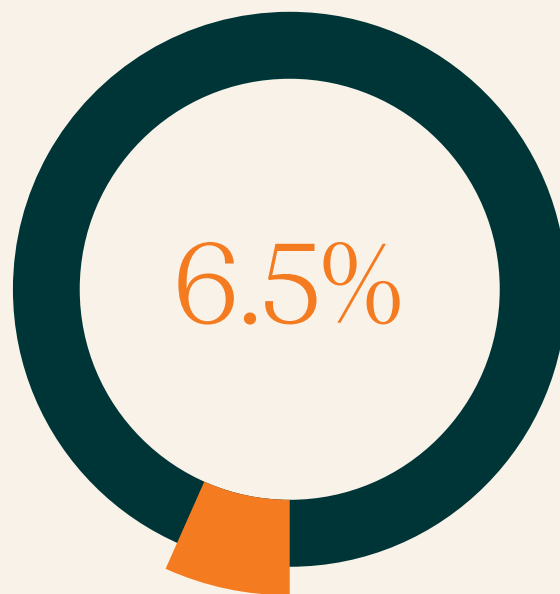
³ Australian Energy Market Operator, <https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp>

Hydropower generation in 2023



**of total clean
electricity generated
in Australia in 2023**

(2022: 19.7%)



**of total electricity
generation in Australia
in 2023**

(2022: 7.1%)

Hydropower contribution to Australian electricity generation

Year	Generation (GWh)	Contribution to renewables	Contribution to total electricity
2013	19,243	55.4%	8.2%
2014	14,555	45.9%	6.2%
2015	14,046	40.1%	5.9%
2016	17,747	42.3%	7.3%
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%
2022	16,537	19.7%	7.1%
2023	15,307	16.1%	6.4%

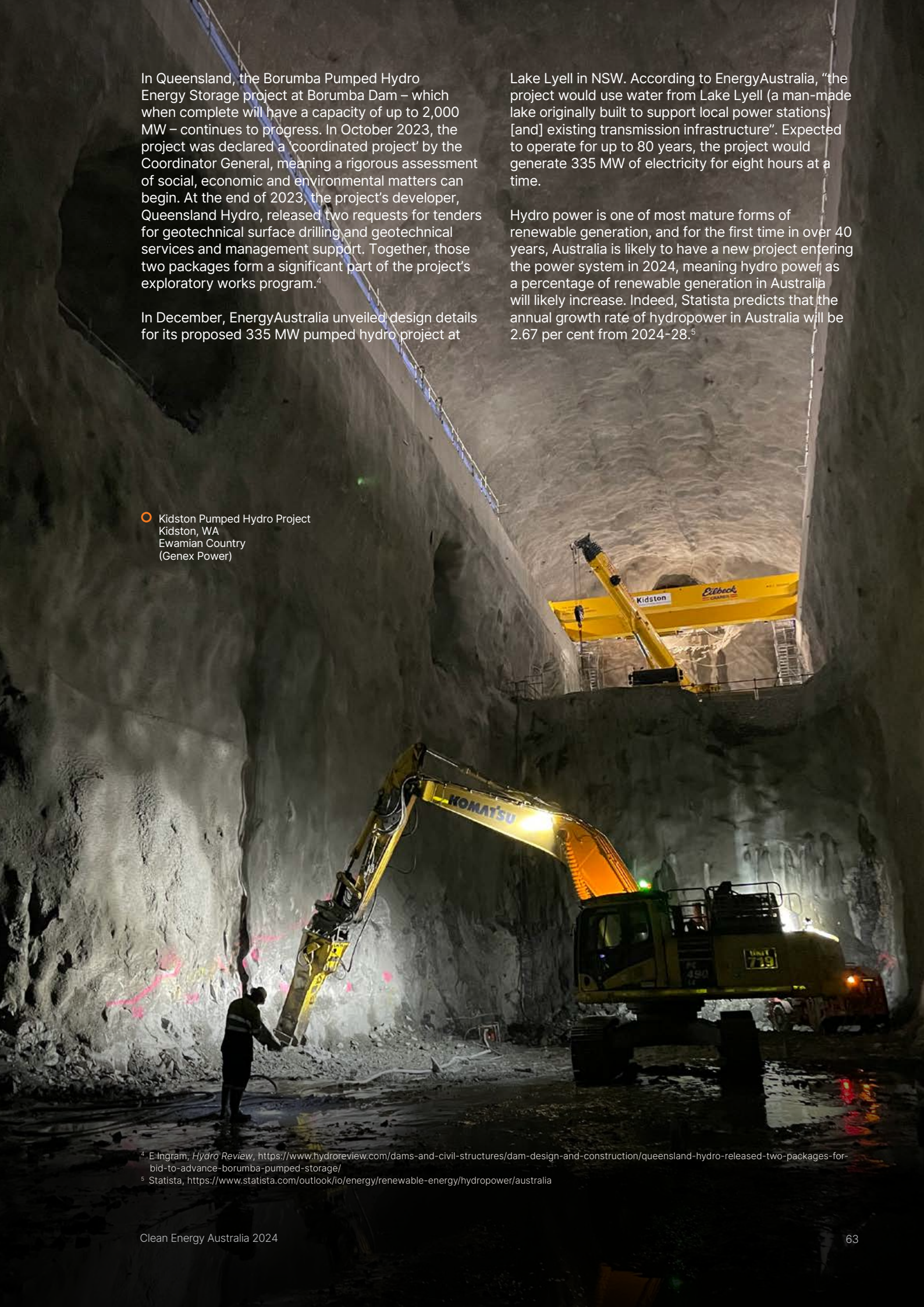
In Queensland, the Borumba Pumped Hydro Energy Storage project at Borumba Dam – which when complete will have a capacity of up to 2,000 MW – continues to progress. In October 2023, the project was declared a ‘coordinated project’ by the Coordinator General, meaning a rigorous assessment of social, economic and environmental matters can begin. At the end of 2023, the project’s developer, Queensland Hydro, released two requests for tenders for geotechnical surface drilling and geotechnical services and management support. Together, those two packages form a significant part of the project’s exploratory works program.⁴

In December, EnergyAustralia unveiled design details for its proposed 335 MW pumped hydro project at

Lake Lyell in NSW. According to EnergyAustralia, “the project would use water from Lake Lyell (a man-made lake originally built to support local power stations) [and] existing transmission infrastructure”. Expected to operate for up to 80 years, the project would generate 335 MW of electricity for eight hours at a time.

Hydro power is one of most mature forms of renewable generation, and for the first time in over 40 years, Australia is likely to have a new project entering the power system in 2024, meaning hydro power as a percentage of renewable generation in Australia will likely increase. Indeed, Statista predicts that the annual growth rate of hydropower in Australia will be 2.67 per cent from 2024-28.⁵

○ Kidston Pumped Hydro Project
Kidston, WA
Ewamian Country
(Genex Power)



⁴ E Ingram, *Hydro Review*, <https://www.hydroreview.com/dams-and-civil-structures/dam-design-and-construction/queensland-hydro-released-two-packages-for-bid-to-advance-borumba-pumped-storage/>

⁵ Statista, <https://www.statista.com/outlook/io/energy/renewable-energy/hydropower/australia>

Hydrogen

2023 was a significant year for Australia's nascent renewable hydrogen industry, with the large pipeline of projects receiving extra impetus from the Federal Government's \$2 billion Hydrogen Headstart program.

Renewable hydrogen represents a major source of new demand for renewable power projects, and an important green fuel for decarbonisation of hard-to-abate energy needs and industrial growth.

May 2023's Federal Budget provided a significant win for renewable hydrogen in Australia, with backing for the nascent industry to the tune of \$2 billion in the form of the Hydrogen Headstart scheme. The scheme is a contract-for-difference program, expected to support at least two large-scale early mover projects, by providing a production credit to bridge the gap between the project's cost of green hydrogen production and the market price.

Following a large industry response, six large-scale renewable hydrogen projects representing a total electrolyser capacity of more than 3.5 GW had been shortlisted for the competitive tendering round, and full detailed applications are due in late June 2024. Successful projects will be announced in late 2024.

While it will be some time until we see the results of the Hydrogen Headstart scheme come to fruition in the shape of completed projects, the future potential for the hydrogen industry in Australia is huge. Rystad Energy predicts that by 2030, Australia could be the world leader in green hydrogen production, with an estimated 2 million tonnes of green hydrogen produced annually.¹ The Clean Energy Council is campaigning for the Australian Government to build on the initial

Headstart program with a longer-term policy and funding program to support the delivery of more early mover, large-scale hydrogen projects.

Policy developments

There were several significant developments in the hydrogen sector in 2023, both at federal and state levels. The Australian Government announced that it would review and refresh the National Hydrogen Strategy, originally published in 2019 to ensure it "positions Australia on a path to be a global hydrogen leader by 2030 on both an export basis and for the decarbonisation of Australian industries". Western Australia, which has strong green hydrogen prospects, also began a review of its own state-based strategy.

Significant milestones were also reached in advancing Australia's emerging hydrogen hubs. In October the Federal Government announced it would invest \$69.2 million to develop the 2.2 GW Central Queensland Hydrogen Hub, the biggest green hydrogen project in Australia,² which is planned to be operational by mid-2027. The Government stated that the hub would be able to produce up to 292,000 tonnes of green hydrogen a year by 2031.

In New South Wales, the Government awarded \$109.3 million of funding from its hydrogen hub initiative to three hub projects in the Illawarra, the Hunter Valley and Moree Plains, as part of its larger Hydrogen Strategy that aims to deliver its 2030 targets of 110,000 tonnes of annual green hydrogen production and 700 MW of electrolyser capacity. Origin Energy will work with Orica to develop a Hunter Valley Hydrogen Hub in the Newcastle industrial and port zone with an initial electrolyser capacity of 55 MW. BOC's Illawarra Hydrogen Technology Hub will initially have 10 MW of electrolyser capacity at Port Kembla to provide four tonnes of green hydrogen per day, and in the long term aims to have 650 MW of electrolyser capacity. The Hiringa Sundown Project near Moree on the Keytah cotton farm near Moree will house an initial 12 MW of electrolyser capacity and targets 112 MW capacity by 2030.

