CLEAN ENERGY AUSTRALIA

REPORT 2023


EXPLORE
INVEST
ACCELERATE
Energy transition is speeding up. Harness the momentum with MinterEllison: your end-to-end renewable energy advisor.
MinterEllison.

Contents

CLEAN ENERGY COUNCIL

We respectfully acknowledge Aboriginal and Torres Strait Islander people 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: Matt Harvey: Ocean Grove, RACV Solar

The energy transition is for **everyone.**

sonnen

sonnen has 13 years of experience in manufacturing innovative home battery storage solutions and more than **100,000 systems installed globally**.

We are committed to the renewable energy transition.

Hear what our customers have to say:

INTRODUCTION

Kane Thornton

Chief Executive
CLEAN ENERGY COUNCIL

After a stellar 2021, Australia's clean energy sector continued to develop – albeit more slowly – in 2022. While project development and megawatt capacity added were down in some areas, a political sea change saw real momentum build behind the transition to Australia's clean energy future. Despite the global headwinds for energy, we're excited about a big year ahead in working to seize Australia's full potential to be a green energy powerhouse.

We transitioned into 2023 with a mixed report card for renewables in 2022, with some key metrics down on the previous year, but overall with a sense of positivity that there are plenty of opportunities for growth.

More than 5 GW of new renewable capacity were installed in 2022 (2.7 GW from rooftop solar and 2.3 GW from large-scale projects), down from 6.3 GW in 2021.

While the rooftop solar rollout slowed slightly due to supply chain and workforce constraints, it's great to see rooftop solar continuing to drive Australia's clean energy transition. It also reached a significant milestone, accounting for more than a quarter of Australia's total renewable generation for the first time.

The large-scale sector underperformed by some metrics compared to 2021, but nevertheless, the Australian renewable energy industry commenced construction on over 5000 MW of wind and solar farms in 2022 – the highest year for new renewable construction commitments on record. There were also encouraging signs on the large-scale investment front, even if it's too early to consider those signs a trend. A more supportive set of government policies at federal and state level provides cause for optimism, even though as an industry we need to quicken the pace of development in order to reach our renewable targets.

Much of my positivity for the future comes from a more favourable political landscape for renewables combined with genuine business leadership. We saw a sea change in Australian politics in August, with a resounding Labor victory in the federal election. Climate change and the clean energy transition became areas of genuine focus, with sensible and ambitious policies following quickly. It feels like the political landscape is finally getting behind clean energy, rather than trying to find ways to cling to the fossil fuels of the past.

'Australia is back' was the clear message to the global community, with a heightened commitment to our goal to become a clean energy superpower. It was fitting that in early 2023, it was announced that Adelaide would be hosting the Australian International Renewable Energy Conference (AusIREC) in 2024. The Clean Energy Council, alongside REN21, the Australian Government and the South Australian Government, will ensure the event – the first time an International Renewable Energy Conference has been held in Oceania – will put Australia at the forefront of the global push for clean energy.

If the developments and progress we saw in renewables in 2021 signalled the inevitability of Australia's clean energy future, 2022 highlighted just how much action and investment is needed to drive towards that future, particularly in light of game-changing international policy announcements such as the US's Inflation Reduction Act.

The political landscape for renewables changed significantly for the better in 2022, and that's great to see. That success gives us the confidence to confront the myriad challenges that lie ahead as clean energy grows and we prepare a renewables-ready market and grid, as well as playing catchup reforming the policies of the past.

Australia must transition to a clean energy economy quickly, decisively and in the right way, without taking sustained growth for granted. We're looking forward to working with our members and the industry to accelerate the clean energy transition.

Fortune favours the...

My marketing team wanted to feature the 'other Garnaut' gazing out across a sea of solar farms, with a cheesy tagline.

Instead of asking you to look out across an endless sea of solar panels (you know what they look like) that might be built by someone else, by some far off date, I'd like you to take one small step.

Sign up to being a 1.5°C company.

It all starts with this simple ambition to do all you can in keeping with the ambitions of the Paris Agreement.

1. **ZEN signed up last year. We've been thriving ever since.**

   Stop selling to customers who don't have a path to being 100% renewable.

2. **ZEN has. Our customer book continues to grow.**

   Keep telling our governments that we need an investment and regulatory landscape that enables us to build and connect more renewable energy, faster.

3. **ZEN is. We think they're listening.**

   The Albanese government's target of 43% by 2030 points us in the right general direction, but we need to go further, faster, if we are to limit warming to 1.5°.

We must do this. Together.

Fortune favours the bold. The sooner we all sign up, the sooner we see energy costs come down, new industries and new jobs rise up, and our energy security improve.

And the more we will avoid the economic costs, environmental impact, and social turmoil of unabated climate change.

And we can finally tell our kids we listened to them. And they will think we're rad. Won't they???

Go on, sign up... I dare you.

Anthony Garnaut (yep...he's my dad).

ZENENERGY

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

Vertex S

reddot winner 2022

Vertex S+

430W 510W 580W 610W 670W

445W 595W 695W

Vertex

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 25TH

CLEAN ENERGY COUNCIL 2022 HIGHLIGHTS

1000+ Members

Ran our Renewables Are Here Now campaign

Advocated for reform on capacity markets and access and congestion

Launched the NETCC, extending consumer protection to all new energy technologies

Worked with the Federal Government on establishing Rewiring the Nation campaign

Led Australia's renewable energy delegation to COP27

Secured Australia as host of the International Renewable Energy Conference in Adelaide in 2024

Published the *Skilling the Energy Transition* report, laying a path to a skilled, diverse clean energy workforce

Coordinated a diversity and inclusion survey of our membership, a first of its kind in Australia

Published report on modern slavery in clean energy supply chains

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, energy storage, hydrogen and emerging technologies, along with more than 8500 solar and battery storage installers.

The Clean Energy Council's mission is to accelerate Australia's clean energy transition. We lead and support the growth of the clean energy industry in Australia by:

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

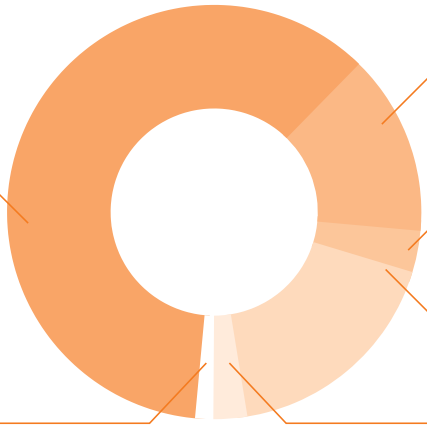
2023 EVENTS CALENDAR

APRIL 20	Sydney Member Mixer
MAY 4	Australian Wind Industry Summit MELBOURNE
JUNE 15	Adelaide Member Mixer
JULY 18	Women in Renewables Luncheon SYDNEY
JULY 18–19	Australian Clean Energy Summit SYDNEY
SEPT 21	Brisbane Member Mixer
SEPT 28	Perth Member Mixer
OCT 25	All Energy Australia MELBOURNE
OCT 26	Women in Renewables Luncheon MELBOURNE
APRIL 2024	AusIREC ADELAIDE

MEMBERSHIP CATEGORIES

Figures correct at time of publication

TOTAL 1011



Associate 140

Professional Services 41

Corporate 183

Sponsoring 18

Emerging technologies 14

Network 615

2022 SNAPSHOT

Clean energy represents a larger share of Australian energy generation than ever. Growth of rooftop solar slowed slightly, but the sector continued to lead Australia's clean energy transition. Although numbers for large-scale completed developments and added capacity are down in some areas, investment figures and positive political sentiment suggest there are plenty of opportunities for growth.

The Australian renewable energy industry accounted for 35.9 per cent of Australia's total electricity generation in 2022, up from 32.5 per cent in 2021. This is just over double what was installed before the boom began in 2017 (16.9 per cent), so while there is still a significant way to go if Australia is to meet its ambition of 82 per cent renewables by 2030, there has nevertheless been encouraging progress.

Rooftop solar once again led the charge for Australian renewable energy in terms of capacity added, with 2.7 GW added throughout 2022. Although that figure is down on 3.3 GW from 2021, it still represents the highest contribution in the renewables sector, and approximately 3.4 million Australian households now have rooftop solar PV systems installed, which is around one in three households. The total number of new rooftop solar installations stood at 310,352, down from 377,408 in 2021. Rooftop solar contributed 25.8 per cent of Australia's renewable energy generation (up from 24.9 per cent in 2021), the first time it has represented more than a quarter of generation.

With 1.4 GW of new capacity added, wind came in second place, also down on its 2021 figure of 1.7 GW. Despite those figures, wind remains Australia's most significant renewable generation contributor overall (when rooftop and utility-scale solar are considered separately), providing 35.6 per cent of all renewable generation and 12.8 per cent of Australia's total energy generation mix.

In general, 2022 has not been a bumper year for project development, at least in terms of the number of projects being completed, though the size of projects in terms of capacity and storage is trending upwards.

Two new wind farms in Victoria became fully operational in 2022: Stockyard Hill (531 MW) and Moorabool (312 MW). Victoria has been the leading state for wind power generation for some time and continues to lead the way, accounting for around a third (33.7 per cent) of Australia's wind generation.

As in 2021, the development of the renewable energy sector has reduced the influence of coal. The share of coal in the generation mix fell from 59.1 per cent in 2021 to 54.6 per cent in 2022. However, gas increased its share of the mix in the same period, up from 7.7 per cent in 2021 to 8.9 per cent in 2022. While positive

35.9%

Australia's electricity generation from renewable sources, 2022

(2021: 32.5%)

21,765 GWh

NSW renewable energy generation, highest of Australian states

2.7 GW

Rooftop solar capacity added in 2022

(2021: 3.3 GW)

72

Large-scale projects under construction or financially committed at the end of 2022

(2021: 68)

← Lisa Healy: Rye Park NSW, Tilt Renewables

movements are being made and sentiment towards renewables is improving, there is clearly still a long way to go to bring those numbers down.

Tentative positivity for large-scale

One area where development has risen is large-scale solar. At the end of 2022, 48 large-scale developments were under construction, up from 42 at the same stage in 2021. While capacity added was down on the previous year (860 MW in 2022 versus 1683 MW in 2021), the larger developments currently under construction should see total generation rise considerably in the coming years. Indeed, large-scale solar recorded its biggest ever month in December 2022, delivering 1505 GWh of renewable power over the month, compared to the previous high in December 2021.

The number of large-scale batteries under construction at the end of 2022 – 19 – was also down on 2021 – 30 – but the approximate combined capacity of those batteries – 1380 MW/2004 MWh – was significantly up on the same figure from 2021 – 921 MW/1169 MWh.

While the figure for large-scale renewable projects completed in 2022 was down on 2021, the number of projects under construction or financially committed at the end of 2022 stood at 72, up from 66 at the end of 2021. Of these projects, 48 are solar, and 21 are wind. The remaining three projects are all bioenergy ventures.

In 2022, the Australian renewable energy industry commenced construction on over 5,000 MW of wind and solar farms: the highest year for new renewable construction commitments on record[1]. Meanwhile, the final quarter of 2022 saw investment in financially committed generation and storage projects reach $4.29 billion, the second-highest quarterly result since Clean Energy Council data collection began in 2017. Year-to-year investment was also up 17 per cent on 2021, with $6.7 billion in 2022.

While the outlook would appear positive, a lot more work is needed at government level to encourage the investment and development needed to reach the Federal Government's stated target of 82 per cent renewable energy in the grid by 2030.

On the smaller-scale side of things, household batteries continue to grow in uptake, with estimates suggesting over 50,000 systems were installed in 2022, up from 34,731 in 2021. However, according to the Australian Energy Market Commission, only around 1.6 per cent of households with rooftop solar PV also have an installed battery[2].

The cost of residential batteries is falling, with warranted lifetimes increasing. As time goes by, owning home batteries will become more and more economically viable for households with solar installations. There will be significant implications for the grid, but more battery storage nationwide is a necessary and positive change.

For more information on the various sectors in Australian clean energy, check out our tech profiles from page 43 onwards.

A changing landscape

A resounding victory for Labor in the 2022 federal election signalled a fresh chapter in Australian climate politics. While Labor's climate agenda was undoubtedly more substantial than the Liberal offering, perhaps the most significant development was the so-called 'greenslide', which saw a wave of new Greens and 'teal independent' MPs enter Parliament on a platform focused on clean energy and climate change. That 'greenslide' may have forever altered the country's political landscape.

The Labor Government wasted no time legislating Australia's target of 43 per cent reduction in emissions by 2030, funding the first projects under its *Rewiring the Nation* initiative. While new initiatives were being announced, Labor had to deal with

[1] T Edis, *RenewEconomy*, https://reneweconomy.com.au/more-than-5gw-of-new-wind-and-solar-committed-to-construction-in-record-breaking-2022/

[2] M Kaka and R Pendlebury, Australian Energy Market Commission, https://www.aemc.gov.au/turning-point-incentives-invest-residential-batteries#:~:text=But%2C%20over%20the%20last%207,Australia%20as%20of%20August%202022.

skyrocketing energy prices caused in part by several unavoidable factors such as Russia's invasion of Ukraine, which caused coal and gas prices to escalate significantly, and an early start to the Australian winter.

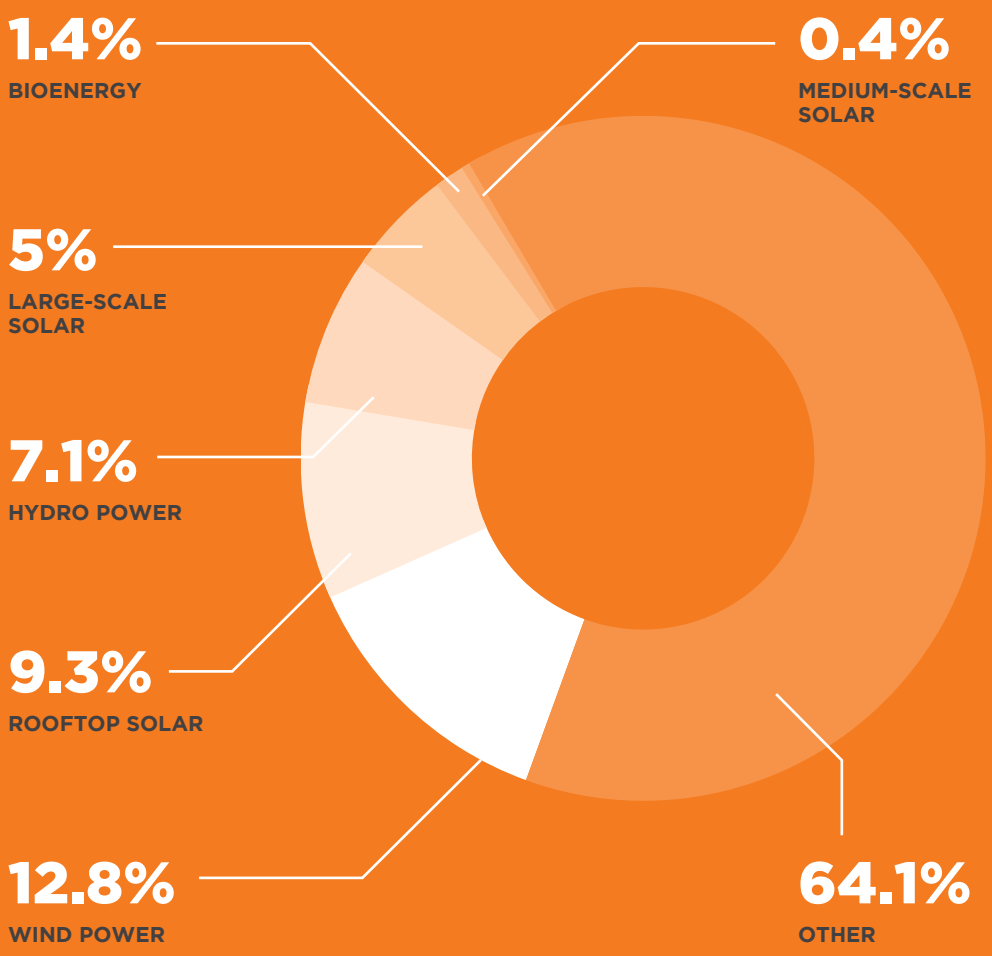
Extraordinary and sustained energy prices led the Labor Government to introduce its Energy Price Relief Plan, which was agreed upon in December. It imposes temporary caps on coal and gas and provide rebates to Australians on low and middle incomes. More information on Australian politics can be found on page 19.

Policy makers and manufacturing sectors worldwide were given a jolt in August 2022 when the Biden administration passed the Inflation Reduction Act into law. A hugely positive step for the global decarbonisation agenda, the Act made a huge splash globally, allocating at least US$369 billion to clean energy incentives to accelerate the US's clean energy transition and revitalise its manufacturing heartlands and domestic supply chains.

Before the year was out, we were already seeing reactions from other countries and regions concerned about the implications for retaining and attracting investment for their own markets, and making preparations to match key incentives within the Act (e.g. Canada), in addition to the EU's proposed 'Green Deal Industrial Plan'. For more on international renewables in 2022, see page 31.

For a more detailed rundown of Australian clean energy in 2022, visit the individual sections in this report.

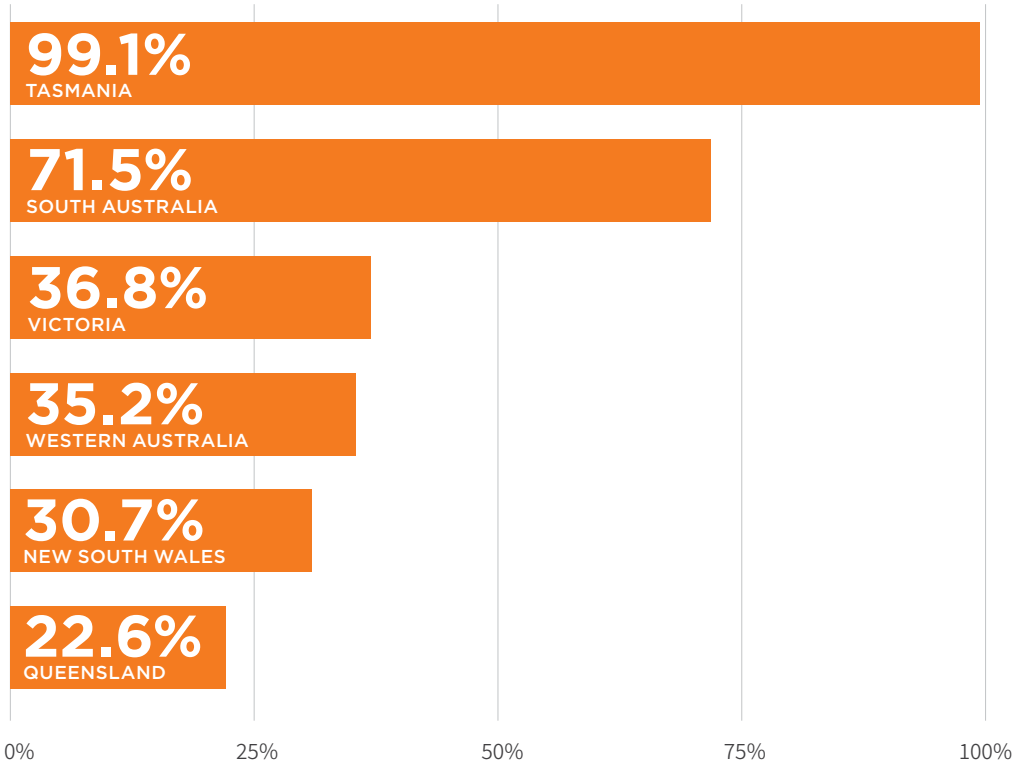
Renewable energy provided 35.9% of Australian electricity generation in 2022, up from 32.5% in 2021



Renewable energy generation by fuel type

Technology	Generation (MWh)	Generation (GWh)	Percentage of renewable generation	Percentage of total generation	Equivalent number of households powered over course of the year
Hydro	16,536,786	16,537	19.7%	7.1%	3,598,082
Wind	29,891,946	29,892	35.6%	12.8%	6,503,905
Small-scale solar PV	21,726,063	21,726	25.8%	9.3%	4,727,168
Bioenergy	3,181,246	3,181	3.8%	1.4%	692,177
Medium-scale solar PV	979,741	980	1.2%	0.4%	213,173
Large-scale solar PV	11,740,244	11,740	14.0%	5.0%	2,554,448
TOTAL	**84,056,027**	**84,056**	**100.0%**	**35.9%**	**18,288,953**