¹ A Klevstrand, *Hydrogen Insight*, <https://www.hydrogeninsight.com/production/exclusive-which-ten-countries-will-be-the-biggest-producers-of-green-hydrogen-in-2030-/2-1-1405571>

² J Bowler, *RenewEconomy*, <https://reneweconomy.com.au/australias-biggest-green-hydrogen-project-given-69m-in-new-round-of-funding/>

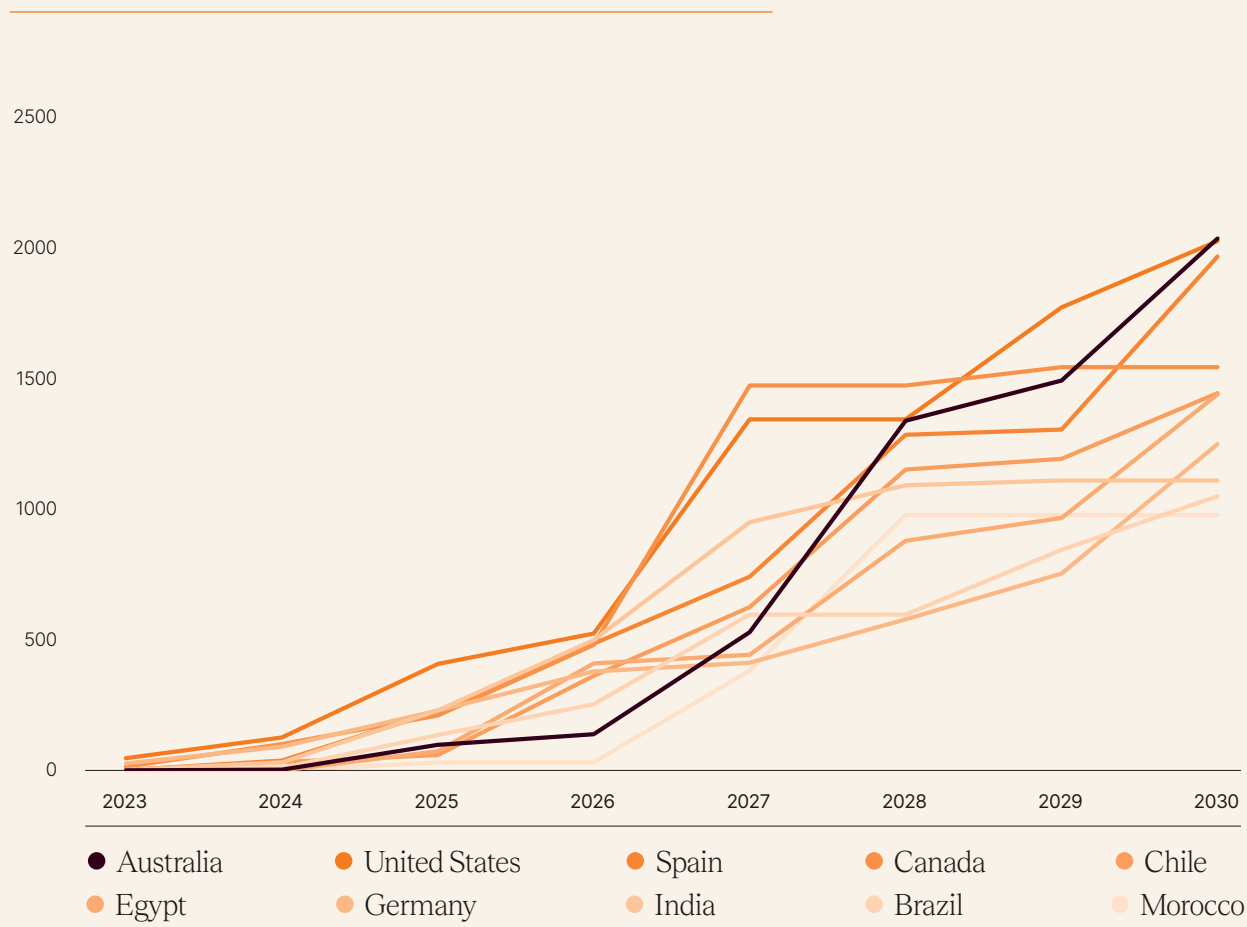
In an Australian first, New South Wales is also developing a new Renewable Fuel Scheme which will place an obligation on gas retailers and large gas users to purchase renewable hydrogen certificates, with liability to commence in 2025. In 2024, the state will also consider the potential expansion of the scheme to include additional renewable fuels and liable parties.

Several large-scale hydrogen production projects also reached final investment decision in 2023. These projects include AGIG's Hydrogen Park Murray Valley renewable hydrogen blending project, which has received support from the Australian Renewable Energy Agency. In late 2023, Fortescue gave the green light to the Gladstone Renewable Hydrogen plant in Queensland and the Christmas Creek Green

Iron Facility at the company's iron ore mine in Western Australia. The Christmas Creek project will use renewable hydrogen to produce 1,500 tonnes of green iron from magnetite and hematite ores with the first green iron production expected in 2025.

Also in Western Australia, Infinite Green Energy (IGE) acquired the Northam Solar Farm in Western Australia in early 2023 with a view to using the 11 MW solar farm to produce four tonnes of renewable hydrogen via electrolysis per day.³ IGE ultimately plans to expand the farm's capacity to 18 MW, with production of green hydrogen set to commence in Q4 2024. If the site is operational by that time, it should be the first commercial-scale producer of green hydrogen in Australia.

Top 10 countries by green hydrogen production (thousands of tonnes annually)



Source: Rystad Energy via *Hydrogen Insight*, Feb 23

³ T Oates, Energy Magazine, <https://www.energymagazine.com.au/australias-first-commercial-scale-green-hydrogen-project-commencement-date-set/>



○ Port Stephens Koala Hospital
One Mile, NSW
Worimi Country
(Solaheart)

TECHNOLOGY PROFILE

Rooftop Solar

(Systems up to 100 KW)

2023 was an outstanding year for rooftop solar, with numbers of installations and capacity added approaching the record levels we saw in 2021.

During a year in which new utility scale generation commitments and developments slowed, Australia's rooftop solar industry has been doing a lot of the heavy lifting in the clean energy transition. This reinforces just how important the industry is to Australia's decarbonisation push, as well as to individual Australians, for whom it can bring reduced energy bills and greater energy independence, particularly when combined with household batteries.

In 2023, 337,498 solar PV systems were installed across Australia (up from 315,499 in 2022) for a total installed capacity of 3.1 GW (up from 2.7 GW). Both numbers represent a fantastic year for rooftop solar in Australia, even if they are slightly lower than the record-high numbers we saw in 2021, when there were 377,448 installations for a combined 3.3 GW capacity.

In 2022, many Australians looked to solar systems as a way of offsetting skyrocketing energy prices following Russia's invasion of Ukraine, seeking the greater energy independence distributed home systems can provide. That trend looks to have continued in 2023, even though the rate of increase in retail energy prices has not been as pronounced, demonstrating that rooftop solar has earned its social licence in Australia and is seen as a viable, achievable shift for consumers as a means of taking more control of their energy costs. According to SunWiz, November 2023 was the biggest ever month for rooftop capacity installed.¹

The 3.1 GW of combined rooftop solar installed capacity in 2023 once again trumps the capacity added by large-scale renewable projects which became operational in 2023, which totalled approximately 2.8 GW in 2023.

337,498

rooftop solar installations in 2023

(2022: 315,499)

3.1 GW

rooftop solar capacity added in 2023

(2022: 2.7 GW)

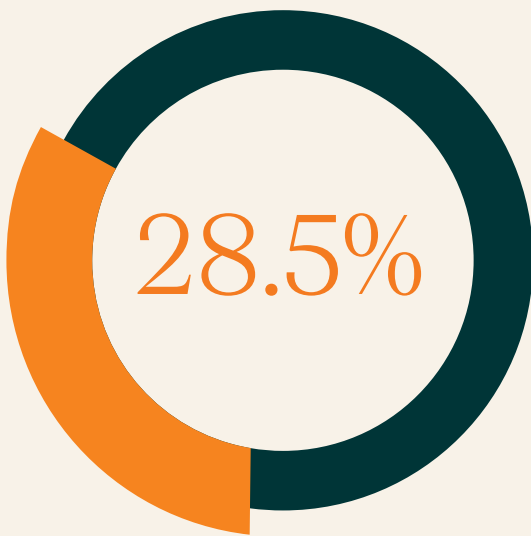
3.7 million

Approx. 3.7 million Australian households with rooftop solar

(2022: 3.4 million)

¹ S Vorrath, *RenewEconomy*, <https://reneweconomy.com.au/rooftop-solar-installs-smash-record-as-households-turn-to-bigger-systems-pu>

Rooftop solar generation in 2023



of clean energy generated in Australia in 2023

(2022: 25.8%)



of total Australian electricity generated in 2023

(2022: 9.3%)

State of the sector

As it did in 2022, NSW added the most installed capacity over the past year, with just over 1 GW, a figure which surpasses even the record year in 2021 (996 MW) and is the single-largest state-specific rise in installed capacity on record. The only states to install less capacity in 2023 than 2022 were WA (276 MW versus 287 MW in 2022) and the NT (15.7 MW versus 19.3 MW in 2022). Although QLD did not lead in 2023 for MW installed or for installations, its 83,529 solar installations mean it is the first state to hit the significant milestone of over one million rooftop solar installations, meaning it has the most in the country.² NSW, with 958,867, is not far behind.

The average size of solar systems installed also continued to trend upwards, reaching 9.3 kW compared to 8.7 kW in 2022. The Australian Energy Council believes that the trend towards larger system sizes may begin to plateau as the years go by, as technological advancements allow for more efficient solar panels and inverters, and there is a growing emphasis on optimising the size of solar installations to match a household's energy needs.³ But that trend would represent effective optimisation and not be seen as a negative.

There are now just over 3.7 million solar households in Australia, up from approximately 3.4 million at this time

last year, demonstrating the enormous commitment Australians have to embracing rooftop solar.

Rooftop solar accounted for 28.5 per cent of renewable generation in 2023 and 11.2 per cent of energy generation overall. Those figures are both up from 2022 – 25.8 per cent and 9.3 per cent respectively.

PV policy

While the Federal Government's big announcement at the end of 2023 – the expanded Capacity Investment Scheme – is primarily focused on utility scale developments, there have nevertheless been significant developments on the smaller-scale side of things.

Perhaps chief among those came in November 2023, when the Energy and Climate Change Ministerial Council agreed to develop a National Consumer Energy Resources Roadmap, as well as the establishment of a set of standards for consumer energy resources, which is something the industry has long needed to improve reliability and efficiency.

In May 2023, the Northern Territory Government announced 15 housing properties in Alice Springs would be fitted with solar panels and battery energy storage systems as part of the \$12.5 million Alice

² J Bowler, *RenewEconomy*, <https://reneweconomy.com.au/sunshine-state-milestone-as-queenslanders-install-one-million-solar-rooftops/>

³ Australian Energy Council, *Solar Report Q3 2023*

Springs Future Grid project, designed to help the government plan future public housing builds.⁴

Following on from Queensland's announcement of an emergency backstop mechanism in 2022, which allows networks to remotely disconnect solar power and battery systems for short periods during emergencies in order to maintain energy security and prevent load emergencies, Victoria enacted its own backstop mechanism in 2023, the first phase of which came into effect in October, affecting newly installed, upgraded or replaced rooftop solar systems over 200 kW. From July 2024, it will also affect systems less than or equal to 200 kW. The necessity for these mechanisms is a result of more solar being installed in the energy grid, which is a positive, and will allow more solar to be safely installed.