Renewable energy penetration by state as proportion of generation



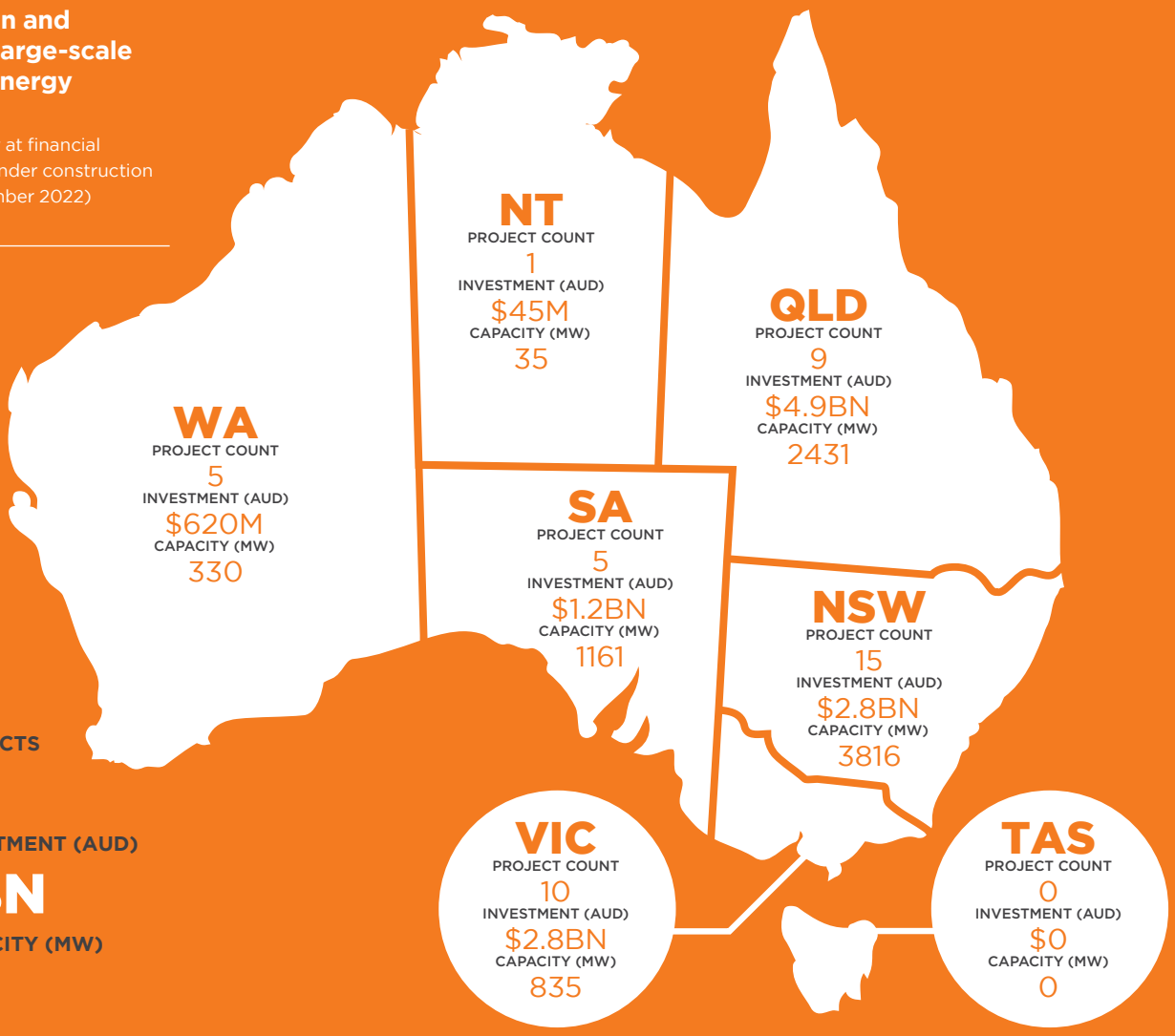
Renewable energy penetration by state

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	70,868	49,103	21,765	30.7%	28.7%
QLD	63,833	49,406	14,427	22.6%	23.3%
SA	13,826	3942	9884	71.5%	68.4%
TAS	10,931	95	10,836	99.1%	93.3%
VIC	53,794	33,973	19,820	36.8%	40.0%
WA	20,790	13,467	7324	35.2%	35.2%
NATIONAL (Excl. NT and minor grids)	**234,042**	**149,986**	**84,056**	**35.9%**	**35.9%**

Footnote: Electricity generation is measured prior to transmission and auxilliary losses. Excludes off-grid and remote grid power supplies

Investment in and capacity of large-scale renewable energy projects

Projects currently at financial commitment or under construction (2017 to 31 December 2022)



TOTAL PROJECTS

45

TOTAL INVESTMENT (AUD)

12.4BN

TOTAL CAPACITY (MW)

8609

Renewable energy projects completed in 2022

Tech	State	Project	Lead Operator-Owner	Capacity (MW)
Wind	VIC	Stockyard Hill Wind Farm	Goldwind Australia	**531.9**
Wind	VIC	Moorabool Wind Farm	Goldwind Australia	**312**
Wind	SA	Port Augusta Wind Farm (PAREP1)	Iberdola Australia	**210**
Solar	NSW	Suntop Solar Farm	CalEnergy Resources	**150**
Solar	QLD	Blue Grass Solar Farm	X-ELIO	**148**
Wind	VIC	Yendon Wind Farm	Lal Lal Wind Farms Consortium	**144.4**
Solar	NSW	Metz Solar Farm	Fotowatio Renewable Ventures	**115**
Solar	NSW	Gunnedah Solar Farm	CalEnergy Resources	**110**
Solar	NSW	Hillston Sun Farm	AMP Energy	**110**
Wind	NSW	Biala Wind Farm (Gullen Range)	Goldwind Australia	**110**
Solar	NSW	Sebastopol Solar Farm	Fotowatio Renewable Ventures	**90**
Wind	SA	Lincoln Gap Wind Farm Stage 2	Nexif	**86**
Solar	NSW	Wagga Wagga North Solar Farm	Metka EGN	**30**
Solar	NSW	Junee Solar Farm	Metka EGN	**30**
Solar	NSW	Corowa Solar Farm	Metka EGN	**27**
Solar	WA	Gryuere Solar Farm	APA Group	**13.6**
Wind-Solar	WA	Shark Lake Renewable Energy Hub	Horizon Power - Pacific Energy	**12.6**
Solar	NT	Batchelor Pell Solar Farm	Merricks Capital	**10**
Wind	VIC	Diapur wind Farm	BayWa R.E.	**8.4**
Solar-Biomass	VIC	McCain Ballarat Hybrid Plant	Solar Bay/McCain Foods	**8.2**

> “Rooftop solar led the charge for Australian renewable energy in terms of capacity added, with 2.7 GW”

INDUSTRY OUTLOOK:

SMALL-SCALE RENEWABLE ENERGY

Rooftop solar growth slowed in 2022 after impressive growth in recent years, but still accounts for more than a quarter (25.8 per cent) of total Australian renewable generation for the first time. On the battery storage front, there are still only a tiny fraction of solar PV households with battery installations. However, battery prices are coming down and growth is likely to follow.

While growth in rooftop solar slowed compared to 2021, 2022 marked the first time the sector provided more than a quarter (25.8 per cent) of total Australian renewable generation – a huge milestone.

New capacity added totalled 2.7 GW from 310,352 new rooftop solar installations. Both of those figures are down on 2021, when 3.3 GW was added from 377,408 new installations. The dip was likely due to a combination of factors, including increasing prices around the middle of the year, unusually poor weather in many states, and supply chain issues. As energy prices skyrocketed throughout the year, driven by external factors relating to fossil fuels, such as the war in Ukraine, there was renewed interesting in solar installations as a way of offsetting high electricity prices.

Although the total number of installed systems was down on 2021, rooftop solar once again led the charge for Australian renewable energy in terms of capacity added, surpassing the 2.3 GW added by large-scale projects.

In 2021, every state and territory except the Northern Territory set new records for installed capacity. In 2022, all states except ACT and Tasmania fell below their 2021 levels. Although these numbers fell, the average size of installed solar systems continued its trend of increasing year-on-year, rising from 8.79 kW in 2021 to 8.84 kW in 2022.

The household battery segment, meanwhile, continued to grow in uptake, with estimates suggesting over 50,000 systems were installed in 2022, up from 34,731 in 2021. That said, only a fraction (1.6 per cent) of solar PV households have a battery system installed. The cost of batteries is falling, and warranted lifetimes are increasing, which should help grow battery uptake, especially as more solar PV systems are installed.

By the end of 2022, 1577 companies were participating in the Clean Energy Council's Approved Solar Retailer program, an increase of 121 (8 per cent) on the previous year. The Clean Energy Council continued its rigorous compliance activity in 2022, opening 399 cases against Approved Solar Retailers, of which 91 resulted in compliance action. These actions are vital in maintaining the program's integrity and ensuring that Australian consumers purchase from a retailer committed to a high level of service and industry best practice.

In February 2023, the Clean Energy Council, alongside a group of other peak and industry bodies, launched the New Energy Tech Consumer Code (NETCC). NETCC replaced the Approved Solar Retailer 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 number of Clean Energy Council accredited individuals (installers and designers) now sits at 8988, having passed 8000 for the first time in 2021. While there has been a slight decrease in the number of accredited installers in NT and WA, at a national level, the total number of accredited individuals has grown steadily for seven years.

← Yulara Solar Farm, NT, ARENA

310,352

rooftop solar installations in 2022

(2021: 377,408)

2.7 GW

rooftop solar capacity added in 2022

(2021: 3.3 GW)

50,000+

household battery systems installed in 2022

(2021: 34,731)

> “In 2022, construction commenced on over 5000 MW of wind and solar farms – the highest year for new renewable construction commitments on record”

INDUSTRY OUTLOOK:

LARGE-SCALE RENEWABLE ENERGY

While added capacity and number of projects added are down on 2021, levels of large-scale investment towards the end of 2022, combined with new supportive policies at federal and state levels, suggest there could be growth on the horizon.

The large-scale renewable energy industry added 2257 MW of new capacity in 2022 across 20 completed projects. Both the capacity added and the number of projects are down on 2021, when 27 projects contributed 2955 MW of renewable capacity. In 2021, although the number of projects had fallen since the previous year, there was still more capacity added than in 2020 thanks to the completion of some of Australia's largest wind and solar projects.

Now that there are broadly supportive policies in place at federal and state levels around the country, we expect to see a resurgence of large-scale projects in 2023 and beyond.

Of the 20 projects completed in 2022, 11 were solar farms and seven were wind farms. The remaining two are the Shark Lake combined solar-wind project and the McCain Ballarant hybrid solar-biomass plant.

As in 2021, the wind sector contributed the highest amount of new large-scale capacity, with approximately 1411 MW. Large-scale solar was not too far behind at 860 MW. The largest completed wind project was the Stockyard Hill Wind Farm in Victoria, at 532 MW, while the largest solar project completed was the Suntop Solar Farm in Queensland, at 150 MW.

Meanwhile, 72 projects were under construction at the end of 2022, up from 66 at the end of 2021. Of these projects, 48 are solar, and 21 are wind. The remaining three projects are all bioenergy ventures. The combined capacity of these 72 projects is approximately 9.5 GW.

Wind was once again the leader in renewable energy generation in 2022. With 35.6 per cent of total renewable generation, wind led the pack ahead of rooftop solar (25.8 per cent) and hydro (19.7 per cent). Large-scale solar, meanwhile, contributed 14 per cent. However, when combined, rooftop and utility-scale solar made solar the leader in generation.

As with many of the large-scale renewable sectors, battery storage experienced something of a dip in 2022, with 19 large-scale batteries under construction at the end of the year, compared to 30 at the same point in 2021. However, the outlook for battery storage is positive, as steady uptake of solar PV at rooftop and large-scale levels, combined with more supportive policy conditions and expected large-scale battery cost reductions, will bring up demand. The largest battery systems under construction at the end of 2022 included the Torrens Island Battery at 250 MW capacity and the Western Downs Green Power Hub at 200 MW capacity.

For the third year in a row, hydropower generation increased in Australia: up to 16,537 GWh from 16,128 GWh in 2021. In terms of pumped hydro energy storage, the 250 MW capacity Kidston Pumped Storage Hydro Project in Queensland is likely to be one of the next pumped hydro projects up and running, expected to be operational in 2024. Although hydro power is one of the most mature forms of renewable generation, and there are a number of potential locations around Australia to take advantage of it, there remain only three pumped hydro projects operating

← Hybrid renewable power station, Jabiru NT, EDL

2257 MW
of large-scale capacity added in 2022
(2021: 2,955 MW)

20
large-scale renewable projects completed in 2022
(2021: 27)

1380 MW
2004 MWh
approximate combined capacity of large-scale batteries under construction at end of 2022
(2021: 921 MW/1169 MWh)

in the country. For more information on some of the most significant projects under development, see page 48.

The bioenergy sector continues to develop and play a useful, if relatively small, role in energy generation. A year on from the release of Australia's Bioenergy Roadmap by former Minister for Energy and Emissions Reduction Angus Taylor, there is continued interest and investment. In 2022, 3.8 per cent of clean energy was generated via bioenergy.

Positive signs but more needed

Although project numbers in some areas are down on 2021 and added capacity has not risen in all large-scale sectors, there are reasons to be positive on the outlook for the large-scale renewables. In 2022, the Australian renewable energy industry commenced construction on over 5000 MW of wind and solar farms – the highest year for new renewable construction commitments on record[1].

Year-to-year investment in the clean energy industry rose 17 per cent from 2021, standing at $6.7 billion in 2022. The final quarter of 2022 saw investment in financially committed generation and storage projects reach $4.29 billion, the second-highest quarterly result since Clean Energy Council data collection began in 2017.

Despite positive signs on the development front in terms of commenced construction and early signs that investment may be picking up, large-scale investment is currently coming online more slowly than required to meet the Government's forecast of 82 per cent renewables in the electricity sector by 2030.

[1] T Edis, *RenewEconomy*, https://reneweconomy.com.au/more-than-5gw-of-new-wind-and-solar-committed-to-construction-in-record-breaking-2022/

FOCUS ON: CONNECTION REFORM INITIATIVE

The Clean Energy Council's joint work on the Connection Reform Initiative (CRI) continued apace in 2022. For those new to CRI, this collaborative effort with the Australian Energy Market Operator (AEMO) seeks to make the process of connecting new plants fit for modern purposes. That means achieving three high-level 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).

Work in 2022 focused on the reform area 'Improving Investor Certainty' during the registration process for new generation plants, specifically during the 'R1' phase between project commitment and receiving revenue. Workshops were held with Clean Energy Council members, investors, and experts from KPMG to gain deeper insights into the key problems they encounter with the current registration process. Those problem areas are:

1. Silence in the rules regarding technical specifications required to demonstrate that a new plant will or will not cause or worsen a system security risk and which party is responsible for demonstrating they are met.
2. Lack of clear guidance for final connection assessment regarding criteria and requirements.
3. No specified process for reviewing AEMO and NSP decisions.
4. Inflexibility for AEMO and NSPs to provide conditional registration approval where applicants can resolve "immaterial" issues

The Clean Energy Council and KPMG team built on the CRI's analysis of these challenges, working to develop a proposed change to the national electricity rules that would standardise the assessment process so that it provides enhanced certainty for investors. The draft rule change request focuses on six areas of reform:

1. Creating certainty around time frames for AEMO and NSP decisions;
2. Increasing transparency in decision-making;
3. Allowing for conditional approval of R1 models, where this will not pose a material risk to system security or operability;
4. Allowing networks to identify and procure the lowest-cost solutions to address any significant issues identified, where this is due to changes in the power system beyond the control of the connecting party;
5. Introducing a connections-application specific dispute resolution process; and
6. Creating a materiality threshold process, which would help identify changes between connection application modelling and R1, where those changes are unlikely to have a material impact on the power system and can therefore be resolved at a later point in time.

Key elements of the proposed rule change request

Time bound decisions

The rule change seeks to set the R1 process in the NER. As part of this NSPs are required, on the advice of AEMO where relevant, to make a time defined decision on an applicant's R1 model which is provided to demonstrate compliance with the negotiated connection agreement.

Network can procure security services

Allow NSPs to procure services from any provider, including the applicant, in response to system security/grid issues identified in the R1 model without holding up the registration process.

Materiality allowance

Create the possibility of a materiality to be applied to the assessment of the R1 model to enable connections with minimal impacts on network security to be proceed. If the Applicant's performance is within materiality threshold, then it is deemed complaint, with performance standards being updated accordingly.

Transparency in decision making

Require NSPs, on the advice of AEMO where relevant, to demonstrate reasons why to reject applicant R1 modelling and assessment.

Conditions approval

Facilitate conditional approval of an applicant's compliance with its performance standards by NSPs to enable registration, conditional on the applicant making subsequent setting or design changes by a date set by AEMO (which could be post commissioning). This would only apply to minor issues which can easily be resolved at a later date and therefore should not unreasonably delay registration.

Dispute resolution

Introducing a additional dispute resolution process where the NSP raises a concern with R1 application that allows for facilitated discussions with all parties participating in good faith. This is to encourage collaboration on addressing the problem.

CLEAN ENERGY COUNCIL

Some of Labor's clean energy spending promises (Oct 2022 Budget)

$25BN clean energy spending

INCLUDING:

$20BN fund providing low-cost finance to expand and modernise the electricity grid

$1.9BN to create new clean energy industries across regional Australia

$500M to build charging infrastructure to support the uptake of electric vehicles

$224M to support installation of community batteries

$102M to help apartments and low-income households get access to solar

"The wave of Greens and 'teal independent' MPs entering Parliament focused on clean energy may have forever altered the country's political landscape"

FEDERAL AND STATE POLITICS

A resounding Labor victory in the federal election signalled a fresh chapter in Australian climate politics as the newly elected government wasted no time putting Australia back on the path to net-zero by 2050. However, the Albanese Government faced its fair share of hurdles in its first six months in power as rising electricity prices wreaked havoc on the electricity system and energy bills.

The federal election dominated politics in 2022, with political debate stuck in a loop of pre-election speculation in the early months of the year as everyone waited for the election to be called.

When Prime Minister Scott Morrison called the election in April, it set a frantic and sometimes bruising six-week campaign in motion.

Climate and energy were downplayed during the campaign, despite being identified as some of the most important issues to voters in the leadup to election day. While this was partly due to the cost-of-living bombshells that dropped during the campaign – including increases in inflation, interest rates and wholesale electricity prices – the major parties also actively avoided the issue as both saw it as a potential weakness.

Come election night, the Australian public sent a clear message that they were ready for change and fed up with the climate inaction and infighting of the past two decades, delivering the Labor party a resounding victory and installing Anthony Albanese as Australia's 31st Prime Minister.

However, perhaps the biggest development was the so-called 'greenslide', which saw a wave of new Greens and 'teal independent' MPs enter Parliament on a platform focused on clean energy and climate change. This new phenomenon in Australian politics may have forever altered the country's political landscape.

Promised change and rising prices

The newly elected Albanese Government wasted no time in re-establishing Australia's climate credentials, legislating its target of a 43 per cent reduction in emissions by 2030[1], funding the first projects under its Rewiring the Nation initiative[2] and taking a leading role at COP27 in Egypt.

However, the monumental scale of the task ahead hit home just two weeks after the government's election win. The energy market descended into chaos as coal outages and high gas prices – primarily caused by international events such as the war in Ukraine – sent wholesale prices skyrocketing.

The government attempted to address these issues in its first budget in October, which committed $25 billion to clean energy spending. This included $500 million to encourage the uptake of electric vehicles, $1.9 billion to encourage regional communities and businesses to switch to cleaner energy, $224 million to support the installation of community batteries and $102 million for solar installations on apartments and low-income households[3].

Those measures were added to in December when the Government's Energy Price Relief Plan was agreed upon, imposing temporary caps on coal and gas and providing rebates to Australians on low and middle incomes.

←
Clean Energy Council CEO Kane Thornton watches on as Prime Minister Anthony Albanese and Energy Minister Chris Bowen sign the Nationally Determined Contribution to a 43% cut in emissions by 2030.

←←
Mieka White:
Collector Wind Farm NSW,
RATCH Renewables

1 Prime Minister of Australia, media release, pm.gov.au/media/australia-legislates-emissions-reduction-targets

2 Department of Climate Change, Energy, the Environment and Water, energy.gov.au/news-media/news/rewiring-nation-supports-its-first-two-transmission-projects

3 M Foley, *The Sydney Morning Herald*, smh.com.au/politics/federal/record-boost-to-clean-energy-spend-as-global-crunch-looms-20221023-p5bs40.html

STATE TARGETS AND COMMITMENTS

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

Tasmania

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

Queensland

- Queensland Energy and Jobs Plan, released Sept 2022, targets 70 per cent renewable energy by 2032 and 80 per cent by 2050
- $145 million Queensland Renewable Energy Zones initiative
- Investing $22 million to investigate constructing a 2 GW pumped hydro energy storage facility at Borumba Dam

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
- 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 1600 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 state asset 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 emissions by 2050


Nikon
Nikon

EMPLOYMENT

The new government promises change for the clean energy workforce, while global headwinds indicate intensifying competition for investment and workers.

Clean energy workforce demands already outstrip supply and will rapidly increase this decade. As confirmed in several 2022 publications, most jobs will be in regional areas. Without intervention, the industry will likely face greater shortfalls in capacity, leading to delays and increased capital costs for projects[1].

At the same time, there is ongoing uncertainty around continued inflation and the risk of a recession. Unemployment remains low on average (though high in some regions), while state governments further tighten the labour market with infrastructure projects that compete for the same workers. Ambitious state-based local content and workforce requirements in public clean energy processes and announcements of public ownership in new renewable energy developments also increase workforce pressures.