Rooftop solar future

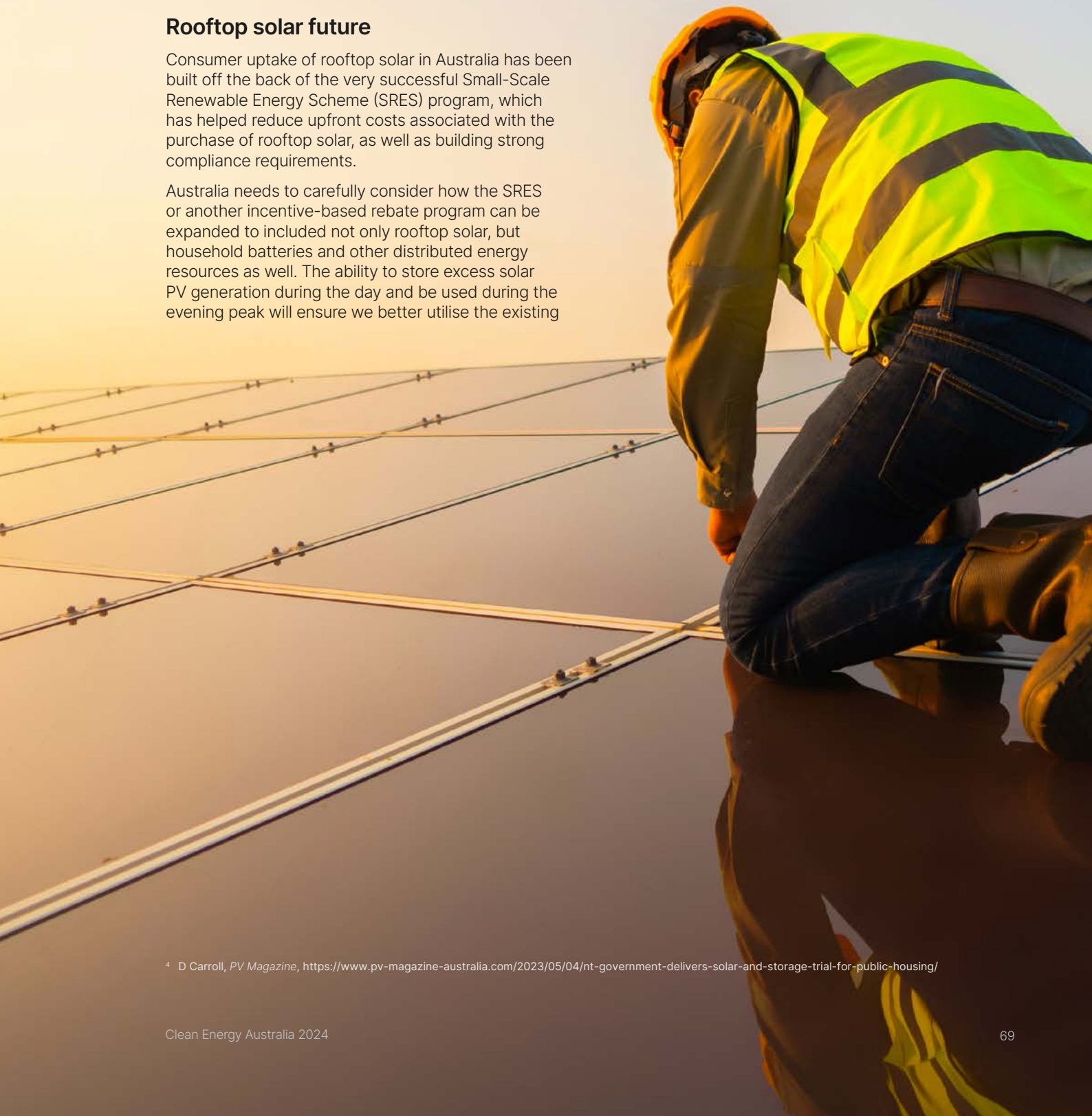
Consumer uptake of rooftop solar in Australia has been built off the back of the very successful Small-Scale Renewable Energy Scheme (SRES) program, which has helped reduce upfront costs associated with the purchase of rooftop solar, as well as building strong compliance requirements.

Australia needs to carefully consider how the SRES or another incentive-based rebate program can be expanded to include not only rooftop solar, but household batteries and other distributed energy resources as well. The ability to store excess solar PV generation during the day and be used during the evening peak will ensure we better utilise the existing

distribution network. This will bring down costs not only for the owners of the solar and battery systems, but for all energy users.

The focus needs to be on how to encourage more orchestration of rooftop solar and storage, but that needs to be driven by consumers who make informed choices and have trust in the installation process and the quality of the product.

Australia's rooftop solar industry is already world-leading, and with the right policy settings it could really take off and accelerate the clean energy transition.



⁴ D Carroll, *PV Magazine*, <https://www.pv-magazine-australia.com/2023/05/04/nt-government-delivers-solar-and-storage-trial-for-public-housing/>

Medium-scale solar

(Systems between 100 kW and 5 MW)

85 MW

New medium-scale solar capacity added in 2023

(2022: 66 MW)

830 MW

Total capacity of the medium-scale solar sector

(2022: 745 MW)

Medium-scale solar generation in 2023



1.8%

of renewable energy generation in Australia 2023

(2022: 1.2%)



0.7%

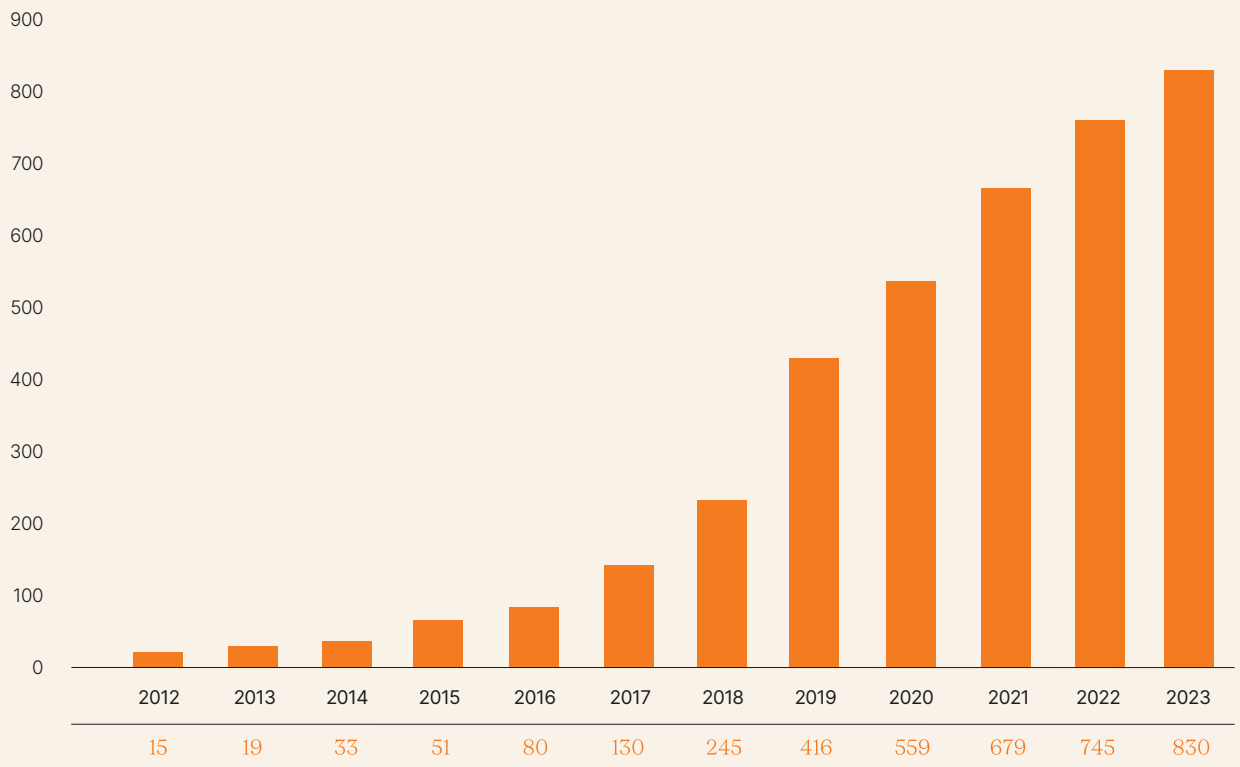
of total energy generation in Australia 2023

(2022: 0.4%)



○ St Augustine's College
Brookvale, NSW
Curingai Country
(Solaheart)

Cumulative installed capacity (MW) of medium-scale solar systems



Note: Due to lags in Clean Energy Regulator processes for registration and publishing of data on the capacity of medium-scale solar systems, the capacity listed for the 2022 and 2023 year is likely to be underestimated.

Solar Design and Installation awards



The Clean Energy Council's Solar Design and Installation Awards celebrate those in Australia's flourishing solar installation and design industry who take their ideas to the next level.

The 2023 winners demonstrated innovation and ingenuity, and the inherent flexibility of rooftop solar to meet the energy needs of Australian households and businesses.



WINNER:
UNDER 100 KW – DOMESTIC

Phillip Christian
Solpac Energy Solutions

Working with Solpac Energy Solutions, Phillip installed two stacks of BYD HV batteries, each connected to a 5 kW Fronius Gen24 inverter on a three-level building overlooking Queensland Alumina Limited (QAL) and the Gladstone Harbour. Solpac's design objective was simple: to get as close to eliminating the \$1,500 quarterly power bill as possible, while using only the available roof space and staying within the photovoltaic (PV) 2x oversize ruling for hybrid solar inverters.



WINNERS:
UNDER 100 KW - COMMERCIAL

Matthew Linney and Joel Cronan
Iberdrola Australia

Mark Fanning
Flow Power

Working with Iberdrola Australia, Matthew and Joel designed and installed a combined solar and EV charging solution for the Lismore Council. The structure used bifacial solar panels to generate electricity from the high reflected light in the car park as well as directly from the sun.

The structure was also designed to reflect the shape of a butterfly and provide a habitat for the local, endangered Richmond Birdwing Butterfly, which had also been a focus of local environmental groups. The panels provided water collection for native plants and vines favoured by the butterflies, with a storage tank and reclaimed timber panels helping improve sustainability.

Flow Power, teaming with Mark, designed and installed a 96.8 kWp (80 kVA) solar PV system on the Lake Mountain Alpine resort, to help manage the extreme seasonal load, and reduce carbon emissions and operating costs of the resort's microgrid.



WINNER:
OVER 100 KW

Sam Saada, Eddie Greco,
Michael O'Mahony, Alex
Musgrove, Joel Gilchrist, Veli
Markovic and Pat Carne
Greenwood Solutions

Greenwood Solutions was contracted to design and install a solar system to help power the substantial pump electrical loads that a Victorian wastewater treatment plant experiences, reducing the plant's energy bills and carbon footprint. At the core of this pioneering venture lay the ingenious concept of harnessing solar energy through a floating PV system.



Peel Microgrid
Nambelup, WA
Binjareb Country
(Peel Renewable Energy)

CASE STUDY:

Peel Microgrid

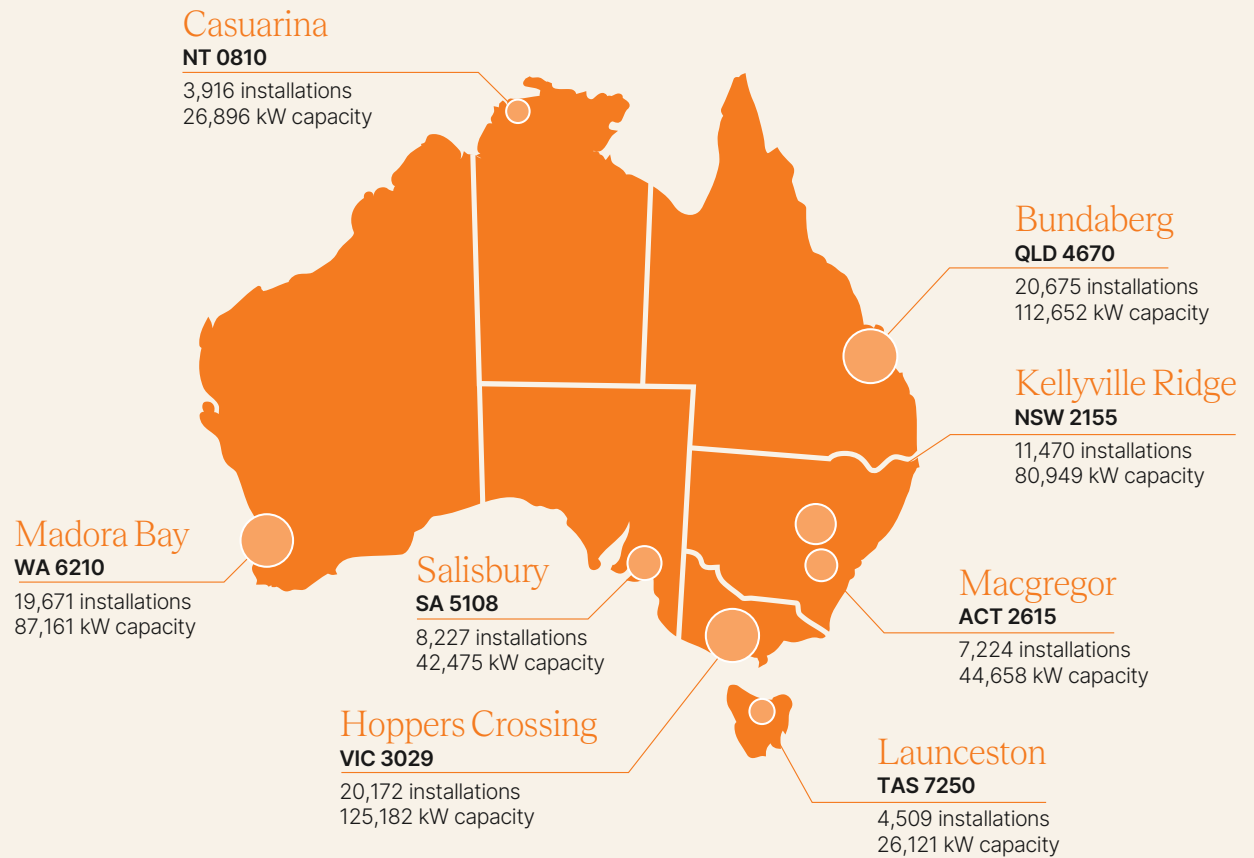
The Peel Microgrid is an embedded-network power system, with a single connection to the South West Interconnected System, that feeds all of the businesses at the Nambelup Kaadadjan business park where it resides. It has on-site solar generation and battery storage for storing energy which isn't used during the day, and is the first renewable industrial microgrid in Western Australia serving multiple green titled lots.

Microgrids – groups of interconnected loads and distributed energy resources that act as a single grid entity – support existing electricity networks through embedded renewable generation and storage, allowing costs to be localised. The Peel Microgrid currently features a 1.2 MW peak ground-mounted solar array, supported by a 1.8 MW/2.5 MWh batter storage system.

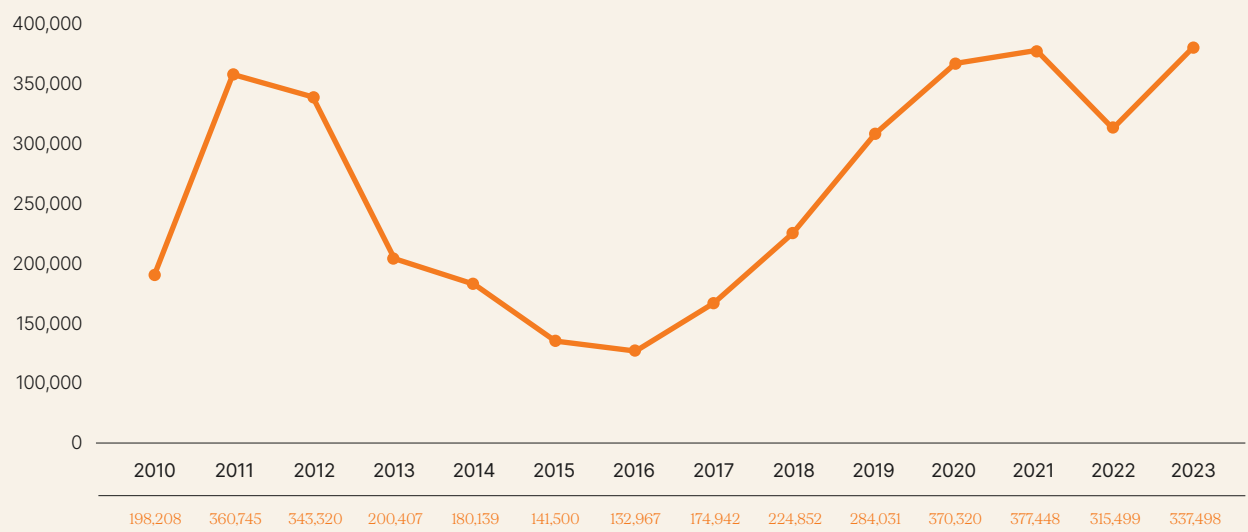
Stage one of the industrial estate is fully sold, with stage two almost fully sold. There are plans to expand the solar generation onsite, either on rooftops or the ground, and additional storage is also being considered. Onsite generation is anticipated to grow over the next decade towards 30 MW of solar power and 58 MWh through its battery energy storage system. The microgrid currently delivers a minimum of 50 per cent renewable energy to all customers of the business park, as well as savings of up to 30 per cent on regulated tariffs.

Distributed energy systems such as the Peel Microgrid are essential for bolstering Australia's clean energy transition, providing reliable, low-cost renewable power.

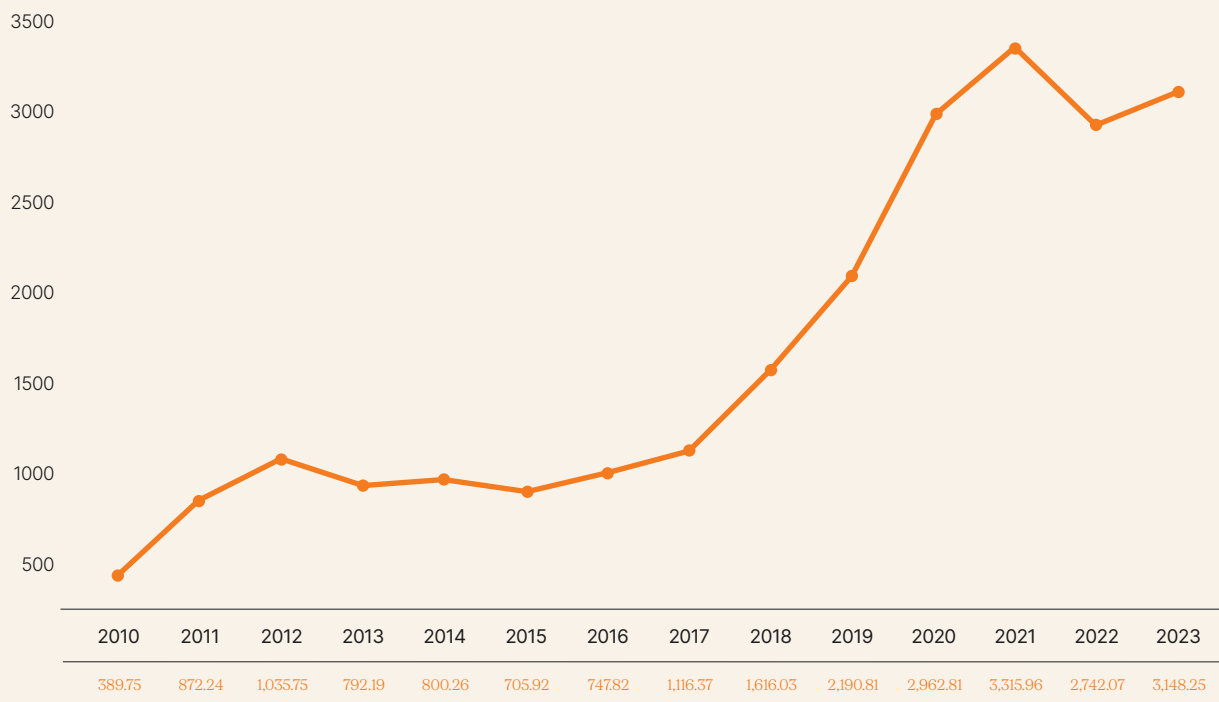
Top solar postcodes in each state, by number of installations