The Federal Government is keenly aware of these challenges. As promised in its election platform, the Albanese Government has taken immediate steps to boost the attraction and retention of the clean energy workforce. This included legislating new industrial relations laws, enacting a 43 per cent emissions reduction target, and convening a Jobs and Skills Summit in which clean energy held a flagship focus.

The Jobs and Skills Summit provided the stage for the Clean Energy Council to release its Skilling the Energy Transition report, summarising the enduring challenges experienced by the clean energy workforce and making six key recommendations for change:

1. **Calibrate higher education to meet the clean energy industries' interests.**
2. **Anticipate clean energy workforce needs.**
3. **Raise the profile of working in clean energy as an opportunity for all Australians.**
4. **Establish a Transition Authority.**
5. **Enhance the VET sector's capacity to understand and meet demands of industry.**
6. **Raise the international profile of Australia as a centre of clean energy expertise.**

Accompanying the report, the Clean Energy Council also released the online Clean Energy Careers Guide, which aims to demystify the clean energy sector for prospective workers and provide information about education requirements. The guide identifies in-demand roles, grouped by technology, occupation, and pathway.

The Federal Government committed to and subsequently launched the Australian Energy Employment Report (AEER) in line with the Clean Energy Council's second recommendation on anticipating workforce demands. This is a national survey of businesses and organisations in the Australian energy sector to address a persistent data gap concerning energy sector jobs, skills, and occupations and how these jobs change over time. A new entity, Jobs and Skills Australia, has been commissioned to undertake a capacity study of the Australian workforce needed to transition to a clean energy economy. The capacity study and the AEER will provide critical evidence and insights to support the workforce planning and policy development needed to build a strong and vibrant clean energy sector.

Responding to Clean Energy Council advocacy, the rooftop solar and small-scale renewables sector also experienced a major review of vocational training. The changes aim to raise standards, address

← Hybrid renewable power station, Jabiru NT, EDL

[1] Net Zero Australia, *Employment Impacts*, https://www.netzeroaustralia.net.au/employment-impacts-aug-2022
Race for 30, https://www.racefor2030.com.au/fast-track-reports
Construction Skills Queenslan, https://www.csq.org.au/renewables

job shortages, and better equip the industry for modern energy demands. They represent the first comprehensive upgrade to training in the sector in over 10 years.

Looking forward to 2023, industrial relations legislation passed in late 2022, and newly established vocational education and training governance frameworks increase the need for employers to understand exactly what qualifications and skills are needed to support the sector in its growth trajectory.

WOMEN REPRESENTATION

39% of Australian clean energy workforce

50% of Australian workforce

32% representation in renewables globally

BY AGE (clean energy workforce)

46% of those under 40 are women

33% over those over 40 are women

ABORIGINAL AND TORRES STRAIT ISLANDER REPRESENTATION

0.8% of Australian clean energy workforce

3.3% of Australian population

DISABILITY AND DISADVANTAGE AT WORK

3% of Australia clean energy workforce

18% of Australian population

The energy transition challenge will not be met without skilled migration. Although the Federal Government is reviewing and reforming skilled migration policies to facilitate the employment of international workers, foreign policies such as the US Inflation Reduction Act and the European Union Commission's Green Deal Industrial Plan will heighten competition for global talent. Good talent will be mobile; we need a compelling case to lure them to Australia.

Diversity and inclusion in renewables

In 2021, the Clean Energy Council launched the report, *Empowering Everyone: Diversity in the Australian Clean Energy Sector*. Some of the highlights from that report are found below. If you're interested in the full report, visit our website at cleanenergycouncil.org.au

Energy is an essential service, meaning customers are all Australians and Australian communities.

On a fundamental level, our workplaces should reflect and respect the ideals and perspectives of our customers. On a practical level, businesses with inclusive practices and high levels of diversity are more successful, boasting higher profits and performance and tending to have fewer safety incidents.

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

When employees feel valued and connected at work, they are five times more likely to be satisfied with their job and three times less likely to leave. Employers that are known to be inclusive and have employees that are empowered to bring their authentic self to work tend to attract a larger pool of highly skilled and capable talent. In the context of a growing industry with concerns around skills shortages, expanding the talent pool is critical.

What the industry needs to work on

While representation of women is generally encouraging, it decreases at the higher echelons, suggesting women may be being overlooked for promotion. Organisational culture starts at the top, which is where more women are needed.

Participation of women is very low in the trades. This is not unique to clean energy, but we can work with relevant stakeholders to help improve the attractiveness and retention of women in the trades.

The sector already struggles to recruit enough engineers and electricians, and this challenge is only likely to increase over the next decade. If we are to meet this challenge, we need to invest more in recruiting and training young workers graduating from university or in apprenticeships.

There is scope to bolster Aboriginal and Torres Strait Islander employment across all parts of the industry in both blue-collar and white-collar roles. This should be considered in close collaboration and consultation with Indigenous groups.

More research and information is needed on why the rate of disability is so low in the workforce and how employers can better accommodate employees with mental or physical disabilities.

We also need to address and eliminate any culture of sexism or other forms of discrimination in the workplace if we want the clean energy sector to be seen as a first-choice employer.

Fostering a culture of inclusion

Following on from the *Empowering Everyone* report, in 2022 we launched a survey of our members to collect data on how they understand, report on, and promote inclusion and diversity in their organisations. The findings will be used to support our members in promoting greater diversity in their organisations and within the Australian renewable energy sector.

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 10 recipients in 2022.

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.

CHLOE MONROE SCHOLARSHIP FOR TRANSFORMATIONAL LEADERSHIP 2022 RECIPIENTS

Briar Blount

Legal Counsel
IBERDROLA AUSTRALIA

Taegan Calnan

Senior Project Officer
DEPARTMENT OF BIODIVERSITY, CONSERVATION AND ATTRACTIONS, WA

Mio Dart

Head of Technical Partnerships
ALLUME ENERGY

Tegan Doblinger

Quality Manager
CWP RENEWABLES

Kyungjin Yu

Project Development Manager
TRINA SOLAR

Kim van Hattum

Head of Development
MINT RENEWABLES

Brittany Pistevos

Infrastructure Investment Analysis
AUSNET SERVICES

Leah Powell

Area Coordinator,
HYDRO TASMANIA

Marnie Shaw

Senior Research Fellow,
THE AUSTRALIAN NATIONAL UNIVERSITY

Maheshini Weerackoon

Director Connection Services
LUMEA

CLEAN ENERGY COUNCIL

CASE STUDY:

WOMEN IN RENEWABLES

Satya Tanner

CEO / Managing Director
LAUTEC AUSTRALIA

How did you get into the renewable energy industry?

After 16 years in the Royal Australian Air Force as a pilot and aeronautical engineer, I moved to California and worked briefly in the aerospace industry. While the US was a great experience, I wanted to try living and working in Europe as well as work for an industry that was making a difference in the world.

Changing industry was not easy given that most of my experience was in leadership and project management roles. Typically, you need to be in a specialist role that transcends industries. Given that I had a background with organisational development, I was hired into a project management role at Siemens Gamesa where I supported the offshore engineering team. I helped teams mature their processes and develop their engineers. Within 18 months I was selected as a head of department and was thus able to continue my career in leadership roles.

What do you like most about your job/the renewable energy industry?

I absolutely love working in an industry that aligns with my values: to leave the world in a better place than we found it. When I first started working in the industry in Denmark, I found that others also embodied these values. My colleagues were passionate, friendly and trying to make a positive difference in whatever scope they had. There was a mentality circulating that even though we might have competitors in the industry, our real competitors were fossil fuel companies – that we had to work together to make a green transition possible.

I also love working for an industry that is newer than most other industries. The offshore wind industry has more of a 'start up' feel and for those of us who have experience from other industries such as aerospace, oil and gas and construction, we have an opportunity to contribute to its maturation.

What have been the biggest challenges for you as a woman working in a male dominated industry?

Having worked in three countries (USA, Denmark and Australia), there are cultural differences everywhere you go. These are not only national cultural differences, but also organisational, gender- or age-specific, and many others.

One thing I notice about Australia having spent 10 years overseas is that not many people pay attention to the difference between men's culture vs women's culture. The culture here is very 'blokey'. When you are used to a diverse range of working styles, it can be difficult to explain that vision to people who are used to the thinking that comes from a male-dominated culture.

For example, there is a hyper-rational culture coming from a lot of men who are engineers. This approach is good at finding flaws with an idea but fails to take the next step of envisioning how to overcome it. By contrast, I find that women's culture is more nuanced and pre-disposed to listening, and I would even say that the Danes are far more innovative in their engineering, partly because they embrace not only the masculine, but also feminine qualities such as listening, collaborating and trusting.

'Women's culture' is not necessarily valued in a technical industry. This requires navigating a set of unofficial rules that results in a lot of unnecessary competition, rather than collaborative approaches. Men's culture tends to be based on a hierarchical order, whereas women's culture is based on collaboration. I look forward to the day when we have better gender balance because that typically enhances the good and diminishes the negative qualities of both cultures.

What do you think would encourage more women to enter the clean energy sector?

In my network, I notice that women leave companies that fail to understand the experience of women and thereby fail to support them in their ambitions. To encourage more women to enter the clean energy sector, not only do we need to help women develop, but also make space for women to step up into positions of influence, by removing barriers and setting particular targets. This means providing a supportive workplace culture that recognises good talent in all its forms, and understands the experience of those who experience barriers. All participants need to orient towards an inclusive, egalitarian mindset and culture if we want to attract more women.

RENEWABLES FOR BUSINESS

Corporate renewable power purchase agreements (PPA) reached a new high in 2022. There were 28 renewable PPAs finalised in 2022, directly contracting around 1600 MW – the largest volume since the emergence of corporate PPAs in 2016.

Content and data supplied by Business Renewables Centre Australia

Corporate PPAs were negotiated in 2022 by major corporates, local government buyer groups and smaller professional service firms.

Some of the noteworthy deals in 2022 included:

- Microsoft and Walla Walla Solar Farm (South Australia), 315 MW
- Anglo-American and Clarke Creek Wind Farm, Blue Grass Solar Farm (Queensland) 234 MW
- BHP and Goyder South, Wind Farm (South Australia), 203 MW
- Apple and Upper Burdekin wind farm (Queensland), 164 MW
- Telstra and Macintyre Wind Farm (Queensland), 111 MW
- Woolworths and Port August Renewable Energy Park (South Australia), 38 MW

Financial and sustainability factors well-aligned for PPA growth

The extraordinary wholesale market price volatility in 2022 had mixed impacts on demand for corporate PPAs. There were divergent views on whether the price volatility positively or negatively impacted demand for corporate PPAs in the Business Renewables Centre Australia's industry survey and anecdotal feedback from buyers and advisers. For some buyers, crisis management and uncertainty amid the wholesale electricity price spike stalled plans for a PPA. For others, the crisis stimulated a rush to sign a PPA. In the medium-term, memories of the great price spike are likely to support growth in corporate PPAs to reduce exposure to electricity prices.

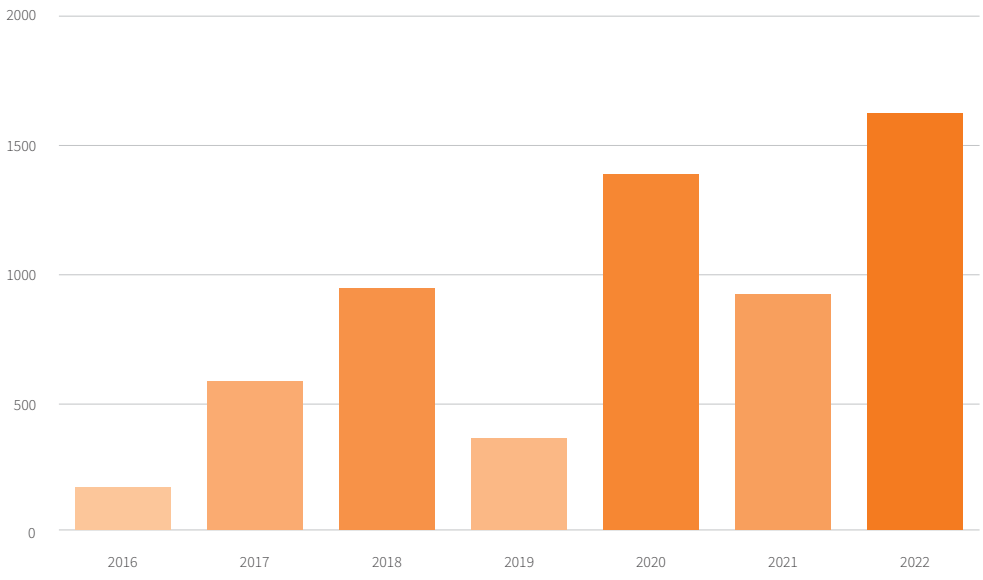
Notwithstanding market volatility, for the third year running, the major drivers for corporate PPA buyers were renewable energy or emissions targets, corporate social responsibility policies or reputation.

The growth in organisations with net- zero targets by 2025 or 2030 will likely solidify this trend. Amid market volatility, there is an alignment of financial and sustainability drivers that is likely to underpin ongoing strength in the corporate PPA market.

The return of the wholesale PPA

While in the last couple of years, there had been a marked shift from wholesale PPAs

Figure 1: Corporate PPAs, volume (MW)



(contracts-for-difference or derivatives directly between buyers and renewable energy projects) to retail PPAs (PPAs intermediated by retailers between the project and buyer), wholesale PPAs staged a return in 2022. Project volumes were evenly split between wholesale and retail PPAs.

The increase in electricity future prices has increased the cost of firming for retail PPAs, improving the relative value of wholesale PPAs as a hedge. There is renewed interest among corporate PPA buyers in negotiating with projects directly.

Corporate PPAs with new projects dived in 2022, but the PPA market is broadly healthy

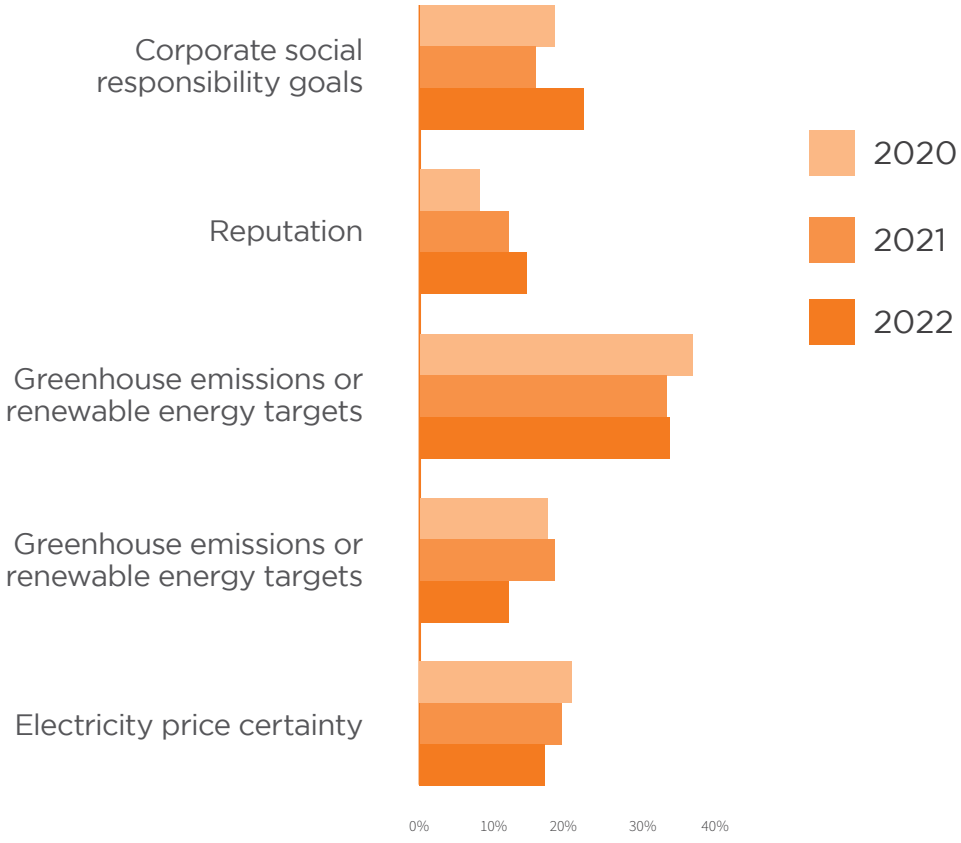
Until the last quarter, there were virtually no corporate PPAs with new projects in 2022.

The growth of PPAs with operating projects has been occurring for several years as retailers supply demand from 'mid-sized' buyers (roughly 5-50 gigawatt hours per annum). However, the decline in corporate PPAs with new projects primarily reflects broader factors shaping the renewable energy market, such as constraints on project supply (e.g. grid connections) and development risks dissuading buyers.

Nonetheless, the corporate PPA market appears broadly healthy. Supply was inadequate to meet buyer demand, with advisers describing it as a 'seller's market' as buyers chased a diminishing pool of projects. The corporate PPA market includes a diverse range of buyer and deal sizes, with growth at both ends of the market. During 2022, for example, deals under 20 MW totalled just under 100 MW, while deals over 100 MW totalled around 800 MW.

As the wave of Federal and State Government programs announced last year scale up, corporate PPAs should continue to be a significant source of demand for large-scale renewable energy.

Figure 2: What is the primary driver for buyer interest in corporate renewable PPAs? (Source: BRC-A Industry Survey, 2022)



Content and data supplied by Business Renewables Centre Australia

Figure 3: Wholesale & retail PPAs, market share (MW), 2022 (%)
(Source: BRC-A PPA Database 2022)

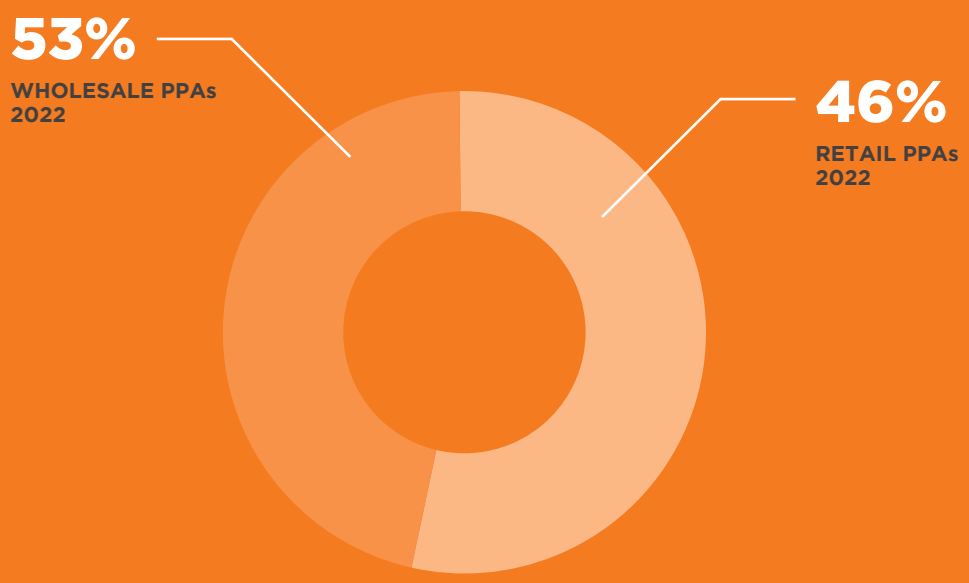


Figure 4: Corporate PPAs (MW), project stage, by quarter (%)
(Source: BRC-A PPA Database 2022)

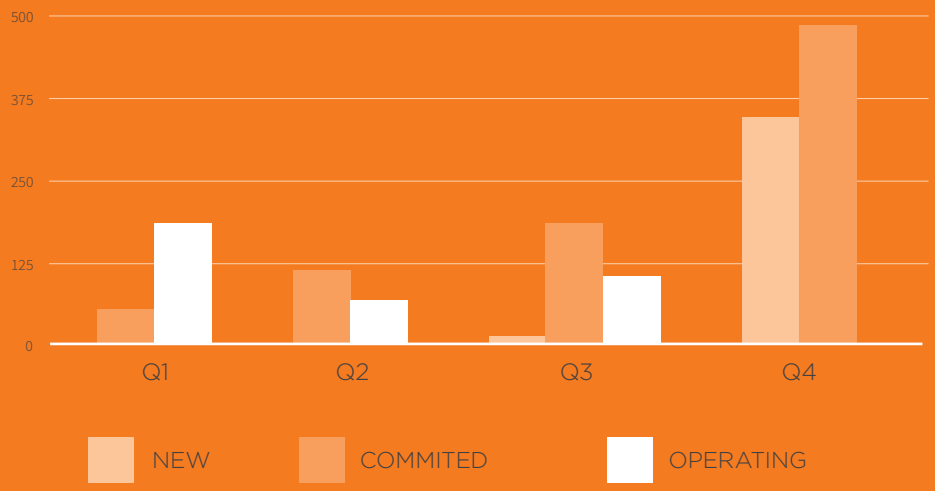
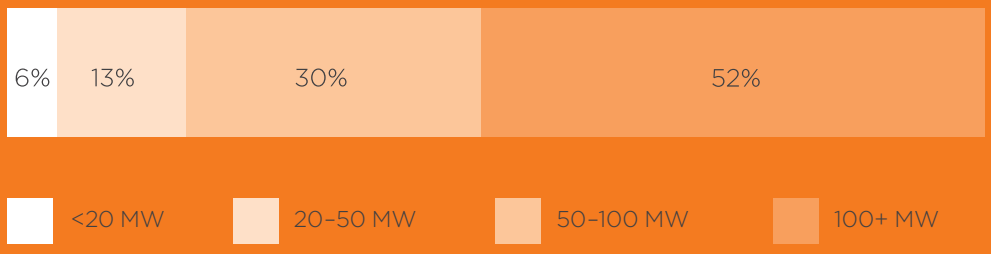


Figure 5: Number of corporate PPAs, segments by size



Content and data supplied by Business Renewables Centre Australia.

For more information, see the full State of the Market report at businessrenewables.org

> “In 2022, global energy transition investment matched investment in fossil fuels for the first time”

INTERNATIONAL UPDATE

Following COP26, and partially as a result of Russia's war in Ukraine, countries' efforts to transition to clean energy continued apace in 2022, and were accelerated following the passing of the US's wide-ranging Inflation Reduction Act.

According to the International Renewable Energy Agency[1], renewables accounted for 40 per cent of global installed power capacity by the end of 2022, a year that saw the largest increase in renewable energy capacity to date – almost 295 GW were added across the globe.

Those are significant numbers, and forecasts from the International Energy Agency[2] (IEA) suggest that annual additions will continue to increase, reaching an estimated total of 460 GW per year by 2027. At that point, the IEA forecasts solar PV and wind will account for 95 per cent of renewable capacity additions.

With US$546 billion, China was once again the leader for energy transition investment in 2022, with almost half of the world's total spending. The US remained the second-largest funding destination for energy transition technologies, although the European Union (EU) places second if treated as a single bloc[3].

According to BloombergNEF, global energy transition investment matched investment in fossil fuels for the first time in 2022 (growing by US$261 billion from the previous year), signifying an historic milestone for the international renewables movement. Russia's invasion of Ukraine has partially inspired the surge in interest in renewables, as it has demonstrated how essential domestic generation is, both in terms of availability and cost. That applies to governments and international bodies as well as individuals: the EU, for example, for whom Russia was the supplier of 40 per cent of its gas and 27 per cent of its oil before the war began, announced its REPowerEU plan in May 2022, which is aimed at achieving energy independence, as well as accelerating the transition to clean energy.

While the movement towards domestic generation has been a huge positive to come from a terrible and ongoing tragedy, the war has also negatively affected the supply chain, with prices for commodities such as steel and aluminium rising, as well as transportation costs[4].

The global outlook appears more positive in the longer term, however. The International Energy Agency (IEA) forecasts that the renewables share of the global power mix will continue to grow, with renewables tipped to become the largest source of electricity generation by 2027, overtaking coal for the first time.

The IRA effect

It is impossible to talk about renewables in an international context without mentioning the US's Inflation Reduction Act (IRA), passed into law by the Biden administration in August 2022.

295 GW

Approximate renewable capacity added worldwide in 2022

(2021: approx. 290 GW)

$495BN

Global investment in renewable energy (USD)

(+17% year-on-year)

$466BN

Global investment in electrified vehicles and charging infrastructure (USD)

(+54% year-on-year)

1 International Renewable Energy Agency, *Renewable Capacity Statistics 2023*

2 International Energy Agency, *Renewables 2022*. https://www.iea.org/reports/renewables-2022

3 BloombergNEF, *Energy Transition Investment Trends 2023*. https://about.bnef.com/energy-transition-investment

4 J Hiller and K Blunt, *The Australian Business Review*. https://www.theaustralian.com.au/business/the-wall-street-journal/ukraine-war-drives-up-cost-of-wind-solar-power/news-story/c1a25c7fa8e04934c2574c5b0e1d9ea0?btr=7b173bd71b140ec3f82da4083852e086

It introduces a huge swathe of measures and financial packages aimed at clean energy and climate crisis-battling initiatives, and was a hugely positive development for the global decarbonisation agenda.

It also sparked a clean energy investment race, as countries and organisations around the globe scrambled to match its scope of ambition. We have already seen responses such as the EU's 'Green Deal Industrial Plan' (which will sit alongside the REPowerEU program) and Canada's announced plans to introduce an investment tax credit for clean hydrogen.

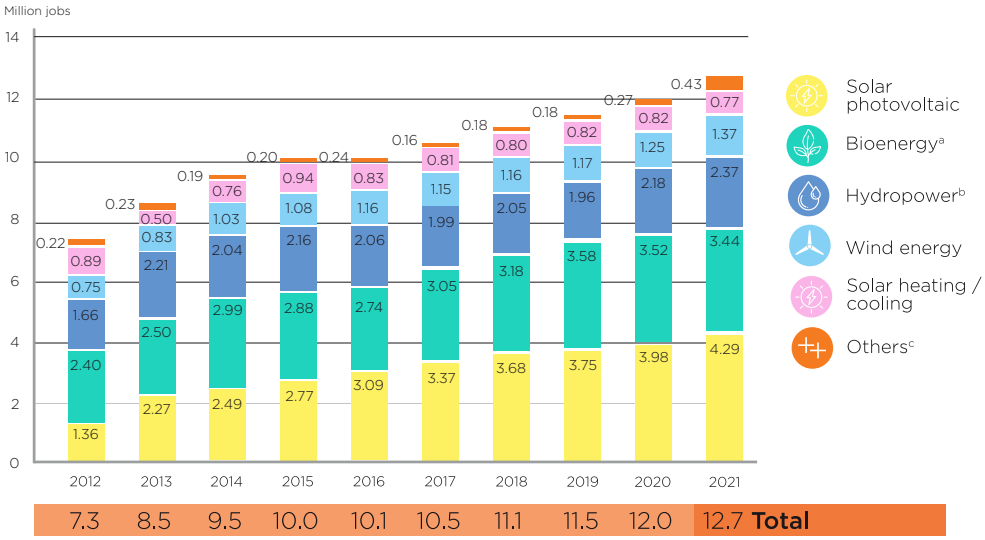
There is no question the IRA was momentous for renewables on the international stage and will no doubt shape the global development of the industry for many years to come.

In November 2022, Egypt hosted COP27, which was a mixed bag in terms of developments and didn't land as firmly as the much-anticipated COP26 summit in Glasgow 2021.

One of the most significant developments was the creation of a fund[5] to aid the most vulnerable countries facing "losses and damage" as a result of climate change, which is something many had been calling for. Elsewhere, the transition away from fossil fuels was again a hot topic, though discussions didn't result in the level of ambition required for meaningful change.

The IEA notes that while momentum for the clean energy transition is building, policy and regulatory uncertainties, as well as infrastructure and access issues, are still barriers to progress. Those problems must be overcome, and the drive for energy transformation must continue, if the world is to make the 'net-zero by 2050' goal look like a realistic and achievable target.

Evolution of global renewable energy employment by technology, 2012-2021
(Source: IRENA jobs database)



a. Includes liquid biofuels, solid boimass and biogas.
b. Direct jobs only.
c. "Others" includes geothermal energy, concentrated solar power, heat pumps (ground based) municipal and industrial waste and ocean energy

[5] World Resources Institute, www.wri.org/insights/cop27-key-outcomes-un-climate-talks-sharm-el-sheikh#:~:text=The%20COP27%20climate%20summit%20in,the%20impacts%20of%20climate%20change

ELECTRICITY PRICES

It was a year of soaring electricity prices and all around market uncertainty, with huge spikes in wholesale prices driven primarily by external factors, ultimately leading to Federal Government intervention.

As anybody living in Australia will know, 2022 has been a rollercoaster year for electricity prices. The market has been disrupted by several unavoidable factors such as an early start to the Australian winter creating higher-than-expected demand, and significant external factors such as Russia's invasion of Ukraine, which caused coal and gas prices to skyrocket.

In 2021, we saw a significant hike in electricity prices in the winter, and subsequent disruption throughout the rest of the year, but the first half of 2022 dwarfed even those circumstances. In July, the monthly average National Energy Market (NEM) wholesale electricity price reached a record high of $360/MWh, $23/MWh higher than June's already astonishing average of $337/MWh. In July, Victoria, South Australia and Tasmania all recorded their highest ever monthly prices, and New South Wales and Queensland their second-highest[1].

Since those unprecedented times, average electricity prices in the National Energy Market did ease off as the year progressed, though the average wholesale price in the fourth quarter of 2022 - $93/MWh - was still significantly higher than at the same period in 2021, when it was $52/MWh[2]. Consumers are feeling those wholesale price hikes: customers in New South Wales, South East Queensland and South Australia faced price increases of between 7.2 per cent and 18.3 per cent from 1 July to the end of 2022. For customers in Victoria, that was between 1.2 and 9.2 per cent[3].

Those extraordinary mid-year prices led the Labor Government to introduce its Energy Price Relief Plan, which was agreed upon in December 2022. It will impose temporary caps on coal and gas and provide rebates to Australians on low and middle incomes. It is a $1.5 billion effort to try to offset the increasingly out-of-control prices[4].

Assuming the plan takes effect in the way the government believes it will, Australian energy consumers should start to see prices balancing out mid-way through 2023 and could save around $230 off their annual bill.

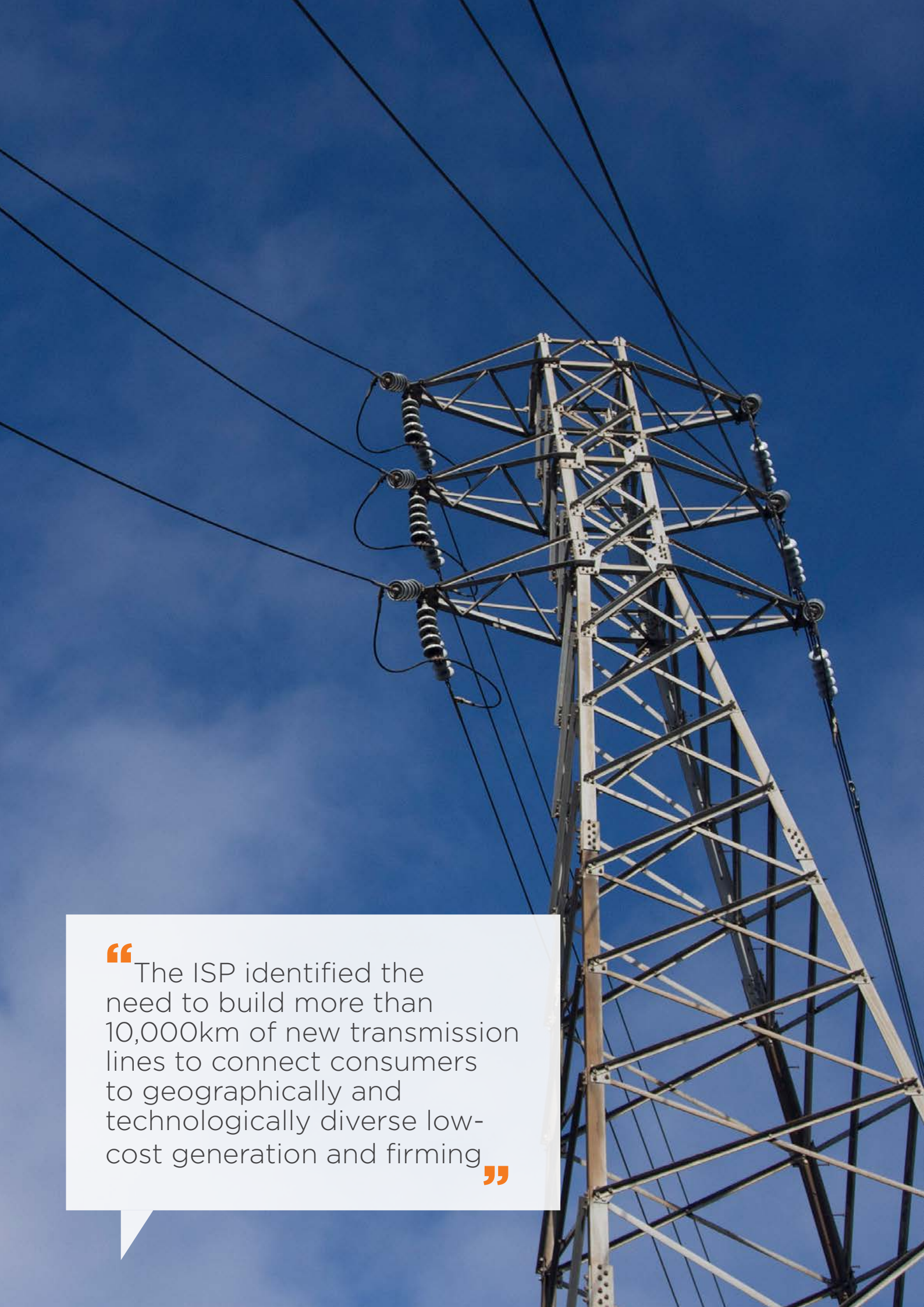
↑
Western Downs Green Power Hub, QLD, Neoen

1 Australian Energy Market Operator, *Quarterly Energy Dynamics Q3 2022*

2 Australian Energy Market Operator, *Quarterly Energy Dynamics Q4 2022*

3 Australian Competition and Consumer Commission, *Inquiry into the National Electricity Market 2022*

4 A Remeikis, *The Guardian*. https://www.theguardian.com/australia-news/2022/dec/09/15bn-energy-price-relief-package-for-australians-including-caps-on-coal-and-gas



> “The ISP identified the need to build more than 10,000km of new transmission lines to connect consumers to geographically and technologically diverse low-cost generation and firming”

TRANSMISSION

2022 was a positive year for the transmission sector, with projects across the country progressing and positive developments in the regulatory space.

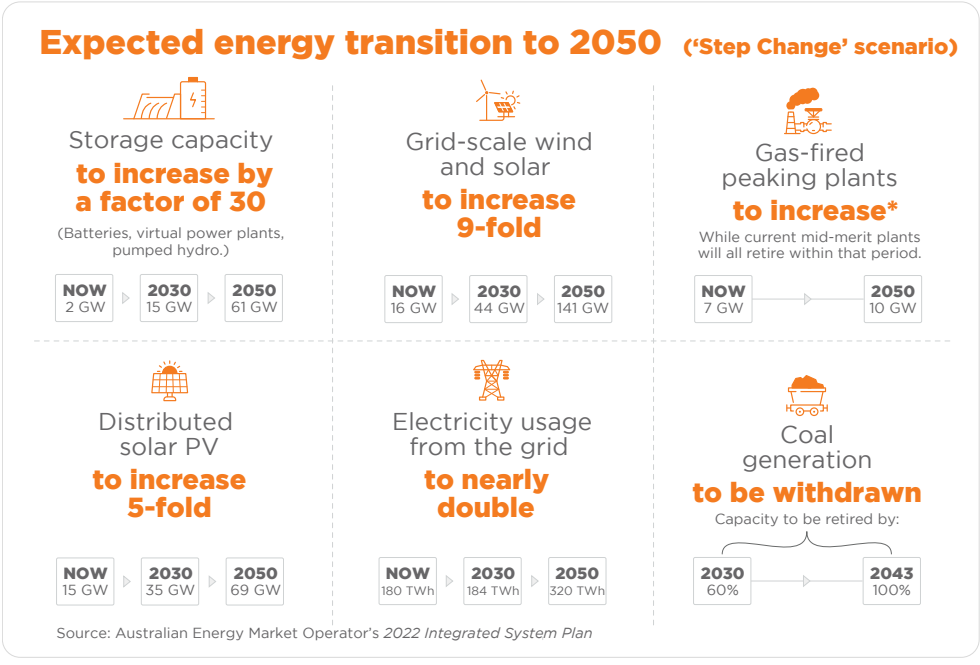
In June 2022, the final version of the Integrated System Plan (ISP) was published, outlining an integrated roadmap for the efficient development of the National Electricity Market (NEM) over the decades ahead. The ISP identified the need to build more than 10,000km of new transmission lines to connect consumers to geographically and technologically diverse low-cost generation and firming[1].

The Australian Energy Market Operator (AEMO) identified that, as part of its main forecast for the NEM out to 2050, significant investment was needed to drive a ninefold increase in utility-scale renewable energy capacity, most of this built in coordinated renewable energy zones (REZs). In addition, Australia would need to treble the firming capacity that can respond to a dispatch signal, including utility-scale batteries and pumped hydro storage, to manage the rapid exit of thermal coal generation, noting that there is the potential for 14 GW of thermal coal capacity to exit by 2030[2].

Specific REZ announcements came out throughout the year. In NSW, EnergyCo formally declared the South-West NSW REZ in November, followed by the Hunter-Central Coast REZ in December. The Illawarra REZ was declared as the fifth zone in February 2023.

In Queensland, the Palaszczuk Government announced plans to build a Super Grid as part of its Energy and Jobs Plan. This plan brings Queensland into the REZ race by announcing the Northern, Central and Southern Queensland REZ regions. The Queensland Government committed $145 million for transmission upgrades to support the plan[3].

A key element of this Super Grid will be the Copperstring 2.0 project, which was granted Federal Government approval in September to build a 1100km HVAC transmission network, intended to generate over 3000 MW of renewable generation by connecting Mount Isa,



*Degree of increase to be tiny compared to renewables and storage

[1] Australian Energy Market Operator, *2022 Integrated System Plan*, June 2022, p.15, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf

[2] AEMO, *2022 Integrated System Plan*, June 2022, p.9, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf

[3] Queensland Government, *Queensland Energy and Jobs Plan*, September 2022, p.30, https://www.epw.qld.gov.au/__data/assets/pdf_file/0029/32987/queensland-energy-and-jobs-plan.pdf

Cloncurry and the North-West Minerals Province to the NEM[4]. While the project had been privately developed for over a decade, the $5 billion development was acquired by the Queensland Government, with construction set to commence in 2024. Copperstring 2.0 will bring increased connectivity to the clean energy resource- and minerals-rich region of North Queensland, reducing energy prices while also increasing the export capabilities of the Australian critical minerals market.

Following AEMO's declaration of the Marinus Link project as a critical part of the ISP, TasNetworks received Federal, Victorian, and Tasmanian funding for the project in October. TasNetworks intends the project to be delivered in two stages and to be operational by 2028/29 and 2030/31. They expect it to include two 255km HVDC subsea cables, each with 750 MW capacity, to strengthen connectivity between Tasmania and Victoria. With their existing hydro capacity operating the 'battery of the nation', these connections will further enable Tasmania to grow its renewable export capabilities.

The Victoria-NSW Interconnector (VNI West) continued progressing through the technical and economic viability assessment phase, with AEMO Victoria Planning (AVP) completing the project assessment draft report in July. Stakeholders raised concerns about the cost-benefit analysis, with several arguing that costs far exceed the benefits.

After receiving a Ministerial Order under the National Electricity (Victoria) Act 2005 (NEVA) issued by Minister D'Ambrosio, Minister for Energy and Resources, AVP had the ability to consider alternate options while prioritising the prompt and cost-effective delivery of the project, providing industry assurance that the project will continue[5]. To resolve the most contentious connection point, a 500 kV double-circuit overhead transmission is now proposed to connect the Western Renewables Link (WRL) at Bulgana, with AVP finding it has the least negative impact of social, cultural, and environmental factors[6].

Project Energy Connect continues development

In NSW, Project Energy Connect (PEC) continued to meet milestones throughout the year, with the NSW Government approving the NSW-Eastern and NSW-Western sections of the project. Works also began in NSW, with ground broken in Buronga in May. The new 330 kV interconnector will cover 900 km and is expected to be completed by 2025/26, significantly enhancing the ability to share renewable energy between South Australia, Victoria, and New South Wales[7].

Additionally, the 500 kV Humelink transmission line was approved for early works funding by the Australian Energy Regulator in August. The line will span 360km connecting Wagga Wagga, Bannaby and Maragle, with three proponents being shortlisted to deliver the work[8]. The 'super-highway' interconnector is intended to unlock capacity from Snowy Hydro 2.0, while reinforcing transmission on the eastern seaboard by connecting in with project EnergyConnect. Landowners and local community who had been opposing the project welcomed a 200-metre underground corridor being announced as the proposed route in April.

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4 Queensland Government, statements.qld.gov.au/statements/97314

5 AEMO Victoria Planning, aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/victorian_transmission/vni-west-rit-t/project-update-6.pdf?la=en

6 AEMO Victoria Planning, aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/victorian_transmission/vni-west-rit-t/vni-west-consultation-report---options-assessment.pdf?la=en

7 Project Energy Connect, projectenergyconnect.com.au/article.php?id=72

8 Transgrid, *New South Wales Transmission Annual Planning Report 2022*, https://www.transgrid.com.au/media/jn4klv4s/tgr12164-tapr-2022-v5-4-final.pdf

Regulatory developments

On the regulatory front, the Australian Energy Market Commission (AEMC) published the Stage 2 final report as part of the Transmission Planning and Investment Review, which proposed recommendations to manage near-term uncertainty and financeability. AEMC also released a draft of the Stage 3 report, intended as a larger body of work examining economic assessment processes and incentives to support the transition to net zero. Both reports focus on existing regulatory frameworks, aiming to facilitate timely and efficient delivery of transmission services.