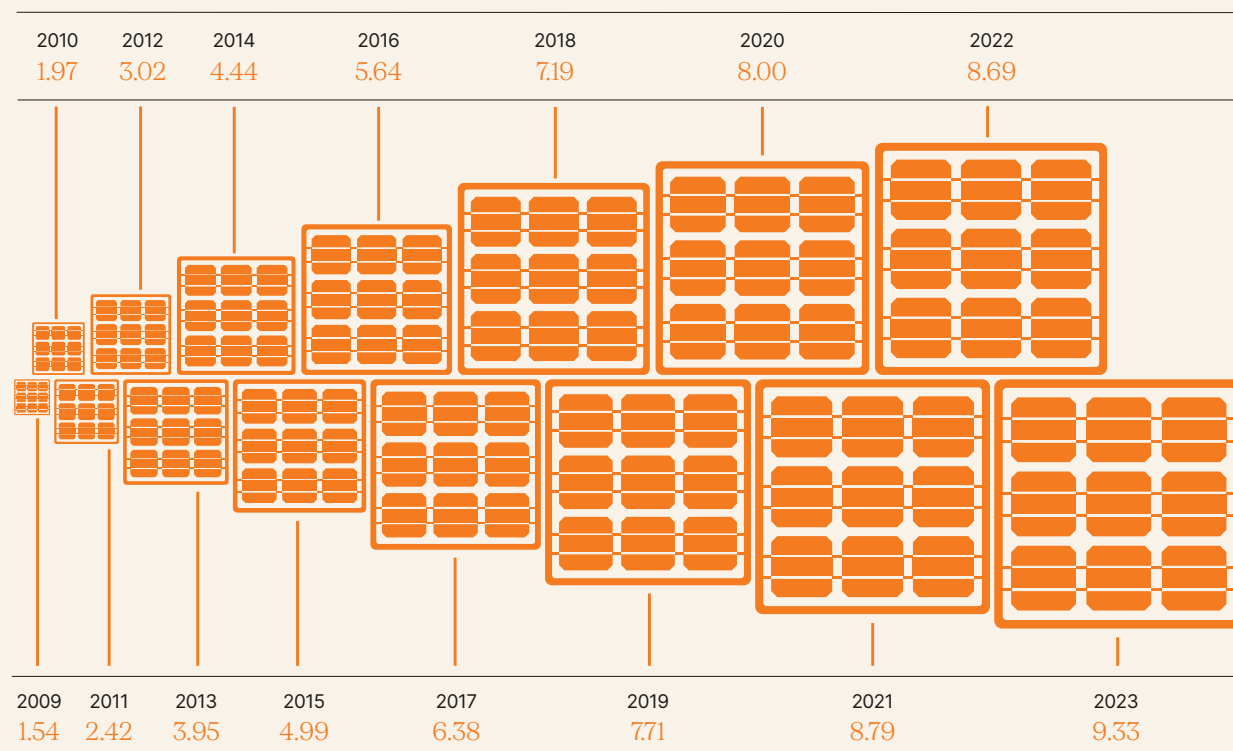
Annual solar PV installations



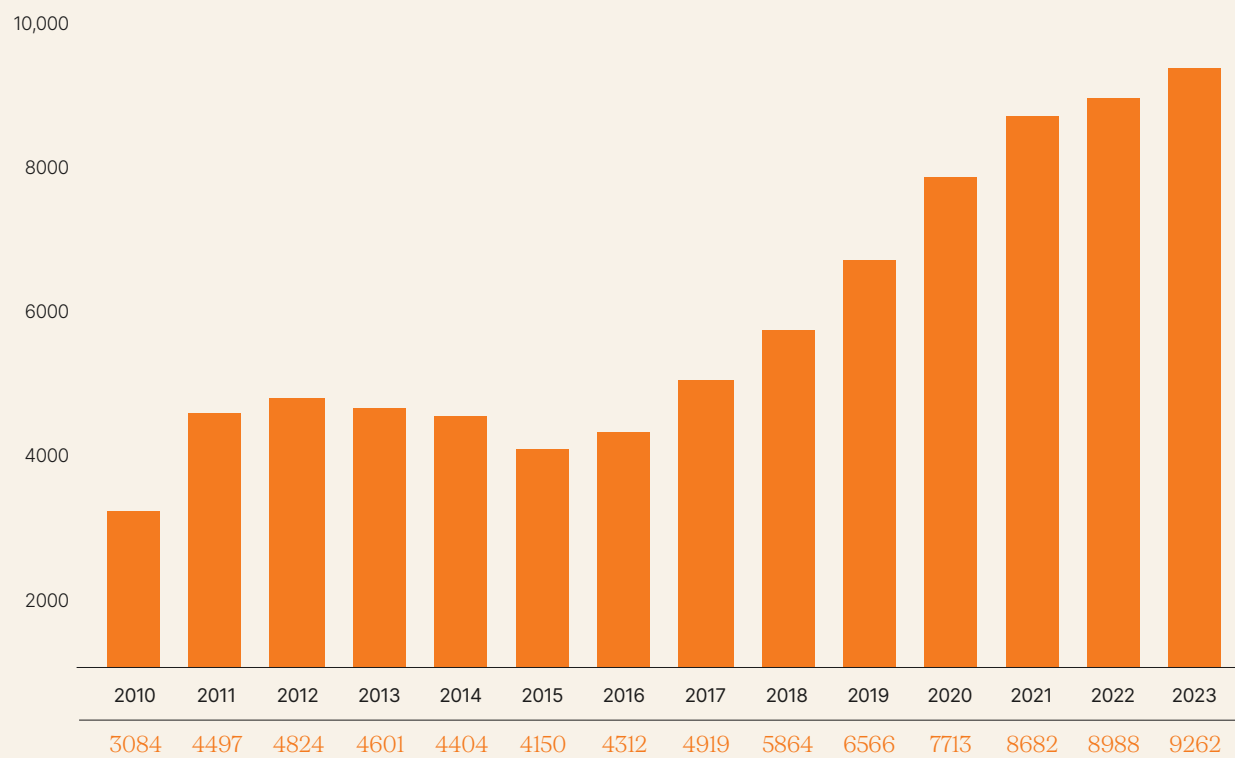
Annual installed capacity of solar PV (MW)



Average solar PV system size (kW)



Total number of Clean Energy Council 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
2022	197	2375	101	2471	881	138	2011	812	2	8988
2023	2520	202	781	2521	2091	90	885	158	3	9262



TECHNOLOGY PROFILE

Large-scale solar

systems larger than 5 MW

Completed large-scale solar projects and capacity added are both up on 2022 levels, but figures for new financial commitments are low, and need to be accelerated.

Fourteen large-scale solar projects were commissioned in 2023, amounting to 1.9 GW of new capacity. Those figures are both up from 2022 (when 12 large-scale projects added 841 MW to the power system) and arrest the three-year trend of large-scale solar projects falling in number and total capacity.

In 2022, NSW was the leading large-scale solar state, commissioning eight of the country's 12 projects. In 2023, Queensland has taken that title, commissioning five of the 14 projects for a combined capacity of 860 MW. NSW comes in second with three projects, for a total of 609 MW.

After a bumper year for large-scale solar in 2021, when all five of Australia's largest solar farms came online in a single year, 2022 was something of a dip in terms of new capacity – the largest solar farm being the 150 MW Suntop Solar Farm. 2023 fared much better, with 400 MW farms entering the grid in both Queensland and NSW: respectively Neoen's Western Downs Green Power Hub and ACEN Australia's New England Solar Farm Stage 1. In 2023, ACEN Australia secured a 20-year Long Term Energy Service Agreement (LTESA) for the project in the NSW Government's first renewable energy and storage auction. Those two projects are now the joint-largest solar farms in Australia.

Of the 56 renewable energy projects under construction as of December 2023, 38 were large-scale solar projects, down from 48 at the same stage in 2022. The largest projects in that list are another two 400 MW developments, both in NSW: BJEI Australia's Wellington North Solar Farm, and ACEN Renewables' Stubbo Solar Farm. Out of all the large-scale solar

1.9 GW

New large-scale solar capacity added in 2023

(2022: 841 MW)

8.2 GW

Cumulative large-scale solar capacity in Australia

(2022: 6,5 GW)

14,802 GWh

Generation from solar farms in Australia in 2023

(2022: 11,733 GWh)

farms currently under construction, the top five are all in NSW, meaning we could possibly see NSW overtaking VIC on the ranking of the states for whom renewables form the highest proportion of their energy mix.

In 2023, seven large-scale solar projects reached financial commitment for a total of 912 MW, down from 10 projects and 1.5 GW in 2022. If hybrid projects with solar generation are included, the number for 2023 is stronger at 11 projects and 1.3 GW of generation. New financial commitments to large-scale solar projects in 2023 stood at \$912 million, down from \$1.5 billion in 2022, reflecting the country wide decline in commitments to new generation projects in 2022.

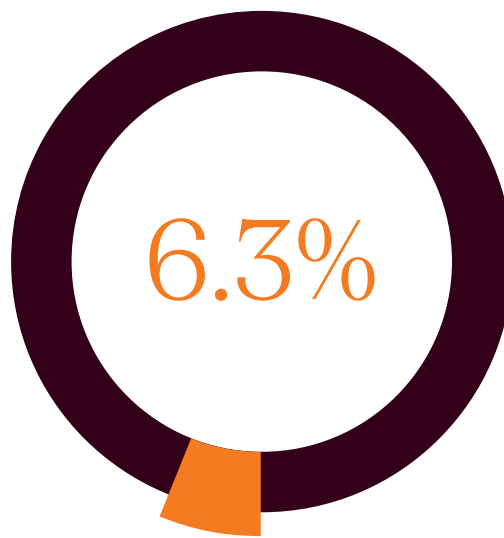
In its report, *Renewables 2023*, the International Energy Agency reined in forecast growth for renewable energy in Australia due to policy uncertainty “following early achievement of its Large-Scale Renewable Energy Target”¹ While there were supportive renewable energy targets announced in 2022, clearly targets alone, in the absence of policy mechanisms, are not always enough to drive investment. Hopefully the Federal Government’s expansion of the Capacity Investment Scheme announced in late 2023 will help bring on the kind of investment Australia needs in order to meet its targets.

Large-scale solar generation in 2023



of total clean energy generated in Australia in 2023

(2022: 14%)