In preparation for the 2024 ISP, in December AEMO published its Draft 2023 Inputs, Assumptions and Scenarios Report, featuring a rebranding and recalibrating of the 2022 scenarios to align them with temperature increase targets as per the Paris Agreement. This is the first time that temperature increases have been used to represent necessary transmission planning.

Looking forward, with the Draft 2024 ISP expected to be published in December 2023, interested parties are pushing for stronger guidance on financeability, supply chain, and workforce capabilities to build the proposed levels of transmission. While there was welcome progression in 2022 – albeit slower than ideal – of transmission projects and REZ developments, delivering the targeted 10,000km of transmission will require coordination among industry, government, and communities at levels Australia has never seen before.

CLEAN ENERGY COUNCIL'S RESPONSE TO TRANSMISSION ACCESS REFORM

The Clean Energy Council has led the clean energy industry's response to Transmission Access Reform, leading the way for a better solution to manage congestion. Working closely with government officials and the Energy Security Board (ESB), the Clean Energy Council proposed a practical solution to a longstanding policy impasse.

Following years of industry campaigning for a better solution than locational marginal pricing, the Clean Energy Council welcomed the decision by senior officials and the ESB to introduce the Congestion Relief Market (CRM) as a key part of their proposed hybrid model.

Representing an innovative solution with broad industry support, the CRM will make better use of existing network capacity by creating opportunities for constrained generators to trade excess or curtailed capacity. It will also create additional revenue streams, reduce spilled energy, and optimise the existing and future transmission network.

This outcome highlights the Clean Energy Council's value proposition: leveraging strong relationships with governments and market bodies to ensure the clean energy industry's position is prioritised.

ENERGY RELIABILITY

Energy reliability was a major issue in 2022 as a cascade of unplanned outages at coal-fired power stations caused energy market chaos, culminating in the first-ever suspension of the National Electricity Market.

The warning signs for a challenging year for energy reliability were apparent early in 2022. January saw supply shortages in Queensland as a heatwave pushed demand to record levels while almost 2 GW of coal capacity was offline[1].

This trend continued over the subsequent months as further unplanned outages at a string of coal-fired power stations put additional strain on the electricity system[2].

By early May, approximately 30 per cent, or 3.6 GW, of the National Electricity Market's (NEM) total coal generation capacity was offline[3] and this rose to 4.6 GW in early June[4], plunging the country into an unprecedented energy crisis.

The crisis began after significant supply shortfalls were forecast for Queensland and New South Wales in mid-June, sending average weekly wholesale prices soaring to $674/MWh and forcing the Australian Energy Market Operator (AEMO) to impose a $300/MWh price cap for the first time in Queensland[5].

These circumstances forced AEMO to take the extraordinary step of suspending the electricity spot market, declaring that it had become "impossible to continue operating the spot market while ensuring a secure and reliable supply of electricity for consumers"[6].

While a series of external factors, including high gas prices caused by the war in Ukraine, contributed to the market suspension, the root of the problem was the ongoing unreliability of Australia's fleet of ageing coal-fired power generators and an energy market in desperate need of reform. Going forward, the focus should be bringing on more transmission, storage and generation investment, as a way of increasing energy reliability overall.

The announcement during the year that several coal-fired generators will retire earlier than previously planned has also raised the prospect of a rocky road for energy reliability in the coming years, with reliability gaps forecast for South Australia, Victoria and New South Wales as early as 2023-24 unless anticipated generation, storage and transmission projects are urgently progressed. While AEMO has stated that there is more than enough new renewable energy generation currently in the pipeline to delay any reliability risks until 2028-29, these projects must be committed now to

1 G Parkinson, *RenewEconomy*, reneweconomy.com.au/car-drives-into-electricity-pole-coalition-blames-green-energy-for-ensuing-outage

2 G Parkinson, *RenewEconomy*, reneweconomy.com.au/vales-point-joins-the-coal-teams-growing-injury-list

3 C Packham and A Macdonald-Smith, *The Australian Financial Review*, afr.com/companies/energy/grok-to-intensify-attack-on-agl-split-as-coal-outages-build-20220508-p5ajid

4 Australian Energy Market Operator, *Quarterly Energy Dynamics Q2 2022*, 29 July 2022, aemo.com.au/-/media/files/major-publications/qed/2022/qed-q2-2022.pdf

5 G Parkinson, *RenewEconomy*, reneweconomy.com.au/aemo-imposes-price-cap-on-queensland-market-amid-supply-crunch

6 Australian Energy Market Operator, aemo.com.au/newsroom/media-release/aemo-suspends-nem-wholesale-market

← Clean Energy Council staff take a tour of the Victorian Big Battery (Neoen/Tesla/AusNet)

ensure that they will be online in time to avert any potential shortfalls[7].

Programs like the Connection Reform Initiative (see page 17), which the Clean Energy Council is working on with AEMO and others, as well as a well-designed capacity investment scheme, will help prevent future issues with energy reliability.

SA network connections

The reliability of South Australia's electricity system came under strain in November when severe storms brought down transmission lines and disconnected the state from the NEM, similar to previous disconnections in recent years.

With the interconnector to Victoria down, South Australia was unable to export its excess renewable energy, which forced AEMO to curtail large-scale wind and solar output and remotely shut off rooftop solar systems to maintain system stability. This was made easier by South Australia's efforts to make solar systems smarter using inverter technologies and software solutions that give AEMO more visibility of the network[8]. Batteries also played a significant role in saving SA's electricity network, as they have in the past, especially the Hornsdale power reserve.

Disconnection is increasingly becoming a problem for networks across Australia as the volume of generation from rooftop solar continues to increase. While states such as South Australia and Western Australia have taken a modern, cloud-based approach to this problem, states such as Queensland have adopted a more blunt approach that involves simply turning off systems when needed, which may have unintended consequences for customers and the grid[9].

[7] Australian Energy Market Operator, aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2022/2022-electricity-statement-of-opportunities.pdf

[8] G Parkinson, *RenewEconomy*, reneweconomy.com.au/rooftop-solar-switched-off-in-south-australia-as-state-isolated-after-storm-damage-to-network

[9] S Vorrath, *One Step Off the Grid*, onestepoffthegrid.com.au/industry-slams-antiquated-brutal-rooftop-solar-switch-off-plan-for-sunshine-state

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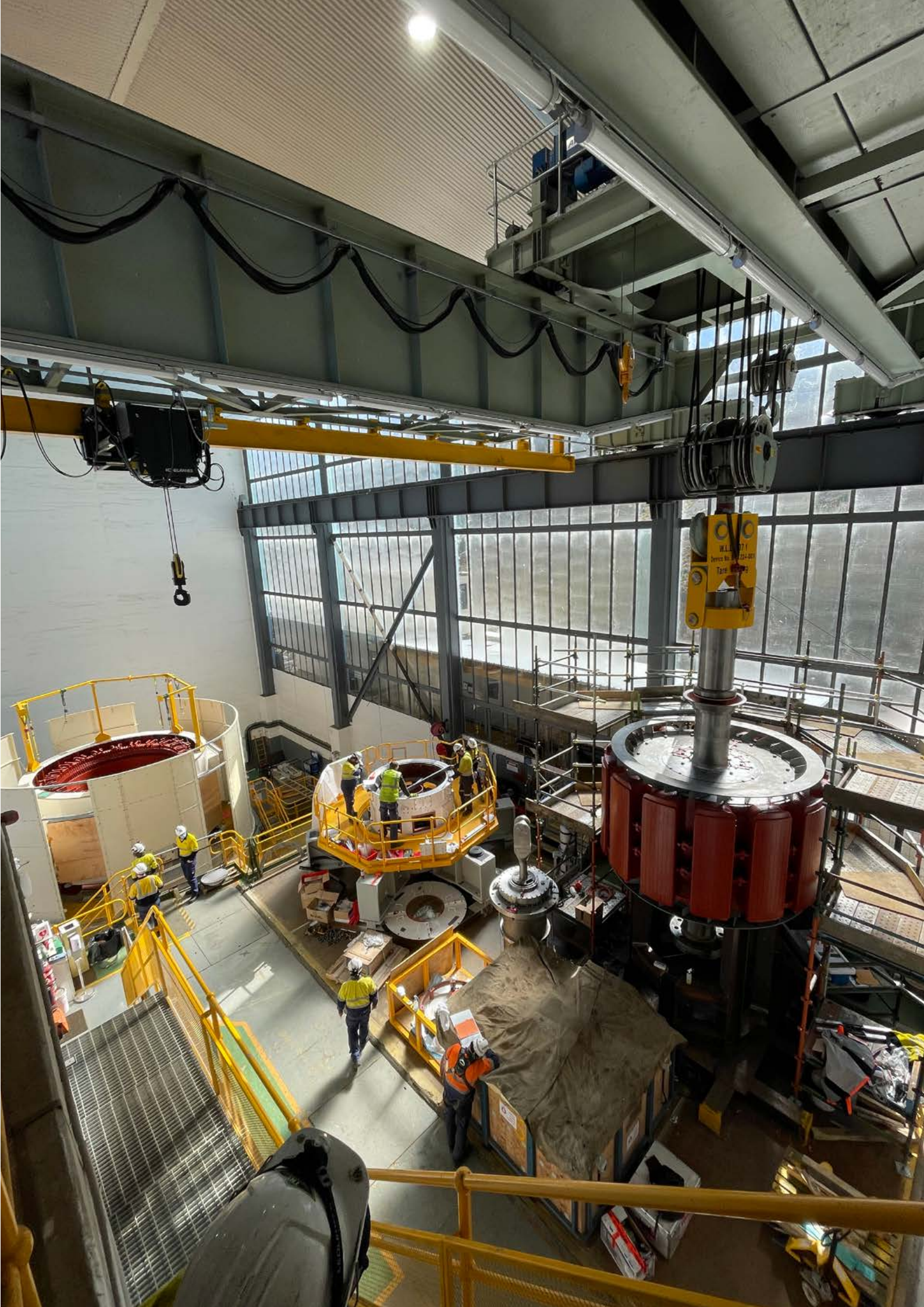
Lake Echo Power Station refurbishment, Hydro Tasmania



TECHNOLOGY PROFILES

TECHNOLOGY PROFILES:

BATTERY STORAGE

Although the number of large-scale batteries under construction is down on 2021, there are several substantial projects in development around Australia, supported by federal policies, suggesting battery storage will grow significantly in the years to come.

In November 2022, Singapore developer Equis was confirmed to jointly develop the Melbourne Renewable Energy Hub (previously known as Melton Renewable Energy Hub) with Syncline Energy. The project will be the largest battery energy storage system (BESS) ever deployed in the Asia-Pacific and when completed, will support approximately 1200 MW of renewable energy storage[1]. It will also be the largest BESS connected to Australia's National Electricity Market. Construction is slated to begin some time in 2023.

In Western Australia, Neoen has filed documents to develop a 1 GW/4 GWh BESS, providing system security for the South West Interconnected System, the state's main energy grid. The construction schedule looks likely to be protracted, spanning up to 10 years.

Nineteen large-scale batteries were under construction at the end of 2022 totalling approximately 1380 MW/2004 MWh of capacity, the largest being the 250 MW/250 MWh Torrens Island Battery in South Australia and the 200 MW/400 MWh Western Downs Green Power Hub in Queensland. Meanwhile, the current largest battery in Queensland – the 100 MW/150 MWh Wandoan South battery – commenced full commercial operations after nearly a year of testing. The projects suggest the Queensland Government's declared "battery blitz" may well be in full effect[2].

The figure of 19 large-scale batteries in development is down on 30 at this point last year, though the combined capacity of those projects is actually higher than in 2021. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) believes battery storage systems will see an acceleration in uptake around 2025, based on current trends and the need for cost reductions to become widely available. However, their immediate outlook for the sector is still broadly positive, based on the logic that the uptake of solar PV has been steadily increasing, and solar PV uptake will increase the demand for batteries.

The Federal Government's $176 million funding injection[3] into battery storage – an effort to stabilise and balance the grid – is likely to have a significant effect on the large-scale battery storage sector, and we will probably see capacity and development pick up in the years to come.

[1] J Thompson, *Energy Magazine*, https://www.energymagazine.com.au/australias-largest-ever-1200mw-battery-storage-system-to-be-built-in-melbourne/

[2] G Parkinsown, *RenewEconomy*, https://reneweconomy.com.au/queenslands-biggest-grid-battery-reaches-full-operation-after-year-of-testing/

[3] D Carroll, *PV Magazine*, https://www.pv-magazine.com/2022/12/19/australian-government-seeks-to-deliver-4-2-gwh-of-battery-energy-storage/

←←
Lisa Healy:
Rye Park NSW, Tilt Renewables

← Capital Battery construction, ACT, Neoen

19

Large-scale batteries under construction at end of 2022

(2021: 30)

1380 MW
2004 MWh

Approximate combined capacity of large-scale batteries under construction at end of 2022

(2021: 921 MW/1169 MWh)

The eight projects set to receive that funding – scheduled to be operational by 2025 – will triple the national grid's battery storage capacity.

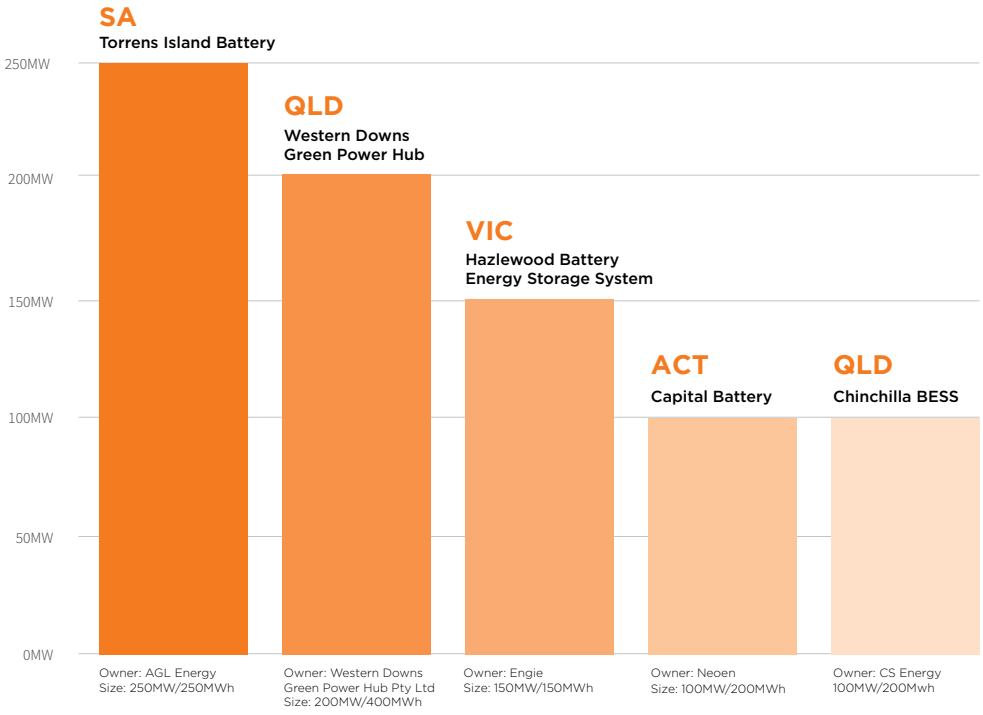
Data from the Australian Energy Council (AEC) suggests that the Albanese Government's measures are contributing to an uptick in the number of battery storage projects proposed and committed. In August 2022, for example, seven battery storage projects were committed in Australia, for a total capacity of 140 MW. In January 2023, that figure had risen to nine projects committed, for a total of 468 MW[4].

On the smaller-scale side of things, household batteries continue to grow in uptake, with estimates suggesting over 50,000 systems were installed in 2022, up from 34,731 in 2021.

However, only a fraction of solar households have batteries installed. According to the Australian Energy Market Commission, only around 1.6 per cent of households with rooftop solar PV, also have an installed battery[5].

The cost of residential batteries is falling, with warranted lifetimes increasing. As time goes by, owning home batteries will become more and more economically viable for households with solar installations. There will be significant implications for the grid, but more battery storage nationwide is a necessary and positive change.

Five biggest large-scale battery systems under construction at end of 2022



[4] Australian Energy Council. *Solar Report Q4 2022*

[5] M Kaka and R Pendlebury, Australian Energy Market Commission, https://www.aemc.gov.au/turning-point-incentives-invest-residential-batteries#:~:text=But%2C%20over%20the%20last%207,Australia%20as%20of%20August%202022

TECHNOLOGY PROFILES:

BIOENERGY

2022 saw increased acknowledgement of the role of bioenergy in achieving the Federal Government's commitment to reduce greenhouse gas emissions by 43 per cent by 2030, with funding announcements, key research developments and new large-scale projects.

A year on from the release of Australia's Bioenergy Roadmap by former Minister for Energy and Emissions Reduction Angus Taylor, there is continued interest and investment in bioenergy and steps toward the sector playing a useful role in the nation's energy market.

The roadmap focused on areas where bioenergy has a comparative advantage and complements other low emissions technologies, including renewable industrial heat generation, sustainable aviation fuels (SAF) and biomethane grid injection.

Leading industry association Bioenergy Australia's CEO Shahana McKenzie said bioenergy has great potential to supply these sectors with appropriate backing.

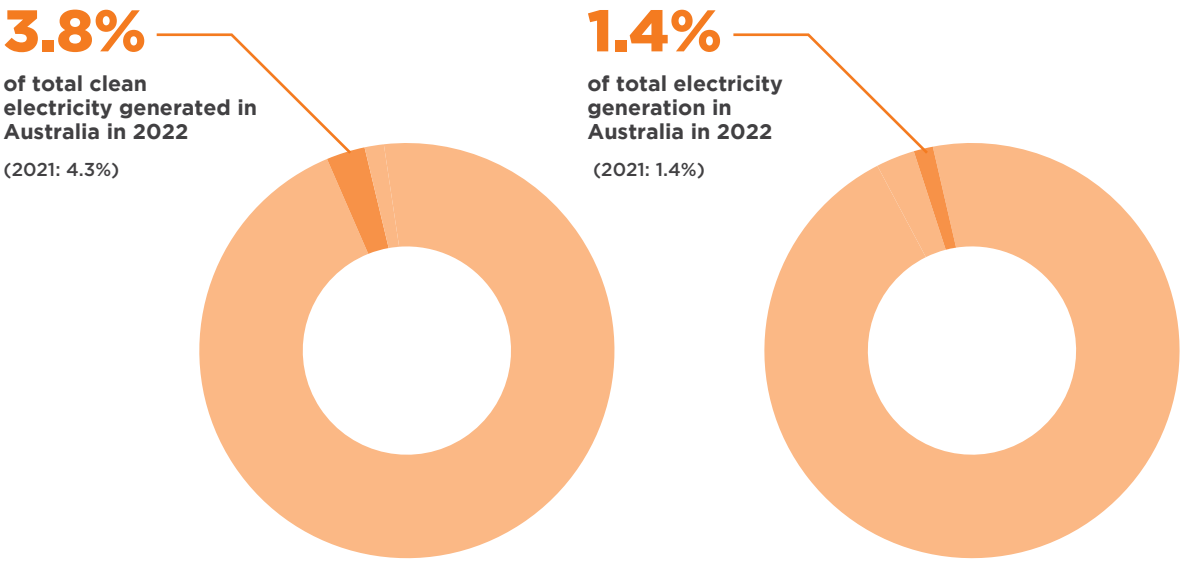
"We could be providing 23 per cent of Australia's domestic gas consumption with biogas, and 18 per cent of our domestic aviation with sustainable jet fuel by 2030, as well as providing 33 per cent of Australia's industrial heat," McKenzie said.

Domestic SAF production received attention with the Federal Government including the establishment of a SAF Council in the 2022 Budget and the Queensland Government backing a $500 million SAF biorefinery in Gladstone. Industry has also made progress, with Qantas moving to invest $50 million towards the establishment of a local SAF industry in Australia and the Sustainable Fuels Coalition Program.

Bioenergy Australia continues to advocate for biomethane grid injection to leverage the existing gas network in Australia and certification to incentivise industry to make the switch. The Australian Renewable Energy Agency is co-funding Australia's first biomethane-to-gas-network project to demonstrate how carbon-neutral biomethane can be used successfully.

The Bioenergy Roadmap estimated that continued uptake of bioenergy would see $10 billion added to Australia's GDP by 2030, as well as 26,200 full-time jobs created, significant emissions reductions, fuel security and waste reduction.

Investment, innovation and interest in Australia's bioenergy sector rose steadily throughout 2022, and it is anticipated that trajectory will continue as government and industry approach their renewable energy targets.



Copy provided by Bioenergy Australia

Notable bioenergy projects and announcements made in 2022 include:

INDUSTRY INNOVATION

- Qantas launched the Sustainable Aviation Fuel Coalition program
- MicroBioGen's new Australian laboratory opened as a world-leading biotechnology hub
- Emissions Reduction Fund method for biomethane launched Jan 2022

RESEARCH AND DEVELOPMENT

- Commonweatlth Scientific and Industrial Research Organisation launched the Towards Net Zero Mission with initial allocation of $90 million for research and development
- Lendlease using renewable diesel to power tower cranes on site, reducing greenhouse gas emissions from crane operations by up to 90 per cent
- BusTech builds two state-of-the-art bioethanol-fuelled buses to be rolled out on the Mackay bus network

FUNDING ANNOUNCEMENTS

- Federal Budget announced a 'Jet Zero'-style council to encourage emissions reduction in the aviation industry
- Government commits funding to Gaia EnviroTech for establishment of Anaerobic Digestion for organic waste
- Government committed $5 million to Licella for development of military grade biofuel
- Victorian Government launched $10 million Waste to Energy – Bioenergy Fund
- The bioenergy industry worked closely with the Clean Energy Regulator in developing an Emissions Reduction Fund method for biomethane, released in early 2022

NEW PROJECTS

- Victorian Government announced $19.3 million for two bioenergy projects from its Energy Innovation Fund
- Gladstone selected as the location for a new $500 million renewable biodiesel and sustainable aviation fuel biorefinery
- MicroBioGen opens new biofuels laboratory facilities in Sydney

Copy provided by Bioenergy Australia

TECHNOLOGY PROFILES:

HYDRO & PUMPED HYDRO

Hydro's contribution to Australia's total renewable generation fell in 2022 for the fourth consecutive year, although overall hydro generation was up 2.5 per cent.

Although hydropower's overall contribution to Australia's renewable energy mix (as a percentage of renewable generation) fell for the fourth year in a row, that is more due to other sectors thriving than hydropower falling away. For the third year in a row, total hydropower generation increased – up to 16,537 GWh from 16,128 GWh in 2021 – and its contribution to overall electricity generation in Australia rose from 7 per cent in 2021 to 7.1 per cent.

Progress is being made on Genex Power's Kidston Pumped Storage Hydro Project in Queensland, with 120 workers getting underway building the Wises Dam, the project's upper reservoir. The 250MW project is the first pumped hydro project to be built in Australia in over 40 years and is expected to be ready to generate power in 2024.

Unfortunately, the bad news continued for Snowy 2.0, which was to be a leading pumped-hydro battery in the Kosciuszko National Park. Announced in 2017, it was originally scheduled to be completed in 2021, but has been held back by drastically underestimated costs and a host of other issues, including one of the partners in the deal, Clough Engineering, being placed in administration after its Italian partner We Build pulled out[1].

The Federal Government has pledged to provide additional equity to Snowy 2.0 to help it reach completion, although that is likely to be some years away. As part of its announced support for the pumped hydro industry, the Federal Government has also partnered with the Tasmanian Government to expedite the 1,500 MW second Tasmanian interconnector, known as Marinus Link, through to a final investment decision by 2024. Marinus Link is a proposed electricity and telecommunications interconnector between Tasmania and Victoria, aimed at enabling the flow of electricity in both directions between the two states, delivering low-cost clean energy.

16,537 GWh

Hydropower generation

(2021: 16,128 GWh)

+2.5%

Annual increase in hydropower generation

(2021: +10%)

[1] G Parkinson, *RenewEconomy*, https://reneweconomy.com.au/collapse-of-contractor-puts-question-mark-over-giant-snowy-2-0-project/

←
Trevallyn Power Station, Hydro Tasmania

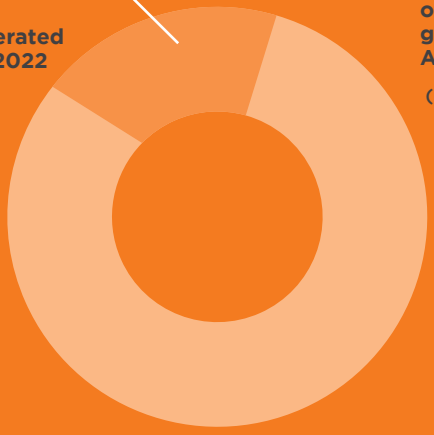
In last year's report, we noted that the Queensland Government had committed $22 million for design and cost analysis for a 1-2 GW pumped hydro project at the Borumba Dam. In February 2022, ground investigations and geotechnical testing began on that project which, if completed, would be capable of powering up to 2 million homes. In August 2022, the Queensland Government committed a further $203.5 million in new funding ($273.5 million in total) to Borumba Dam and a newly-announced project: the Pioneer-Burkedin Pumped Hydro. This project would be located 70km west of Mackay and 5 GW, making it bigger than Snowy 2.0 and the world's largest pumped hydro scheme. The Queensland Government intends for this project to be delivered by 2035.

Although hydro power is one of the most mature forms of renewable generation, and there are plenty of potential locations around Australia to take advantage of it, there remain only three pumped hydro projects operating in Australia. There is acknowledgement at Federal and State levels that pumped hydro should be part of the energy mix going forward, but development needs to proceed at pace to make it a significant contributor to Australia's clean energy transformation.

19.7%

of total clean electricity generated in Australia in 2022

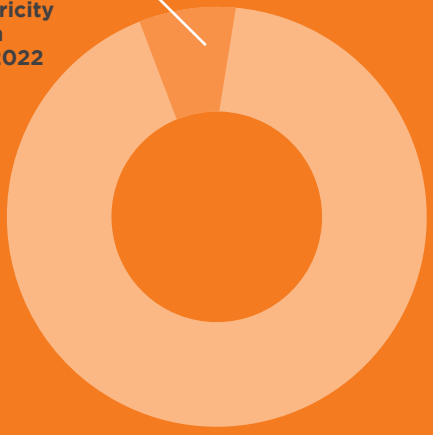
(2021: 21.6%)



7.1%

of total electricity generation in Australia in 2022

(2021: 7%)



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%

TECHNOLOGY PROFILES:

HYDROGEN

Interest in Australia's prospective hydrogen sector continued in 2022, with government and private investment increasing the number of projects in development to over 100 at the end of the year, according to the Commonwealth Scientific and Industrial Research Organisation.

In late 2022, Rystad Energy ranked Australia as number one in the world in terms of green hydrogen production announcements, thanks in large part to the number of mega-scale green hydrogen export projects proposed for development, many of which are based in Western Australia.

The massive potential of Australia's nascent hydrogen sector featured strongly in the 2022 federal election, with the Morrisson Government using the platform to announce the successful recipients of funding under its Clean Hydrogen Industrial Hubs program, awarding $525 million for hubs in the Pilbara, Perth, Darwin, Gladstone, Hunter Valley, Port Bonython and Bell Bay. Both the Morrisson Government and Labor made an election commitment to support a further hub at Townsville.

A change of government at the South Australia state election in March brought with it a promise to build Australia's first green hydrogen power station, following a key announcement by the Labor party in the leadup to the election. The 200 MW power station is slated to be built in Whyalla and will include a 250 MW electrolyser and a hydrogen storage facility[1]. Since the election, the SA Government has received has received 29 proposals to build the state's hydrogen power plant, production and storage facilities in Whyalla by December 2025[2].

In May, the Western Australia (WA) Government announced it would investigate the introduction of a Renewable Hydrogen Target in the state. The proposed target would see electricity retailers in the South West Interconnected System be required to procure 1 per cent of electricity generation from renewable hydrogen sources to create a local market to support emerging hydrogen projects and provide grid stability services[3]. While planning is still ongoing, the target is expected to begin operation in 2024.

WA also made progress on trials during the year to assess the feasibility of making hydrogen a part of the state's future energy infrastructure. In November, the town of Denham became the first in Australia to use hydrogen made from renewable energy for electricity generation. The pilot program uses electricity generated from a 700 kW solar farm to produce hydrogen in two 174 kW electrolysers, which is then fed into a fuel cell to create enough energy to meet approximately a quarter of the town's energy needs. While the project is small in scale, it will save 140,000 litres of diesel and provides an insight into some of the exciting potential uses for hydrogen[4]. The project is slated to be completed in early 2023.

The private sector also upped its commitment to Australia's developing renewable hydrogen industry in 2022, with several big players buying into the emerging sector and others increasing their commitments. In June, British oil and gas company BP announced that it had purchased a 40.5 per cent stake in the Australian Renewable Energy Hub, the proposed 26 GW wind, solar and hydrogen megaproject in the Pilbara region of WA. When completed, the project could produce 1.6 million tonnes of renewable

[1] HyResource, *South Australian Government Hydrogen Facility*, 15 September 2022, research.csiro.au/hyresource/south-australian-government-hydrogen-facility

[2] Government of South Australia, www.premier.sa.gov.au/media-releases/news-items/strong-global-interest-for-sas-hydrogen-jobs-plan

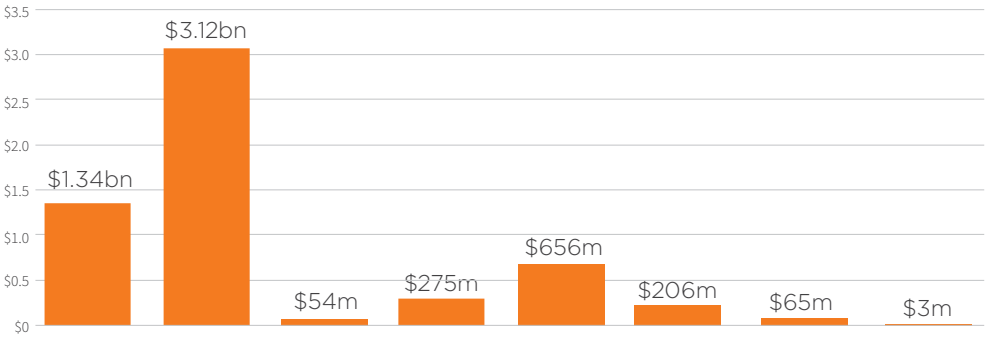
[3] WA Government, *Renewable Hydrogen Target to be investigated*, 16 May 2022, wa.gov.au/government/announcements/renewable-hydrogen-target-be-investigated

[4] HyResource, *Denham Hydrogen Demonstration Plant*, 17 November 2022, research.csiro.au/hyresource/denham-hydrogen-demonstration-plant

hydrogen a year, making it one of the world's largest proposed renewables and green hydrogen hubs[5].

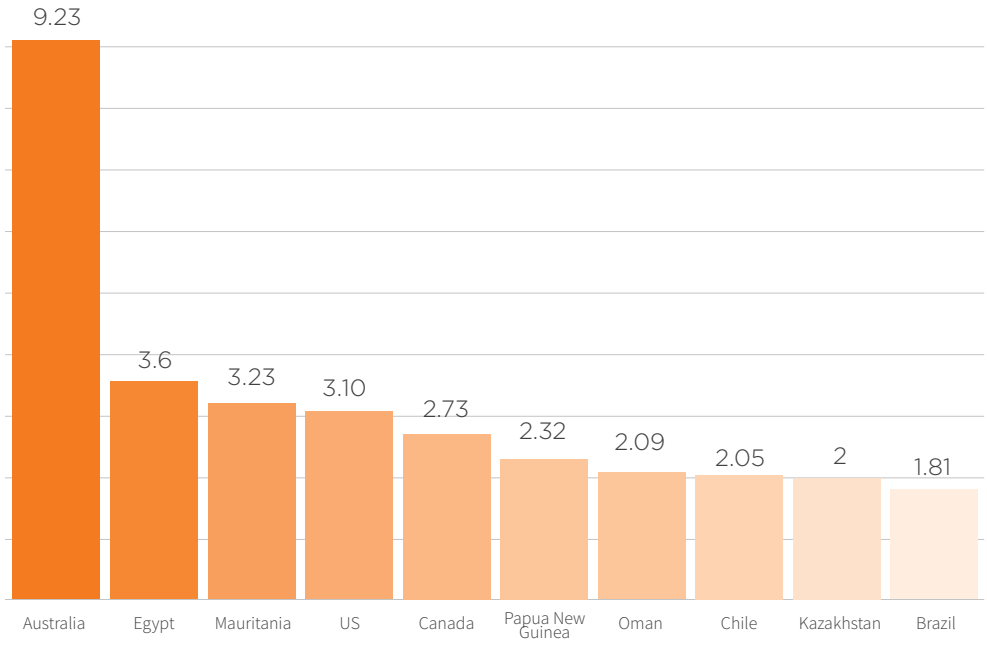
Other significant private sector announcements in 2022 included a proposed $20 billion green hydrogen project in Queensland's Bowen Basin by Korean businesses Hanwha, SK Group and Korea Zinc[6], who signed a memorandum of understanding with Andrew Forrest's Fortescue Future Industries (FFI) and German energy giant E.ON[7] for a potential $50 billion deal to produce up to 5 million tonnes of green hydrogen, as well as the start of construction of the world's largest electrolyser manufacturing facility by FFI in Gladstone, Queensland[8].

Investment in renewable hydrogen by state



World Wide Fund for Nature, *Renewable Superpower Scorecard* 2022

Top 10 countries for green hydrogen production announcements
(million tonnes)



Rystad Energy, October 2022

[5] M Bennet and C Packham, *The Australian Financial Review*, afr.com/companies/energy/bp-takes-major-slice-of-us36b-wa-green-hydrogen-hub-20220614-p5atn1

[6] A Macdonald-Smith, *The Australian Financial Review*, afr.com/companies/energy/korean-giants-20b-hydrogen-plan-for-qld-s-coal-heartland-20220921-p5bjpo

[7] G Parkinson, *RenewEconomy*, reneweconomy.com.au/forrest-strikes-huge-green-hydrogen-plan-with-german-energy-giant-e-on

[8] G Parkinson, *RenewEconomy*, reneweconomy.com.au/fortescue-starts-building-hydrogen-electrolyser-plant-that-will-double-global-production

TECHNOLOGY PROFILES:

ROOFTOP SOLAR
SYSTEMS UP TO 100 KW

Rooftop solar has long been a leading light of Australian clean energy. For the first time, rooftop-scale solar accounts for more than a quarter (25.8 per cent) of total Australian renewable generation. The sector was unable to match 2021's record-breaking 3 GW of new capacity, but still led the charge for Australian clean energy with 2.7 GW added in 2022

In 2022, 310,352 solar PV systems were installed across Australia (down on 377,408 in 2021), totalling 2.7 GW of new capacity. The dip in installed systems is likely a result of the supply chain issues and severe weather conditions Australians experienced in many states. Increasing prices around the middle of the year, as polysilicon prices rose, and subsidies paid through small-scale technology certificates continued their planned reduction, also likely played their part in hampering progress.

Towards the end of the year, as energy prices skyrocketed and following the suspension of the market in June, there was an increased uptake in solar installations as a way to offset those fossil fuel-driven price rises. Energy price uncertainty may continue to inspire increased uptake of solar into 2023.

Although the total number of installed systems was down on 2021, rooftop solar once again led the charge for Australian renewable energy in terms of capacity added, surpassing the 2.3 GW added by large-scale projects.

In 2021, every state and territory except the Northern Territory set new records for installed capacity. In 2022, all states except ACT and Tasmania fell below their 2021 levels. NSW led the pack in terms of highest installed capacity in 2022, with 829 MW, though this was down from 996 MW in 2021. The average solar system size continued its trend of increasing year-on-year, rising from 8.79 in 2021 to 8.84 in 2022.

In 2021, Australia reached over 3 million homes with rooftop solar systems installed. Estimates suggest that the figure is likely closer to 3.4 million now.

Rooftop solar accounted for 25.8 per cent of renewable generation in 2022 and 9.3 per cent of energy generation overall, up from 8.1 per cent in 2021. Figures from the Australian Energy Market Operator (AEMO) on minimum operational demand – the lowest level of demand met by generation from the grid, usually driven by consumer-owned generation such as rooftop solar – show that renewables are really cutting into the traditional energy mix. For example, in October 2022 in South Australia, AEMO reported a minimum demand record of 100 MW, of which 92 per cent was provided by solar[1].

Last year we noted the impact of increased rooftop-scale solar installations on the energy grid, which is struggling to support the new level of renewables in the mix, resulting in some authorities introducing or proposing to introduce measures such as export limits and remote disconnection. As network bodies try to manage grid security, some proposed actions have been more readily accepted than others. South Australia is implementing the use of CSIP-AUS to allow for more dynamic operating envelopes,

← Matt Harvey: Ocean Grove, RACV Solar

310,352
rooftop solar installations in 2022
(2021: 377,408)

2.7 GW
rooftop solar capacity added in 2022
(2021: 3.3 GW)

3.4M
Australian households with rooftop solar (approx)

[1] G Parkinson, *RenewEconomy*, https://reneweconomy.com.au/rooftop-solar-is-eating-coal-and-gas-markets-in-every-mainland-state/

whereby new regulations require all exporting solar systems to be capable of receiving and adhering to site export limits.

The Queensland Government is responding to network demands by introducing an emergency backstop mechanism, which will allow networks to remotely disconnect solar power and battery systems for short periods during emergencies.

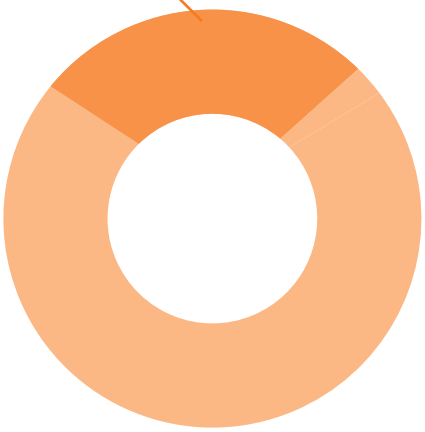
Although the Queensland Government has explained that this mechanism can be implemented quickly, securely and reliably, industry stakeholders have criticised it for being outdated and inferior to the solutions of South Australia and Western Australia.

Despite the great overall results, 2021's rooftop-scale solar growth rate was lower than in previous years, and, in some respects, 2022 has continued that trend, with both the number of systems installed and the MW capacity falling. That said, there is a good chance that increased energy prices will encourage more and more households to embrace solar, and we will see the sector bounce back strongly in 2023.

25.8%

of total clean electricity generated in Australia in 2022

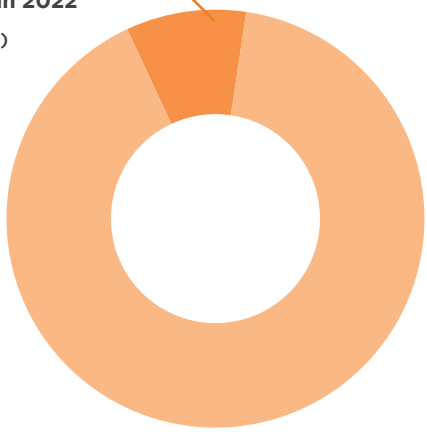
(2021: 24.9%)



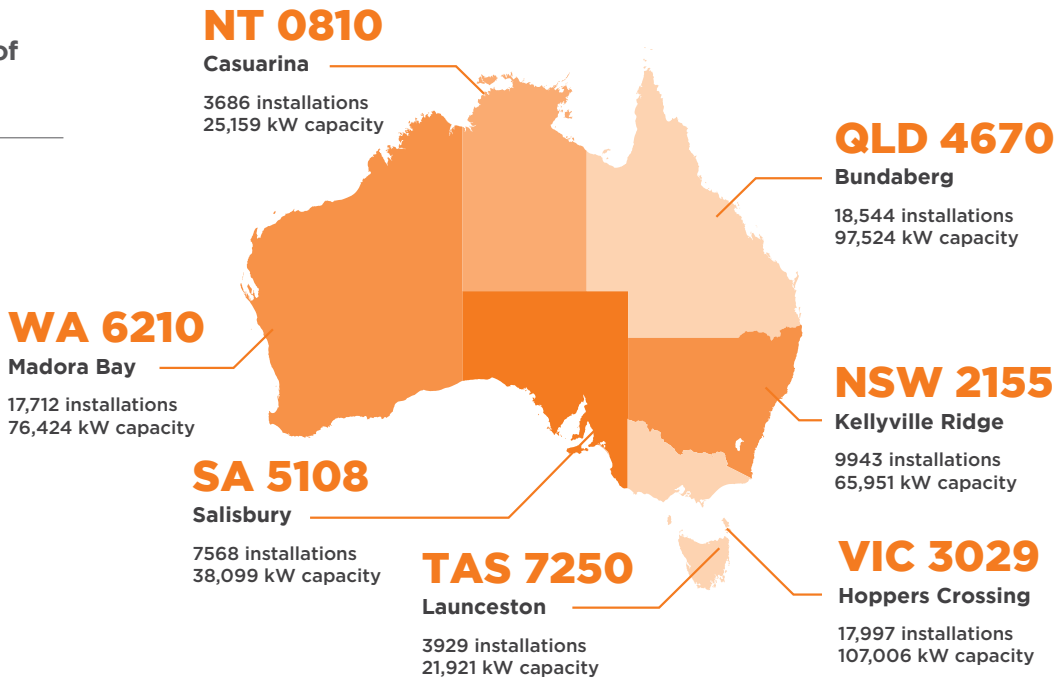
9.3%

of total electricity generation in Australia in 2022

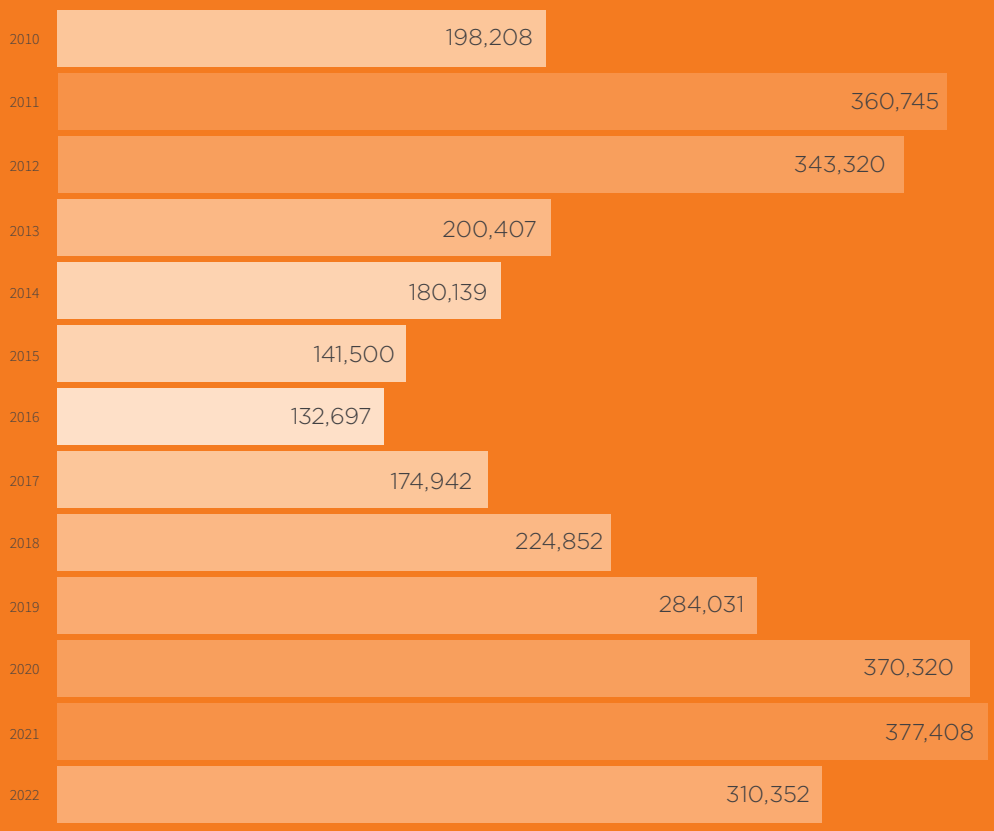
(2021: 8.1%)