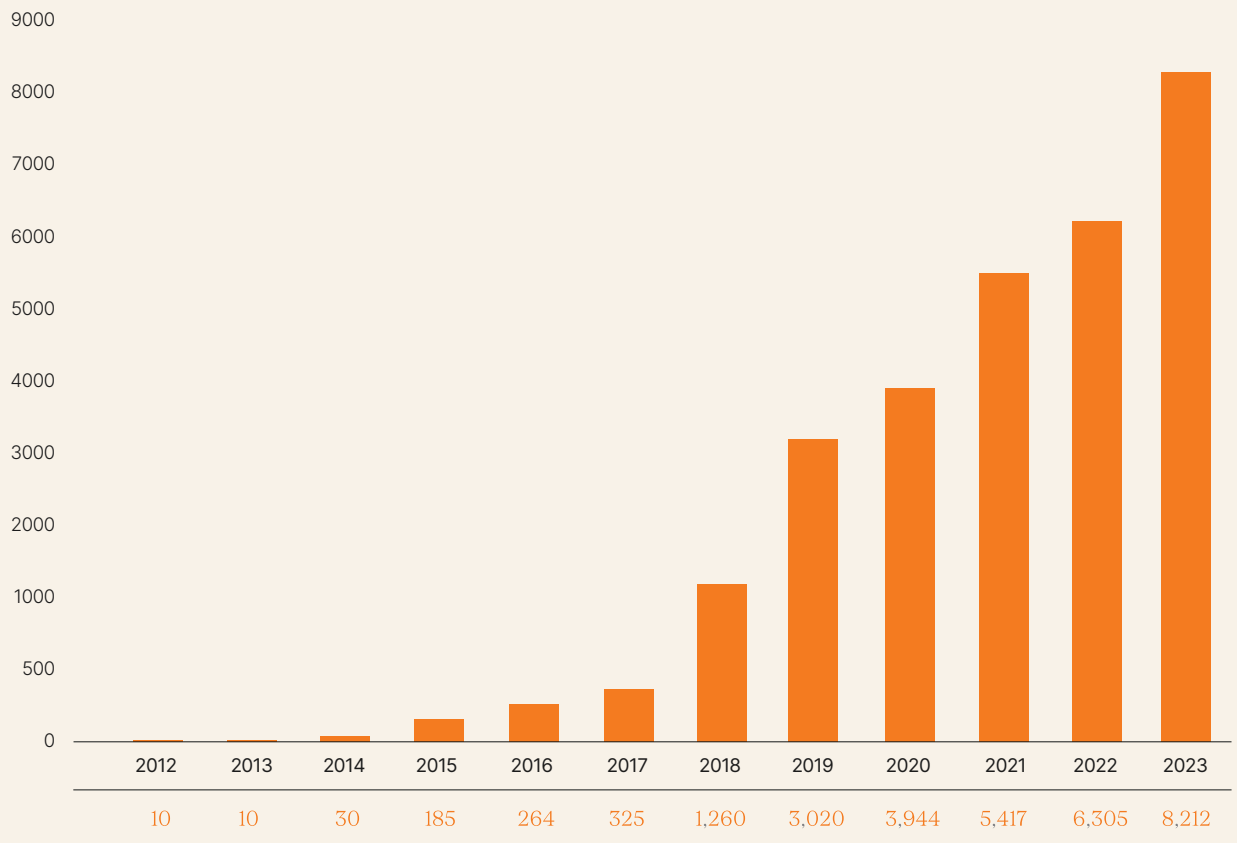


of total Australian electricity generated in 2023

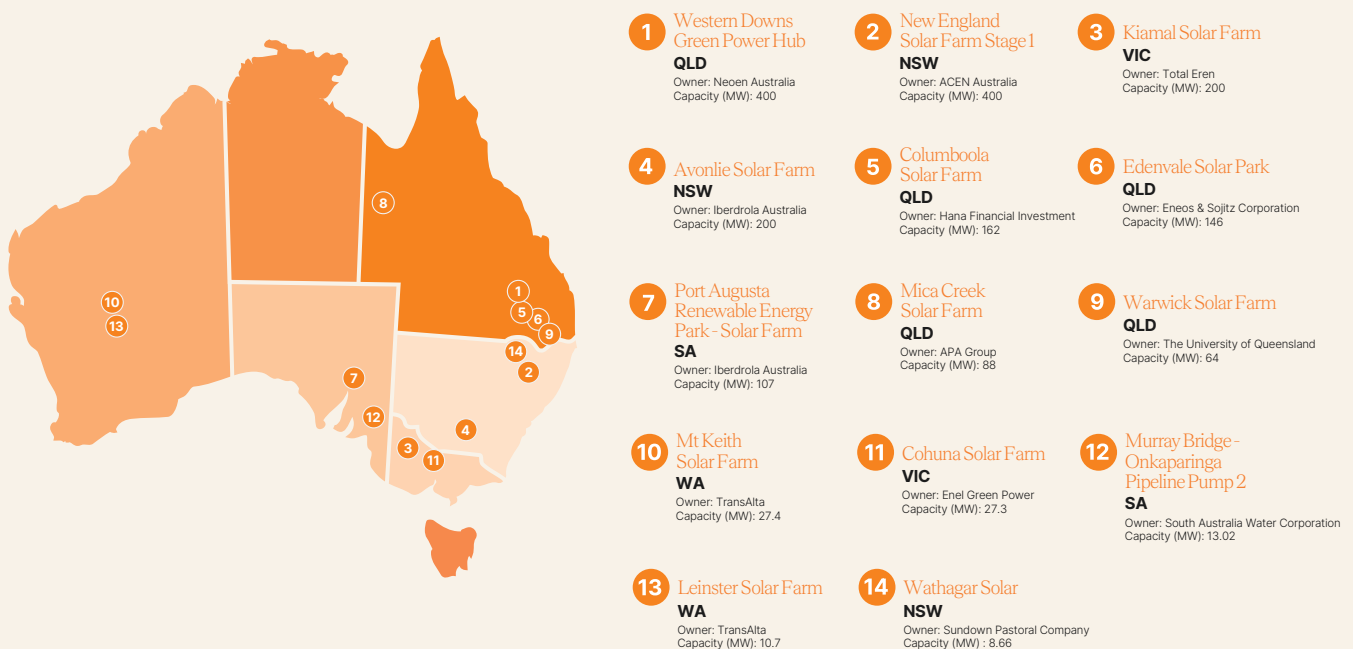
(2022: 5%)

¹ International Energy Agency, *Renewables 2023*

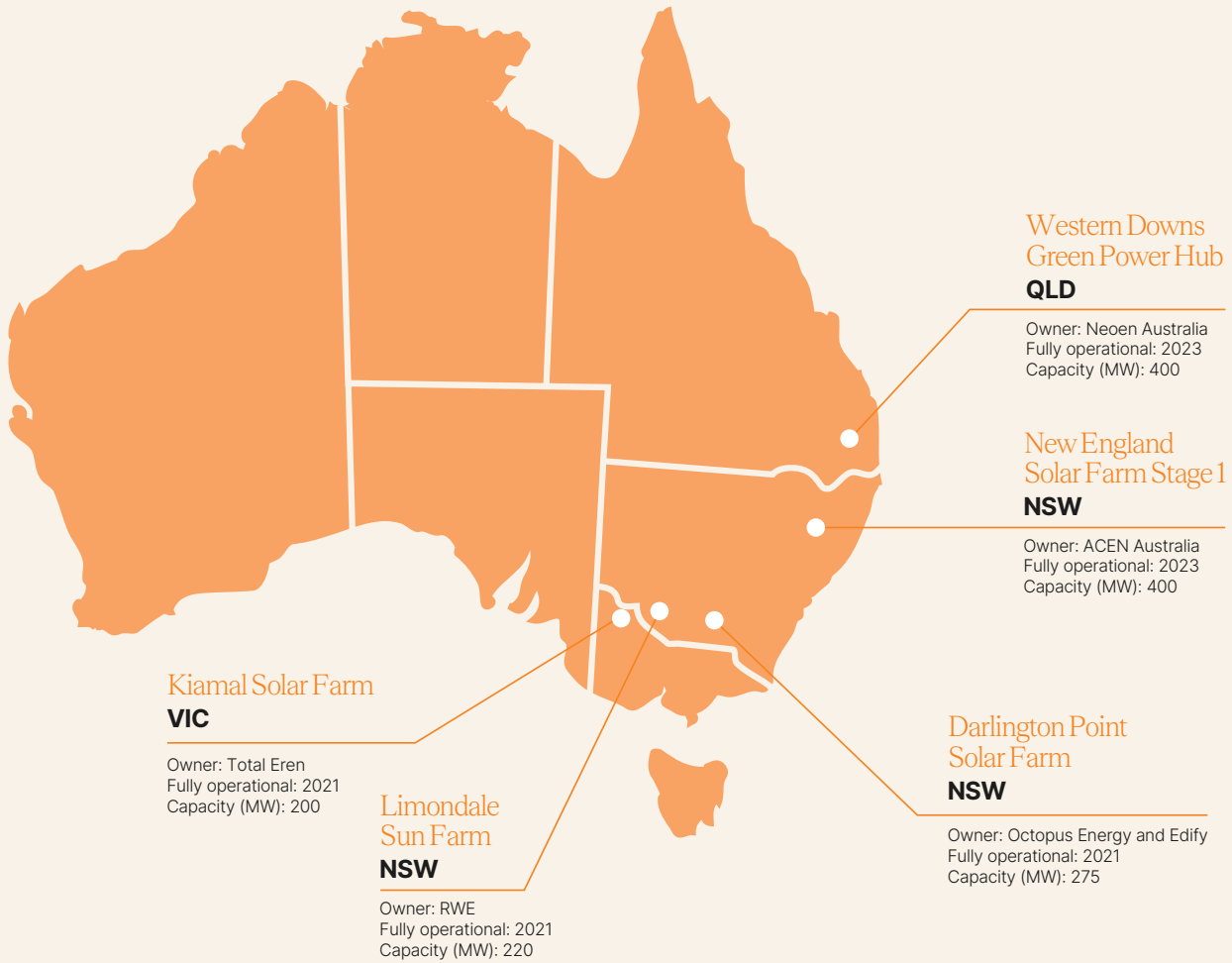
Cumulative installed large-scale solar capacity (MW)



Large-scale solar projects commissioned in 2023



Top five Australian solar farms by capacity



○ New England Solar Farm
Uralla, NSW
Anaiwan Country
(ACEN Australia)



○ Girgarre Solar Project
Stanhope, VIC
Yorta Yorta Country
(Enel Green Power)

CASE STUDY

Girgarre Solar Project

In the third quarter of 2023, construction commenced on the 93 MW Girgarre Solar Farm Project, located approximately 50km west of Shepparton, Victoria. The project, which involves an overall investment of more than \$140 million, is expected to become operation in early 2025. When completed, Girgarre will produce approximately 200 GWh/year, powering approximately 43,000 Victorian households annually.

“The mounting structures and tracking systems that support the solar modules are currently under construction,” says Werther Esposito, CEO at Enel Green Power Australia (EGPA). “Piling (the process of driving mounting piles into the ground) is ongoing across the site.”

“Enel Green Power is committed to a Creating Shared Value approach,” says Esposito. “This includes active engagement with the Girgarre Development Group on a number of initiatives to benefit the local community.

“Earlier this year, we commenced engagement with Yorta Yorta Nation Aboriginal Corporation (YYNAC),

including entering into a formal agreement for the life of the project. The agreement underlines that both EGPA and YYNAC recognise the benefits of working together respectfully and collaboratively to manage, protect and promote Yorta Yorta Cultural and Intellectual Property and local economic development in respect to the project.”

Enel Green Power Australia already operates three solar farms in Australia, totalling approximately 310 MW. It is also currently building the 76 MW Flat Rocks Stage 1 wind project in Western Australia.

As construction began earlier this year, Hon Lily D'Ambrosio, Vic Minister for Energy and Resources, said: “The Girgarre Solar Farm will be an important part of Victoria’s transition to 95 per cent renewable energy generation by 2035. It will deliver affordable and reliable renewable energy to our grid once complete, and create local jobs and opportunities during its construction.”²

² J Hill, *RenewEconomy*, <https://reneweconomy.com.au/construction-begins-at-new-solar-farm-in-regional-victoria-after-sod-turning/>



TECHNOLOGY PROFILE

Wind

2023 was a slow year for wind power in Australia in terms of capacity added, which was down on 2022, and also in terms of new investment commitments.

Wind power accounted for 33.9 per cent of Australia's renewable power generation in 2023, down from 35.6 per cent in 2022. However, as a percentage of Australia's overall power generation, including non-renewables, wind rose from 12.8 per cent in 2022 to 13.4 per cent in 2023.

The fall to 33.9 per cent is likely a result of the fact that while new large-scale additions to the grid were relatively slow in 2023 (seven wind farms were commissioned, compared with eight in 2022), other forms of renewables continued to grow at pace, most notably the rooftop solar sector. The higher percentage of overall generation is likely down to the decreasing prevalence of fossil fuels, which despite their still-widespread use, are falling overall.

Of the seven wind farms commissioned in 2023, the largest is Squadron Energy's 244 MW Bango Wind Farm in NSW, which commenced commercial operations in early 2023. The third-largest wind farm in NSW, it produces enough electricity to power 144,000 homes. The second-largest commissioned project is also run by Squadron Energy, this time in Victoria: the 38-turbine 209 MW Murra Warra Wind Farm (Stage 2). Queensland led the way for commissioned wind farms in 2023, with three.

There were no new financial commitments to utility scale wind projects in 2023 (compared to six in 2022), which is cause for concern in the context of the dominant position that wind power should have in new renewable energy builds over the coming

7

wind farms commissioned in 2023

(2022: 8)

942 MW

new wind capacity added in 2023

(2022: 1,411MW)

decade. The Australian Government's announced expansion of the Capacity Investment Scheme is intended to stimulate increased investment activity, which will need to be complemented by decisive efforts to accelerate the often slow, complex and inefficient planning and assessment processes in many jurisdictions.

In a slow year, the closest the industry came to a new financial commitment was CS Energy's agreement to take a 50 per cent stake in the up-to 372 MW Boulder Creek Wind Farm. CS Energy is a QLD state-owned energy company with, until recently, a focus on thermal generation assets. This is its first major investment in large-scale wind.¹ Construction on the Boulder Creek Wind Farm is expected to commence in mid-2024. Stage one will bring capacity of 228 MW.

¹ S Vorrath, *RenewEconomy*, <https://reneweconomy.com.au/cs-energy-takes-50-stake-in-its-first-wind-farm-in-big-step-away-from-coal/>

The largest wind power project under construction in Australia remains Acciona's MacIntyre Wind Farm, which was to be the country's first gigawatt-scale wind development, but the Karara element (see below) has been cancelled. Significant progress was made in 2023 on MacIntyre Wind Farm, including 85 fully completed wind turbine generators and positioning of final foundations.² The project, which represents a total investment of \$1.96 billion and according to Acciona will power 700,000 homes and create 400 new jobs, is on course to be operational in 2024. The largest operational wind farm in Australia remains Goldwind's 532 MW Stockyard Hill Wind Farm in Victoria, which became fully operational in 2022.

Unfortunately, the 103 MW Karara Wind farm, which was being proposed for development by Queensland Government-owned CleanCo alongside MacIntyre Wind Farm, is no longer progressing. "As a result of significant delays to the connection process, and subsequent impact to costs, CleanCo is pausing development of the [Karara] project," said CleanCo.

States and sanctions

Providing 36.2 per cent of Australia's wind generation, Victoria continues to lead the states. This figure has risen from 33.7 per cent in 2022. As mentioned above, the second-largest wind farm commissioned in 2023 was in Victoria, and the second-largest wind farm in development (after MacIntyre Wind Farm, detailed above) is the 756 MW Golden Plains Wind Farm in Vic, so Victoria's status as Australia's number-one wind generating state is unlikely to change anytime soon. The Golden Plains Wind Farm is divided into two parts – East and West – which, when completed, will add up to around 1,330 MW of capacity.

While 2023 hasn't been a stellar year for new developments in the wind sector, there was good news in June as GPE NemLog2 reported that wind farms in Australia had set a new instantaneous output record of 7,323.9 MW, set at 10:15pm on June 8. Around the same time, Victoria bettered its instantaneous wind output three times in a single week.³

In Victoria there was difficult news in August 2023 for the proposed Willatook Wind Farm, when a decision was made by the Victorian Government to impose a five-month ban on construction work every year in an attempt to protect the endangered broilga and Southern bent-wing bats that live in the area. In addition, the ruling imposed extensive buffer zones around vegetation that would effectively cut the number of turbines that could be installed by almost two-thirds.⁴ The result of the ruling and the fate of Willatook Wind Farm are yet to be determined, but the process revealed an urgent need for clearer, risk-based guidance on bird and bat policies in Victoria.

2023 saw a range of other biodiversity-related challenges for the wind industry, including the ultimate approval for the Robbins Island Wind Farm in Tasmania,

after an initial Tasmanian EPA recommendation that the wind farm could not operate for five months of the year.

Tailwinds for offshore

In mid 2022, the Federal Government announced a process to identify six priority areas in Australia for offshore wind, and the first of those – the Gippsland offshore wind area in the Bass Strait between Victoria and Tasmania – was announced at the end of the year. In 2023, four more of those areas were announced for consultation: Hunter, NSW (now formally declared); the Southern Ocean area, Vic and SA; Illawarra, NSW; and Bass Strait off Northern Tasmania.

The sixth and final offshore wind area was announced in mid-February 2024 in the Indian Ocean off the Bunbury coastal waters in Western Australia. These announcements represent significant progress for the offshore wind industry in Australia, and there is a definite sense of momentum going into 2024.

For the Gippsland offshore wind area, there were 37 feasibility licence applications, across 20 different developers, suggesting interest levels are high. At the time of writing, the Federal government had awarded provisional Feasibility Licences to six projects, which could generate 12 GW of electricity, and is also considering if an additional six projects could resolve overlapping constraints to resubmit for further consideration.

Establishing the Australian Offshore Wind Taskforce

In late 2023 the Clean Energy Council established the Australian Offshore Wind Taskforce to coordinate State and Federal Governments with offshore wind developers to explore opportunities for maximising the economic and environmental benefits of offshore wind in Australia. The Taskforce will also facilitate coordination with the broader industry, with the Clean Energy Council as Chair.

The declaration of areas is of course only the first step in what will likely be a lengthy process to get projects built, but it is a sign the industry has the foundations to grow in the months and years to come. According to Energise Renewables, since October 2022, "almost 102 GW of offshore wind has been announced in Australia"⁵ While due to licencing limitations, overlap constraints and financing it is expected that not all of these

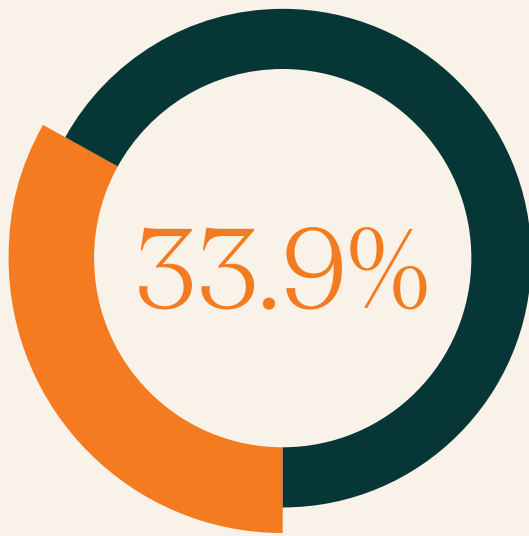
² Warwick Today, <https://warwicktoday.com.au/news/2024-01-16/acciona-energia-reflects-on-a-big-2023/>

³ G Parkinson, *RenewEconomy*, <https://reneweconomy.com.au/wind-farms-set-new-output-record-in-australias-main-grid-for-first-time-in-2023/>

⁴ A Macdonald-Smith, *Australian Financial Review*, <https://www.afr.com/companies/energy/broilga-and-bat-ruling-a-death-knell-for-victorian-wind-farm-20230801-p5dt21>

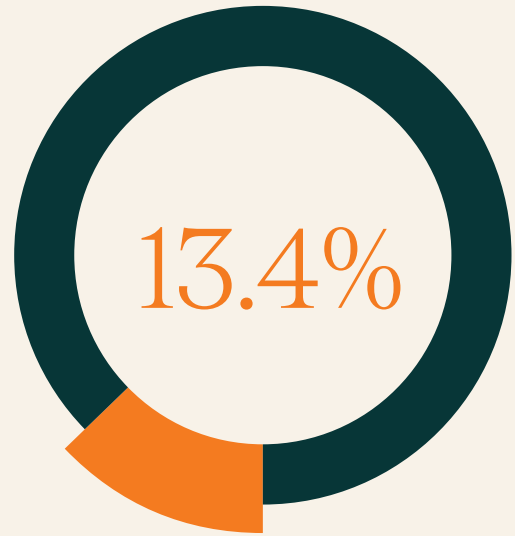
⁵ Energise Renewables, <https://energise-renewables.com/location/australia/>

Wind power generation in 2023



**of total clean energy
generated in Australia
in 2023**

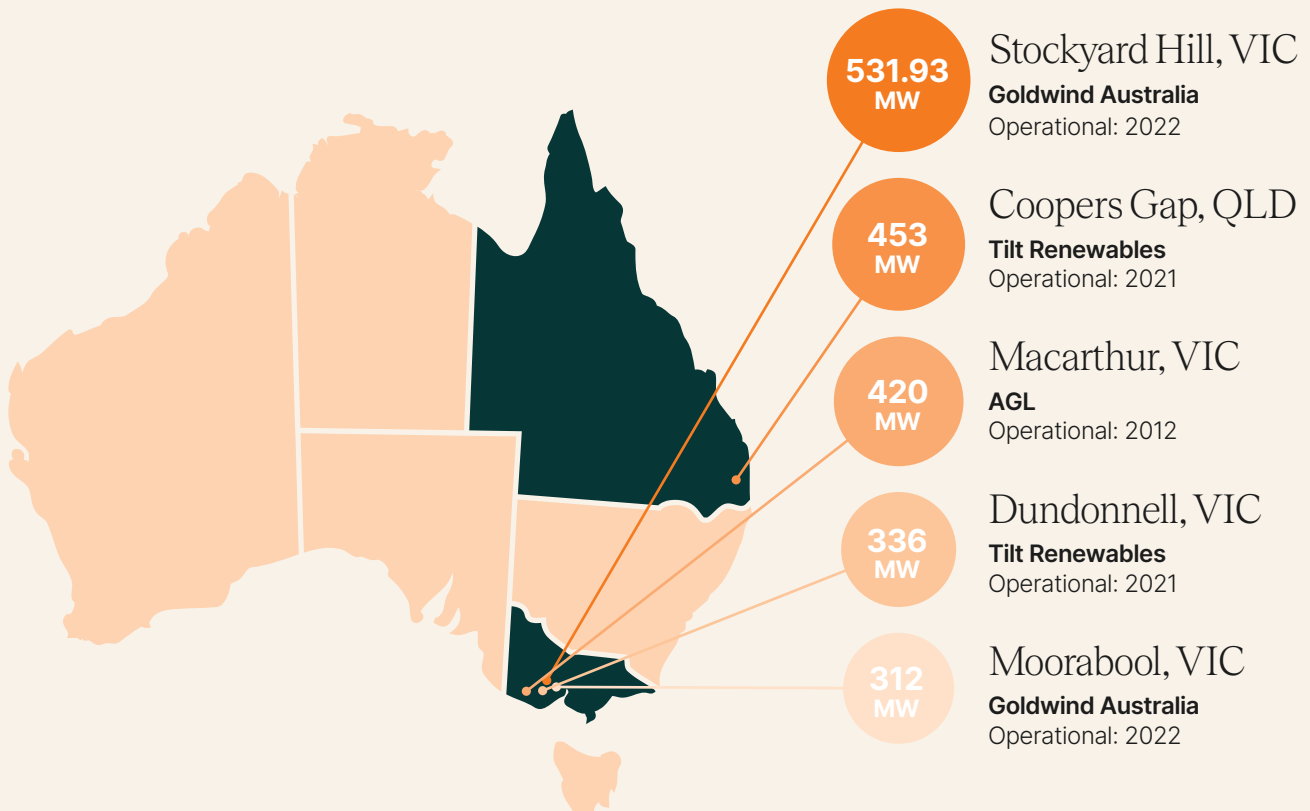
(2022: 35.6%)



**of total Australian
electricity generated
in 2023**

(2022: 12.8%)

5 largest wind farms in Australia by capacity (MW)



projects will eventuate, this number does highlight the significant level of investor interest in the Australian offshore wind market and the world class offshore wind resources we have in our waters.