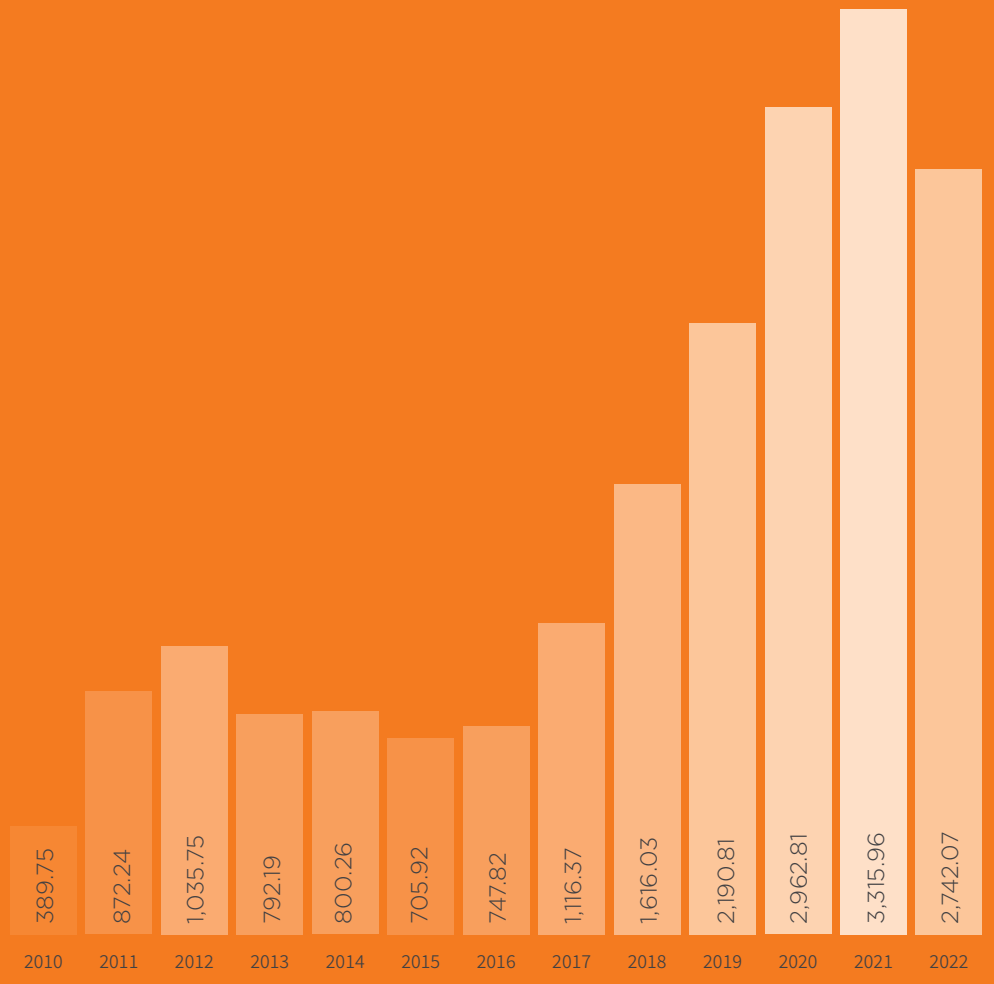
Top solar postcodes in each state, by number of installations



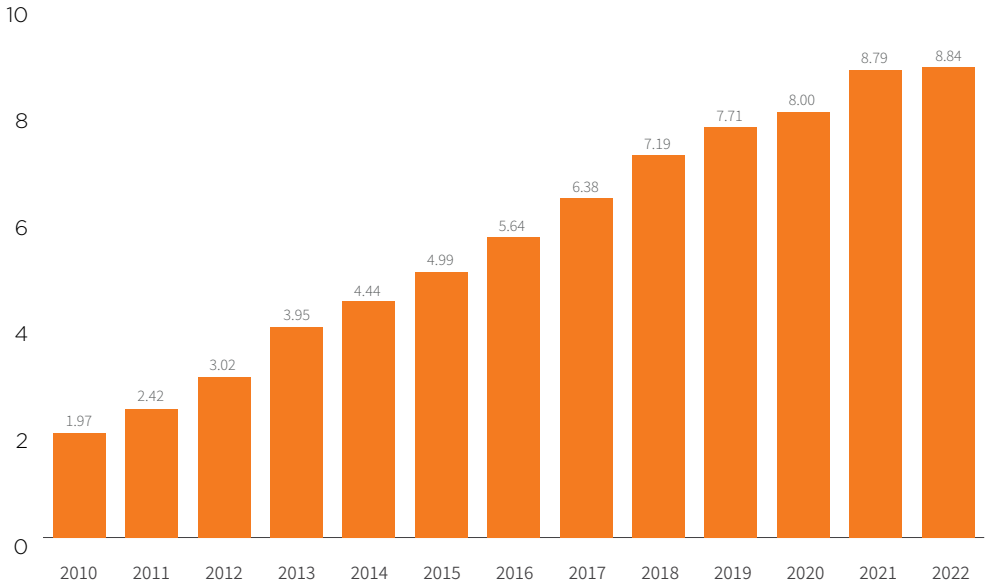
Annual solar PV installations



Annual installed capacity of solar PV (MW)

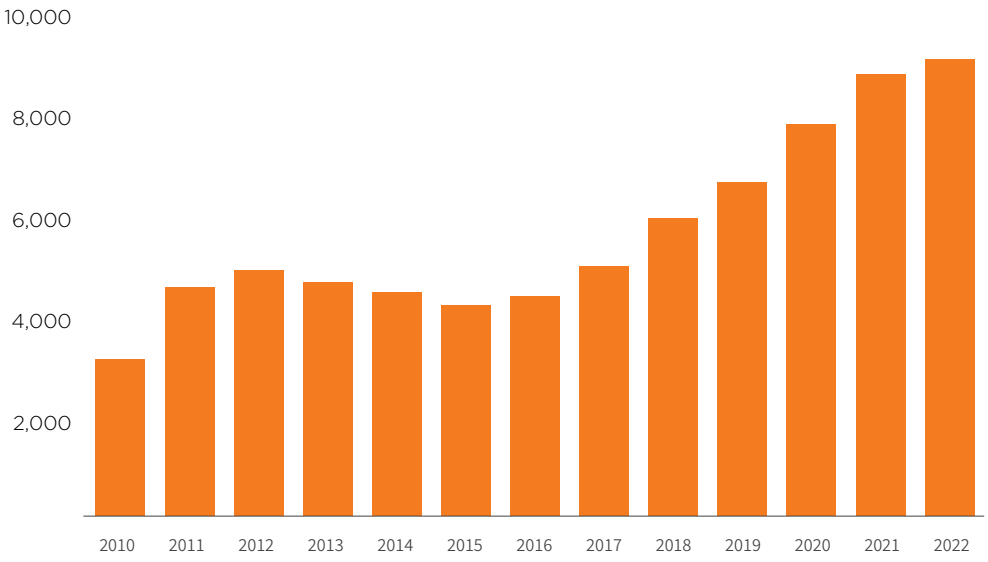


National average solar PV system size (KW)



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**



→
Matt Harvey:
Ocean Grove, RACV Solar

TECHNOLOGY PROFILES:

MEDIUM-SCALE SOLAR
SYSTEMS BETWEEN 100 KW AND 5 MW

Growth in the medium-scale solar sector has been slowing over recent years, but government policy favouring larger-scale investments and imaginative private projects should see that growth pick up in the years to come.

While the cumulative capacity for the medium-scale solar industry has been growing consistently since 2012, the growth rate continued to slow in 2022. In 2022, just 28 MW of medium-scale solar capacity was installed, compared to 86 MW in 2021 and 144 in 2020. That said, the data for medium-scale solar tends to take a little while to stabilise, meaning the estimate for 2022 could be slightly higher or lower than reported.

Medium-scale solar contributed 1.2 per cent of renewable generation in Australia in 2022, up from 1.1 per cent in 2021. Meanwhile, its contribution to Australia's total energy mix was 0.4 per cent, slightly up from 0.3 per cent in 2021.

The sector may be boosted going forward by a combination of supportive government policy and imaginative private endeavours, such as the Australian design studio Kennon's commercial office tower in Melbourne, 550 Spencer, which will feature more than 1,000 glass-like solar panels across its façade[1]. The project, set to complete in 2024, will comprise 1180 solar cells and, according to Kennon, will produce more energy than it uses, meaning it is expected to have almost no ongoing power costs. There is also an

674 MW

Total capacity of the medium-scale solar sector

(2021: 646 MW)

28 MW

New medium-scale solar capacity added in 2022

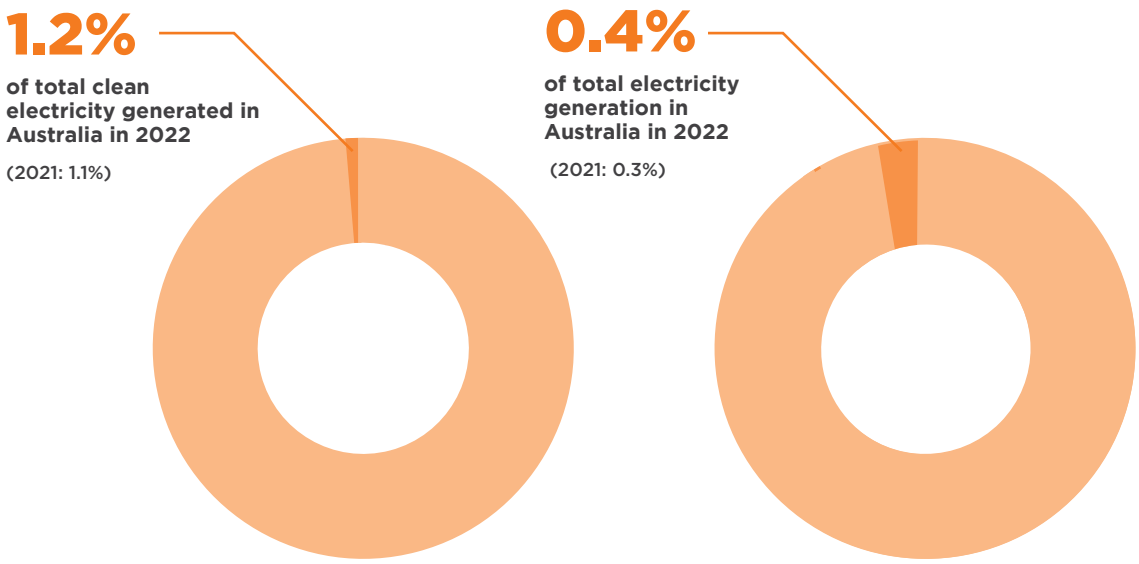
(2021: +86 MW)

[1] L Crook, *Dezeen*. https://www.dezeen.com/2022/08/02/office-tower-solar-facade-melbourne-kennon/#

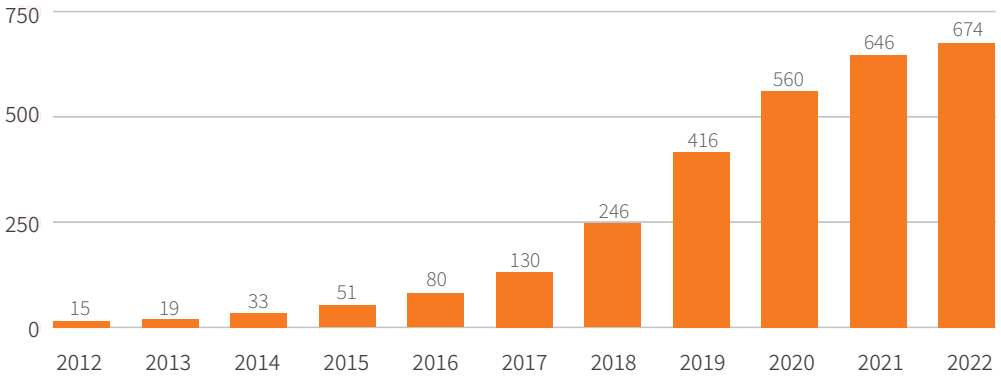
← Sheldon College QLD, Goodhew Electrical and Solar

ongoing solar project by drinks retailer Dan Murphy's, as part of its parent company Endeavour Group's strategy to power its business with 100 per cent renewables by 2050. Nationally, almost 20 per cent of Dan Murphy's stores have solar power, generating more than 7000 MWh of electricity[2].

We've also seen fantastic commercial projects, such as the solar system at Queenland's Sheldon College, which won the Clean Energy Council's 2022 Solar Design and Installation Award for a project over 100 kW. The 1.2 MW system, designed and installed by our award winner Gavin Goodhew, is situated across eight buildings and uses advanced monitoring and logging software to allow students to learn about solar energy and sustainability. The system serves almost all the school's energy needs during school hours, saving up to 5 tons of greenhouse gas emissions daily.



Cumulative installed capacity of medium-scale solar systems



[2] J Cartwright, *Techau.* https://techau.com.au/dan-murphys-is-smashing-solar-85-of-sa-stores-to-run-from-the-sun-by-mid-2022-100-renewables-nationwide-by-2030/

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

TECHNOLOGY PROFILES:

LARGE-SCALE SOLAR
SYSTEMS LARGER THAN 5 MW

While the number of projects commissioned is down on 2021, large-scale solar should have a bright future, thanks to increased backing from federal and state governments. Large-scale's share of Australia's renewable and total electricity generation continues to grow.

There were 12 large-scale solar projects commissioned in 2022 with a cumulative capacity of approximately 840 MW. Both the number of commissioned projects and their capacity were down on 2021, when there were 19 new projects with a combined capacity of 1249 MW. It is the third year in a row that the number of newly commissioned projects has fallen. While in 2021 new projects were shared relatively evenly around the country, in 2022, New South Wales dominated proceedings, commissioning eight of the 12 new projects.

However, the story is far from negative. All of the top five largest Australian solar farms by capacity in 2022 (see table below) became fully operational in 2021, helping large-scale solar to contribute a larger percentage of the clean energy generated in Australia in 2022 (14 per cent) than in 2021 (12.3 per cent) as well as a larger proportion of Australia's total electricity generated in 2022: 5 per cent compared to 4 per cent in 2021.

The largest projects commissioned in 2022 could not match the MW capacity of those commissioned in 2021, with the largest projects being the Suntop Solar Farm in NSW, at 150 MW capacity, and the Blue Grass Solar Farm in QLD, at 148 MW capacity. By comparison, 2021's largest commissioned system was the Darlington Point Solar Farm, with a capacity of 275 MW.

As of December 2022, 48 large-scale solar farms were under construction, up from 42 at the same stage in 2021. The largest of those include the Western Downs Green Power Hub in QLD, which is still under construction but has received approval to export a maximum of 300 MW into the QLD grid. When complete, the facility's final rated capacity will be 400 MW.

Also under construction at the end of 2022 was the first stage of the New England Solar Farm, which will also have a 400 MW capacity. The whole project is slated to have a 720 MW capacity and, when completed, will be Australia's largest combined solar and battery energy storage facility.

860 MW

New large-scale solar capacity added in 2022

(2021: 1683 MW)

6487 MW

Cumulative large-scale installed capacity in 2022

(2021: 5627 MW)

←
Western Downs Green Power Hub, QLD, Neoen

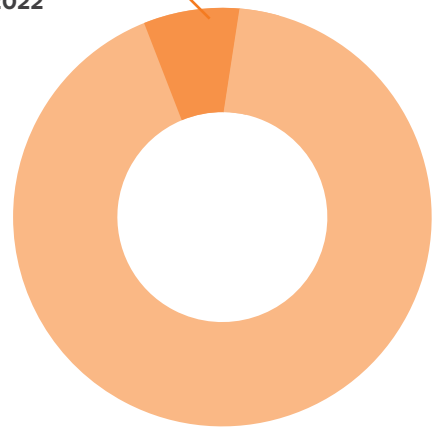
There was good news in December 2022, as large-scale solar recorded its biggest-ever month of generation, delivering 1509 GWh of renewable power over the month, compared to the previous high in December 2021[1]. That's a positive trend and there will hopefully be many similar records broken in the years to come.

Given the supportive policies announced by both federal and state governments, there will likely be a resurgence in large-scale energy project commitments in the future. Numerous energy targets, such as Queensland's Energy and Jobs Plan, which was released in 2022, set targets for renewable generation. For those targets to be met, significant deployment of new generation will be required throughout 2023 and beyond, which will hopefully galvanise the large-scale sector.

14%

of total clean electricity generated in Australia in 2022

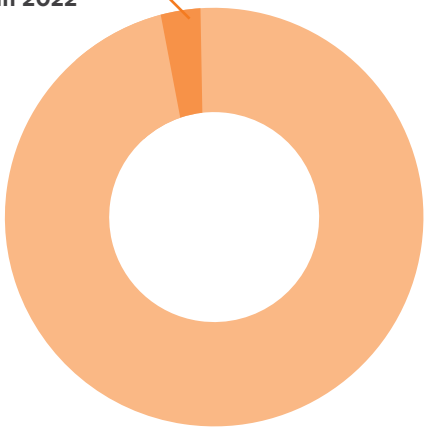
(2021: 12.3%)



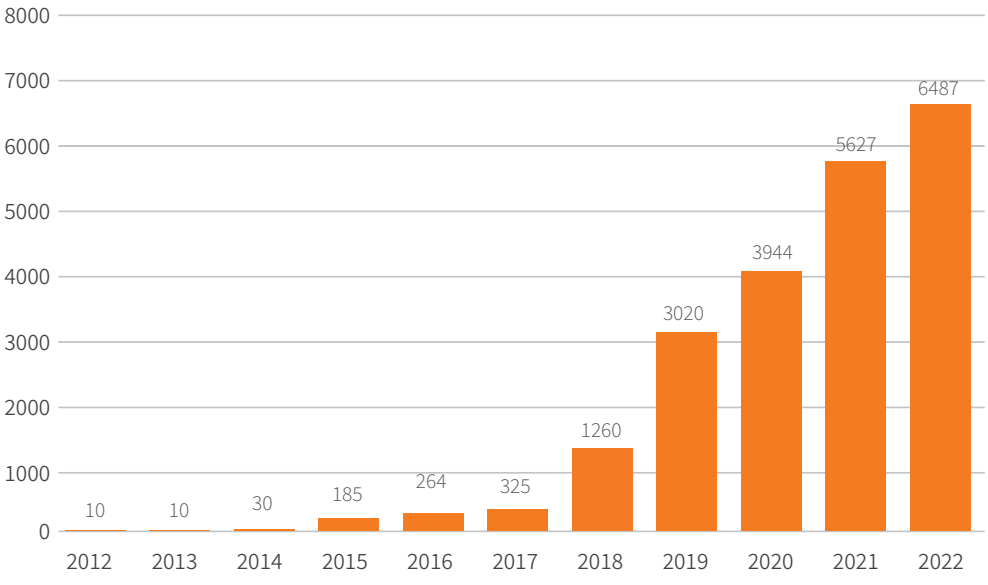
5%

of total electricity generation in Australia in 2022

(2021: 4%)

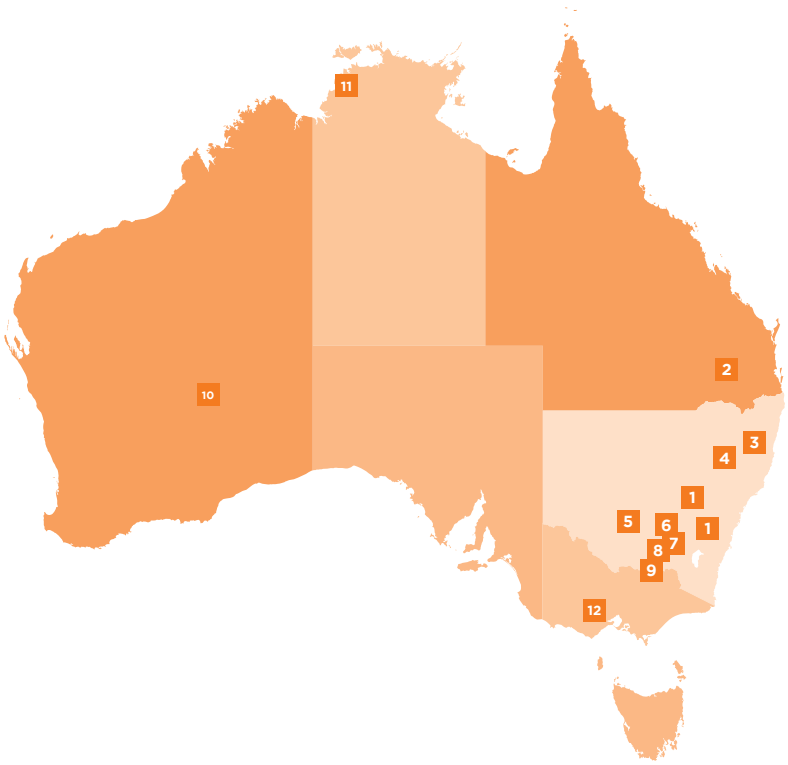


Cumulative installed capacity of large-scale solar systems



[1] S Vorrath, *RenewEconomy.* https://reneweconomy.com.au/big-solar-smashes-australian-generation-record-crunches-coal-to-close-out-2022/

Large-scale solar plants commissioned in 2022



1. Suntop Solar Farm
NSW
Owner: CalEnergy Resources
Capcity: 150 MW

2. Blue Grass Solar Farm
QLD
Owner: X-ELIO
Capcity: 148 MW

3. Metz Solar Farm
NSW
Owner: Fotowatio Renewable Ventures
Capcity: 115 MW

4. Gunnedah Solar Farm
NSW
Owner: CalEnergy Resources
Capcity: 110MW

5. Hillston Sun Farm
NSW
Owner: AMP Energy
Capcity: 110 MW

6. Sebastopol Solar Farm
NSW
Owner: Fotowatio Renewable Ventures
Capcity: 90 MW

7. Junee Solar Farm
NSW
Owner: Metka EGN
Capcity: 30 MW

8. Wagga Wagga North Solar Farm
NSW
Owner: Metka EGN
Capcity: 30 MW

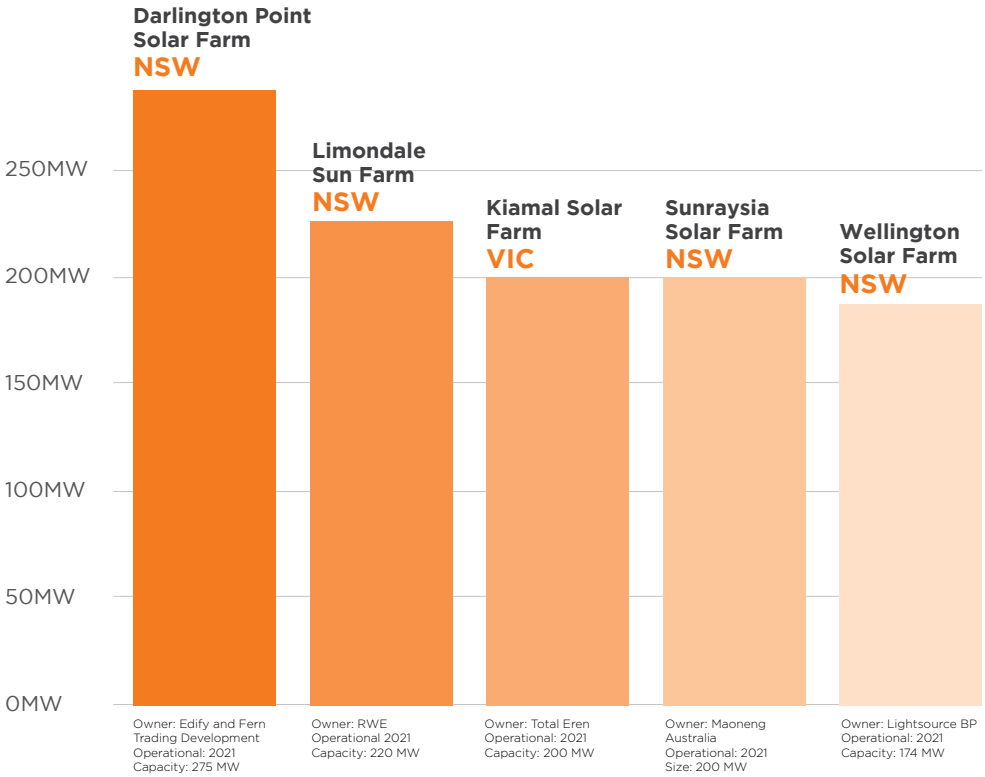
9. Corowa Solar Farm
NSW
Owner: Metka EGN
Capcity: 27 MW

11. Batchelor Pell Solar Farm
NT
Owner: Merricks Capital
Capcity: 10 MW

10. Gruyere Solar Farm
WA
Owner: APA Group
Capcity: 13.6 MW

12. McCain Ballarat Hybrid Plant
VIC
Owner: Solar Bar/McCain Foods
Capcity: 7 MW

Top five Australia solar farms by size



THE RISE OF AGRISOLAR

by Lucinda Tonge, Senior Policy Officer, Clean Energy Council

Since the mid-2010s, Australia has seen the development of many solar farms, reflecting the sharp fall in the cost of solar photovoltaic (PV) technology, which is now the lowest-cost form of electricity. As the sector grows, there is increasing interest in exploring new models for complementary solar energy and agricultural productioncomplementary solar energy and agricultural production models. This coupling is commonly known as 'agrisolar' or 'agrivoltaics'.

Utility-scale solar (generally considered to be greater than 5 MW) typically requires access to relatively flat or gently sloping land in sunny areas within proximity togreater than 5 MW) typically requires access to relatively flat or gently sloping land in sunny areas near electricity transmission networks, where biodiversity impacts can be avoided or minimised. This often means that land which has been previously cleared or zoned for agricultural use is well suited to host solar farm developments.

With the deployment of large utility-scale solar farms commencing in Australia from around 2015, the local experience of agrisolar practices is still developing and currently dominated by the practice of sheep grazing on solar farms. The first Australian solar farm to implement agrisolar practice was the Royalla Solar Farm, which began grazing sheep in 2015. Since then, there have been over a dozen solar farms thatover a dozen solar farms have introduced grazing, and it has proved to be an effective partnership for both solar farm proponents and graziers.

'Solar grazing', as it is known, is the most prevalent form of complementary land use for utility-scale solar farms due to the its compatibility with ground-mounted solar PV panels. The integration of solar energy and grazing within a single site provides the opportunity forallows renewable energy operators and landholders/farmers to work in partnership to maximise the productive use of rural land and reduce operating costs for all parties.

An agrisolar approach may not be suited to all solar farms, and proper consideration must be given to ecological and environmental impact, but optional support will help more industry players adopt these practices where possible. This not only provides potential co-benefits for both solar and agriculture, but also helps to bring communities along the renewable energy journey that is happeningbring communities along the renewable energy journey in their areas.

See the Clean Energy Council's *Australian Guide to Agrisolar for Large-Scale Solar* for more details.

TECHNOLOGY PROFILES:

WIND

Wind is the single-largest contributor to Australia's clean energy transformation (second when rooftop and utility-scale solar are combined), accounting for 35.6 per cent of renewable power generation in 2022, adding 1411 MW of new capacity. While new capacity added was slightly lower than in 2021, the next few years look bright for additional wind power, with several large projects in advanced stages of development.

As well as accounting for 35.6 per cent of renewable power generation, wind power comprised 12.8 per cent of Australia's total energy mix, up from 11.7 per cent in 2021, and 9.9 per cent in 2020.

Eight new wind farms were commissioned in Australia in 2022, the same number as in 2021, although the capacity of those projects amounted to 1410 MW, down from 1746 MW in 2021. The 2022 figure is still above that of 2020, however, indicating that while the market is fluctuating, it is still moving at pace.

Two new wind farms in Victoria became fully operational in 2022: the Stockyard Hill Wind Farm (532 MW) and Moorabool Wind Farm (312 MW). Meanwhile, in South Australia in January, construction began on the first tranche of what will become one of Australia's largest onshore wind farms: the Goyder South development run by French firm Neoen. The first stage of construction is on track to be operational in 2024, and will provide 209 MW of power generation, and the second stage will eventually contribute a similar amount.

The most significant project in development is Australia's first gigawatt-scale wind project in south east Queensland, which will comprise two wind farms: the 923 MW MacIntrye facility, majority owned by Spanish energy firm Acciona, and the 103 MW Karara Wind Farm, which will be owned and operated by state-owned CleanCo. Construction works for the joint project began in May 2022, and are predicted to run for 18-24 months. The facility, Acciona claims, will be capable of generating enough clean electricity to power 700,000 homes[1]. Acciona is working on expanding the project even further, with the proposed Herries Range Wind Farm, which would add another 1000 MW of capacity[2].

Victoria has been the leading state for wind power generation for some time and continues to lead the way, accounting for around a third (33.7 per cent) of Australia's wind generation. Another milestone was reached overnight on the 24 October when wind energy delivered three-quarters of Victoria's energy demand for the first time[3]. Although massive wind projects in Queensland and other states are underway, Victoria also has several significant wind projects in development, including the 756 MW stage one of the Golden Plains development in Rokewood, so it is likely to retain its status as the leading state for wind generation for several years to come.

8

wind farms commissioned in 2022

(2021: 8)

1411 MW

new wind capacity added in 2022

(2021: 1746 MW)

[1] Acciona, www.acciona.com/updates/news/acciona-energia-starts-building-australias-largest-wind-farm-1026mw/?_adin=11551547647

[2] Julianne G, Australian Manufacturing, www.australianmanufacturing.com.au/queenslands-herries-range-wind-farm-to-become-among-worlds-largest/

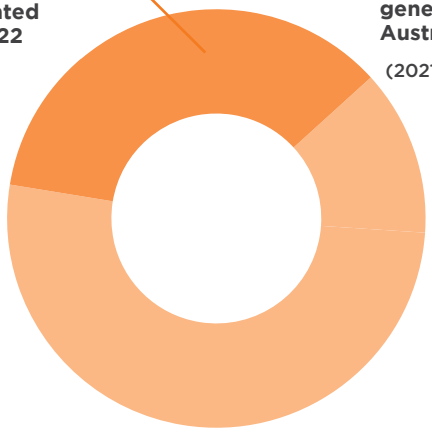
[3] G Parkinson, *RenewEconomy*, reneweconomy.com.au/graph-of-the-day-wind-energy-delivers-three-quarters-of-victorias-demand-for-first-time/

← Lisa Healy: Dundonnell Wind Farm VIC, Tilt Renewables

35.6%

of total clean electricity generated in Australia in 2022

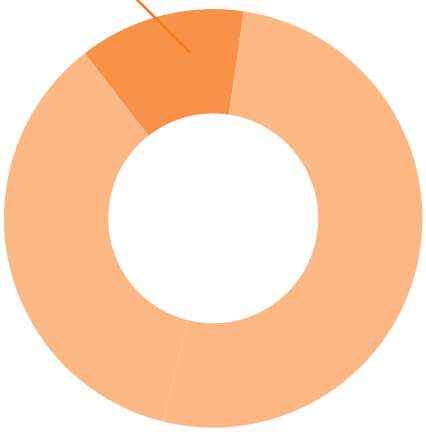
(2021: 35.9%)



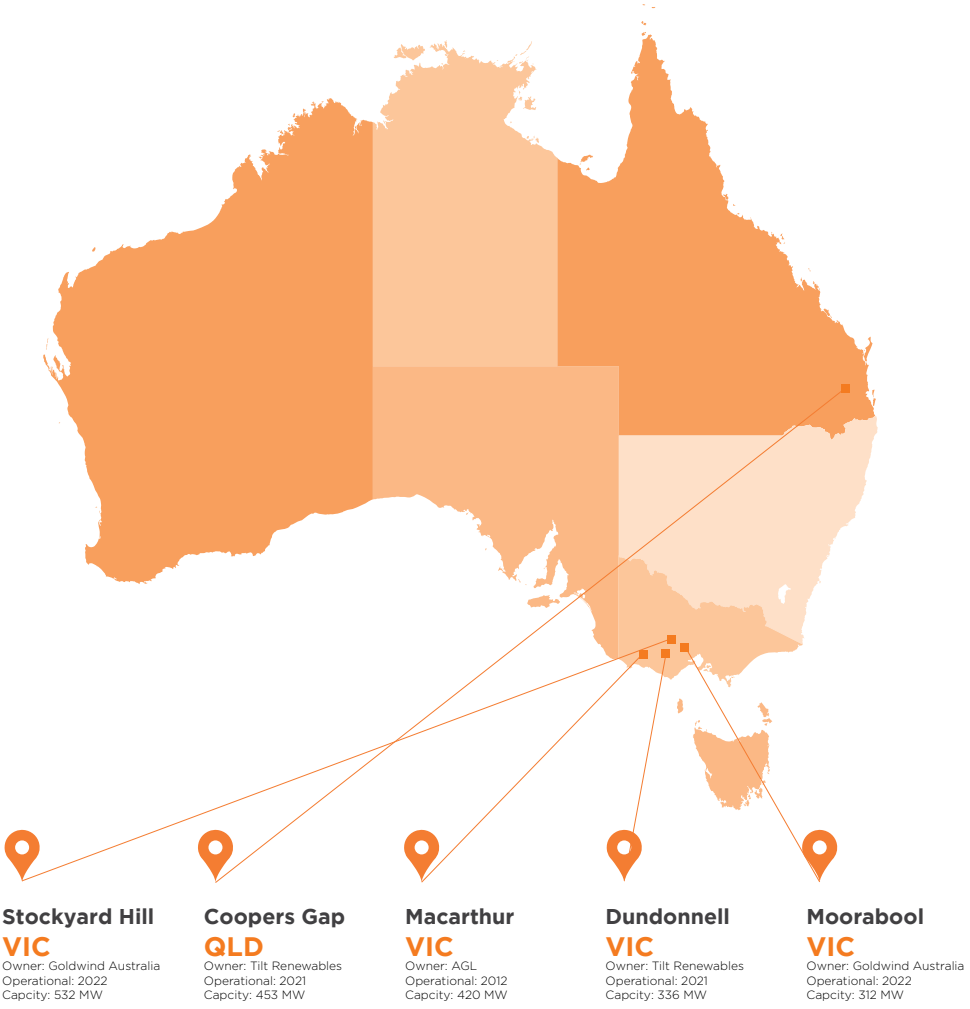
12.8%

of total electricity generation in Australia in 2022

(2021: 11.7%)



5 largest wind farms in Australia by capacity (MW)



→
Mieka White:
Collector Wind Farm NSW,
RATCH Renewables

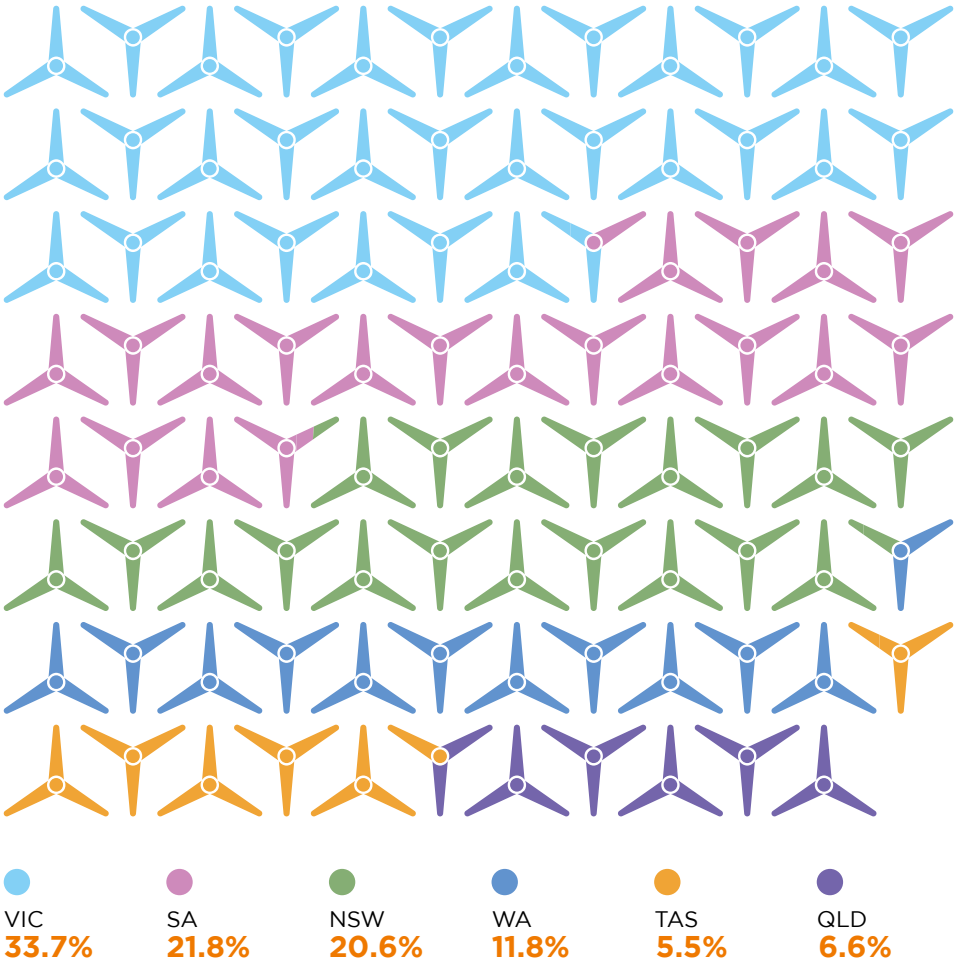
Towards the end of 2021, the Offshore Electricity Infrastructure Act 2021 was passed, finally bringing a legislative framework for offshore wind to Australia. June 2022 marked the next phase of that legislation: the commencement of the licensing regime that will regulate Australia's offshore wind industry in Commonwealth waters. The 2.2 GW Star of the South development off Victoria's Gippsland coast remains the most advanced offshore wind project in Australia. Still, the quality of the offshore wind resource around the country and the growing investment interest, including from many global offshore wind players, indicates the sector will flourish going forward. There is currently more than 50 GW worth of announced offshore wind projects around the country.

The booming interest in offshore wind, combined with the numerous large-scale wind farm projects in development around Australia – 19 onshore projects were under construction or committed by the end of 2022 – suggests there is plenty to look forward to for wind power in 2023 and beyond.

Wind farms under construction or committed at end of 2022

State	Project	Lead operator/owner	Installed Capacity (MW)
QLD	MacIntyre Wind Farm	Acciona	923
VIC	Golden Plains Wind Farm Stage 1	WestWind Energy & TagEnergy	756
QLD	Clarke Creek Wind Farm Stage 1	Squadron Energy	450
NSW	Rye Park Wind Farm	Tilt Renewables	396
VIC	Ryan Corner Wind Farm	Global Power Generation	218
SA	Goyder South Stage 1a Wind Farm	Neoen	209
VIC	Murra Warra Wind Farm Stage 2	RES/Squadron Energy	209
SA	Goyder South Stage 1b Wind Farm	Neoen	203
QLD	Dulacca Renewable Energy Hub	Octopus Australia	180
NSW	Bango Wind Farm 1	Squadron Energy	159
VIC	Mortlake South Wind Farm	Acciona	157.6
QLD	Kaban Wind Farm	Neoen	157
NSW	Flyers Creek Wind Farm	Iberdrola	145
VIC	Berrybank 2 Wind Farm	Global Power Generation	109.2
QLD	Karara Wind Farm	Acciona-CleanCo Queensland	103
VIC	Hawkesdale Wind Farm	Global Power Generation	96.6
NSW	Bango Wind Farm 2	Squadron Energy	84.8
QLD	Kennedy Energy Park - Wind and Solar	Windlab	58.2
NSW	Crookwell 3 Wind Farm	Global Power Generation	58

Percentage of wind generation by state



→
Biala Wind Farm NSW, Goldwind

→→
Western Downs Green Power Hub, QLD, Neoen

THANK YOU

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

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Iberdrola
Neoen
RATCH Renewables
X-Elio
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With previous conferences having been held in Beijing, Washington DC, Delhi, Abu Dhabi, Cape Town, Mexico City, Seoul, and Madrid, the selection of Adelaide as the host for the 2024 event is a testament to the strength of Australia's renewable energy industry and South Australia's strategic vision.

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