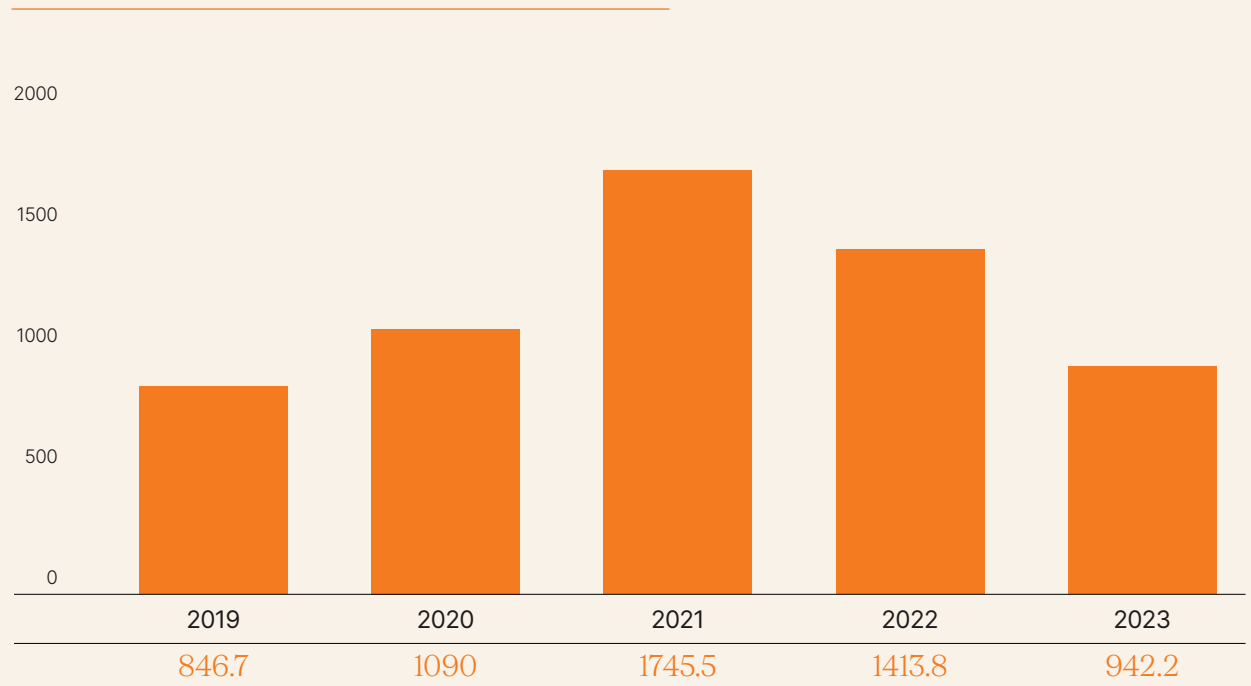
In late 2023, PwC reported that based on the size of announced offshore wind areas in Australia, the country's GDP could be \$40 billion higher between 2027 and 2040, and up to 19,000 jobs could be supported in peak of construction.⁶

Wind farms under construction or committed at end of 2023

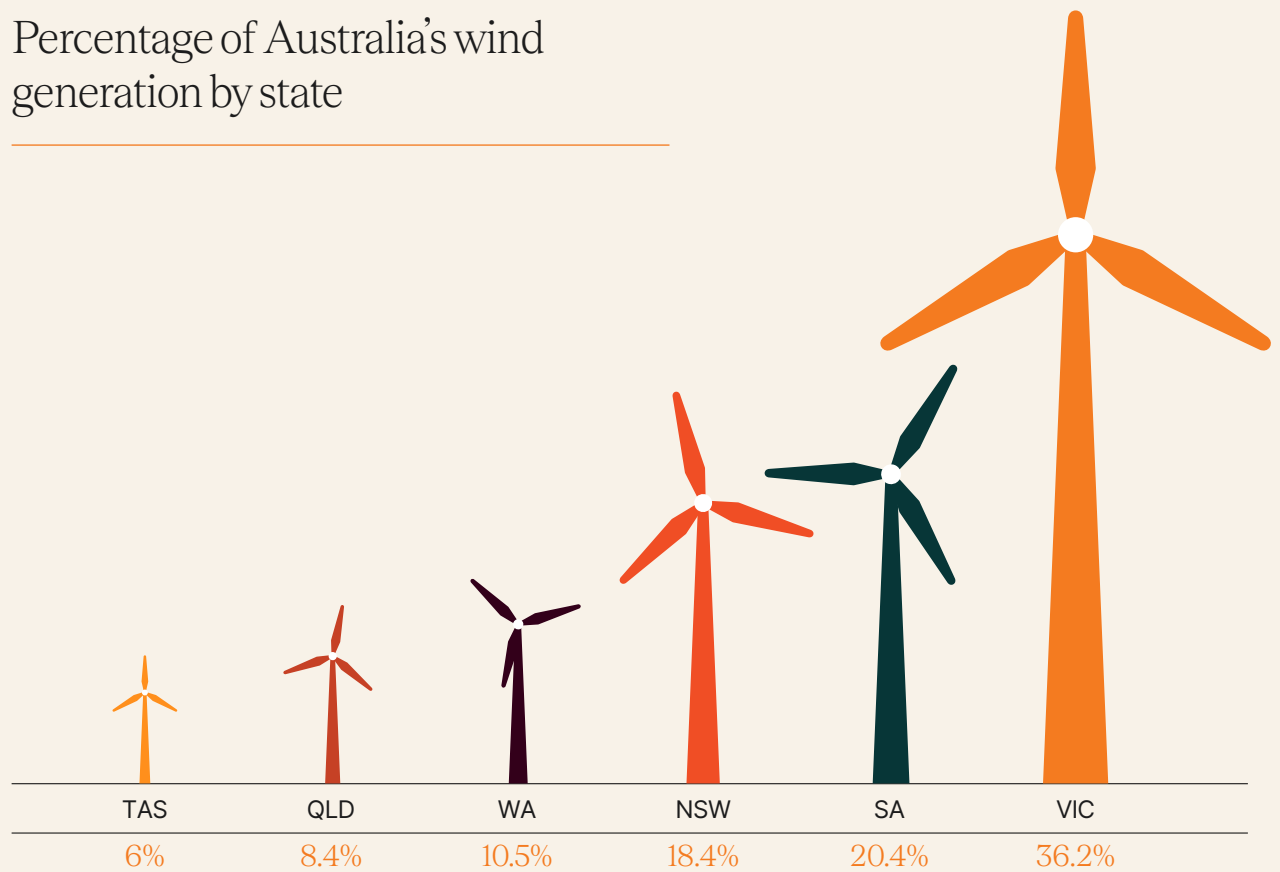
Commitment year	Project	Lead operator-owner	State	Location	Installed Capacity (MW)
2022	MacIntyre Wind Farm	Acciona	QLD	Karara	923
2022	Golden Plains Wind Farm Stage 1	WestWind Energy & TagEnergy	VIC	Rokewood	756
2022	Clarke Creek Wind Farm Stage 1	Squadron Energy	QLD	Clarke Creek	450
2021	Rye Park Wind Farm	Tilt Renewables	NSW	Rye Park	396
2022	Diamondy Wind Farm (Wambo) Stage 1	Stanwell and Cubico Sustainable Investments	QLD	Diamondy	252
2020	Ryan Corner Wind Farm	Global Power Generation	VIC	Port Fairy	218
2022	Goyder South Wind Farm Stage 1A	Neoen Australia	SA	Burra	209
2022	Goyder South Wind Farm Stage 1B	Neoen Australia	SA	Burra	203
2019	Mortlake South Wind Farm	Acciona	VIC	Kolora	157.5
2022	Flyers Creek Wind Farm	Iberdrola Australia	NSW	Springside	145
2020	Hawkesdale Wind Farm	Global Power Generation	VIC	Hawkesdale	96.6
2022	Flatrocks Wind Farm Stage 1	Enel Green Power	WA	Kojonup	76
2021	Crookwell 3 wind farm	Global Power Generation	NSW	Goulburn	58
2023	Kathleen Valley Hybrid Project-Wind	Zenith Energy	WA	Sir Samuel	30
2023	Bellevue Gold Hybrid Power Station - Wind	Zenith Energy	WA	Leinster	24
2023	Northern Star Resources Jundee Gold Mine-Wind	Zenith Energy	WA	Wiluna	24

⁶ PwC, <https://www.pwc.com.au/energy-transition/australias-pathway-to-energy-transition-is-blowing-in-the-wind.html>

Annual installed wind capacity in Australia (MW)



Percentage of Australia's wind generation by state





○ Worker on site at Golden Plains Wind Farm Rokewood, VIC Wadawurrung and Gulidjan Country (TagEnergy)

CASE STUDY

Golden Plains Wind Farm East – under construction

The Golden Plains Wind Farm, located 60km northwest of Geelong in Victoria, is a significant clean energy project that, when completed, will be Australia's largest wind farm, hosting 215 turbines with a combined installed capacity of 1.3 GW. It will power 765,000 homes, preventing more than 4.5 million tonnes of carbon dioxide being emitted into the atmosphere each year, equivalent to three per cent of Victoria's total greenhouse gas emissions.

The project is being delivered in two stages: east and west. Golden Plains Wind Farm East, which will house 122 turbines – is owned by TagEnergy (85 per cent) and Ingka Group (15 per cent) and commenced construction in late 2022. Components have been arriving at the site since October 2023, and green energy production is expected to commence in August 2024. The second phase, Golden Plains Wind Farm West, is being prepared for Financial Close by TagEnergy and WestWind Energy, and is expected to commence construction in 2024.

It is estimated that 700 jobs will be created during construction, with 70 ongoing operational jobs expected to remain once construction is complete. There is a dedicated Community Engagement Manager in place for the project, and a range of community benefits are being delivered, including local jobs, contracting opportunities and increased economic activity. The wind farm also provides sponsorships, community grants, and a community energy program which includes free home energy audits, in addition to neighbour benefits and landscaping programs.

INGKA
INVESTMENTS

tagenergy

goldenplains
wind farm east

Thank you

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

Acciona
ACEN Australia
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EDL Energy
Enel Green Power
Fluence

GE Vernova
Genex Power
Gentari
Goldwind
Hydro Tasmania
Neoen
Pollination Group
RES
Solahart
Squadron Energy
Tilt Renewables
WestWind Energy



○ Murra Warra II Wind Farm
Murra Warra, VIC
Jardwadjali Country
(GE Vernova)

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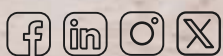
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○ Dulacca Wind Farm
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Barunggam Country
(RES)