

# The role of CCUS towards net-zero in Australia

IEA Joint EOR/GOT Symposium - Stavanger, Norway

Dominic Pepicelli | 24<sup>th</sup> November 2022

[energymining.sa.gov.au](http://energymining.sa.gov.au)



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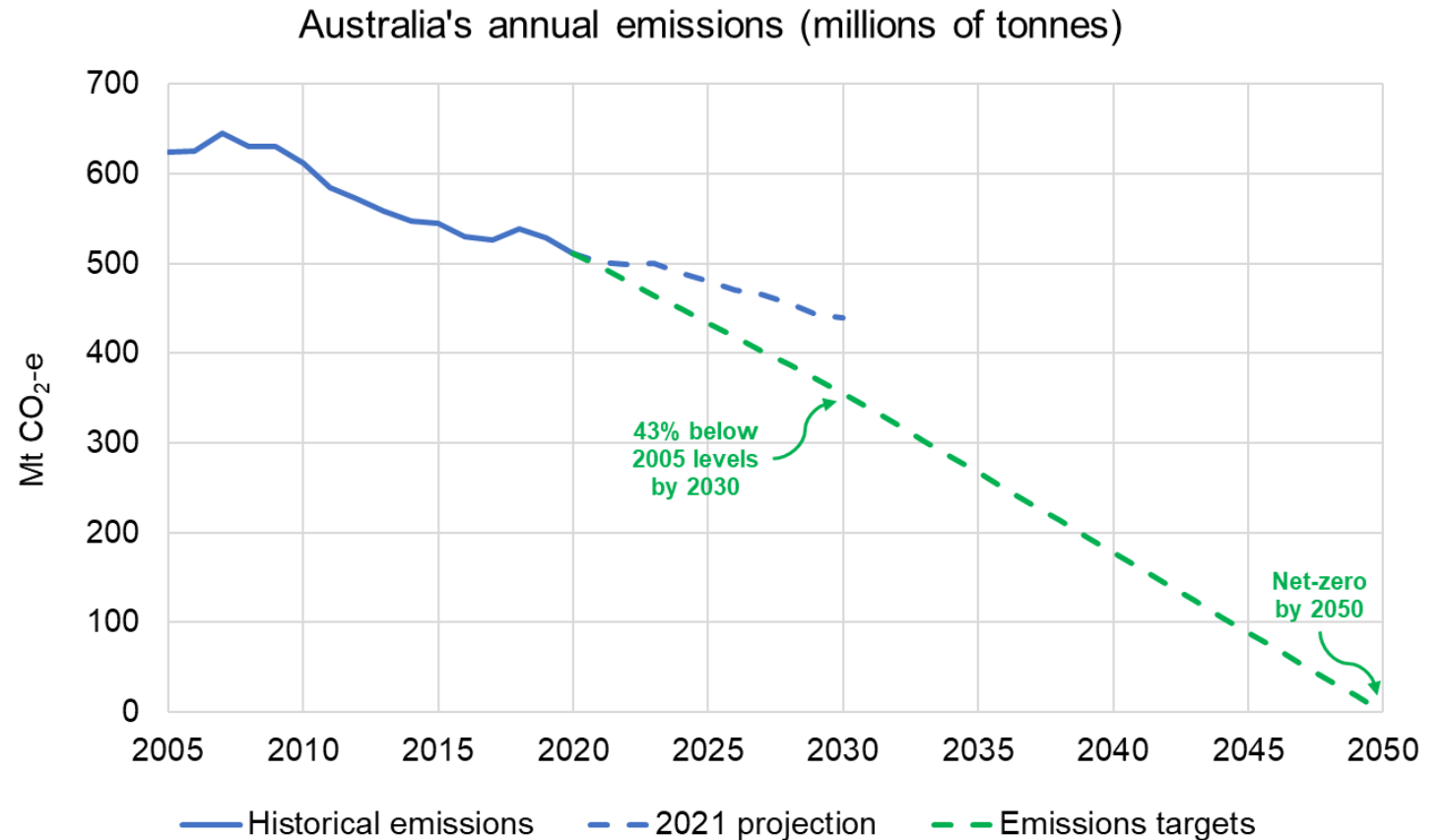
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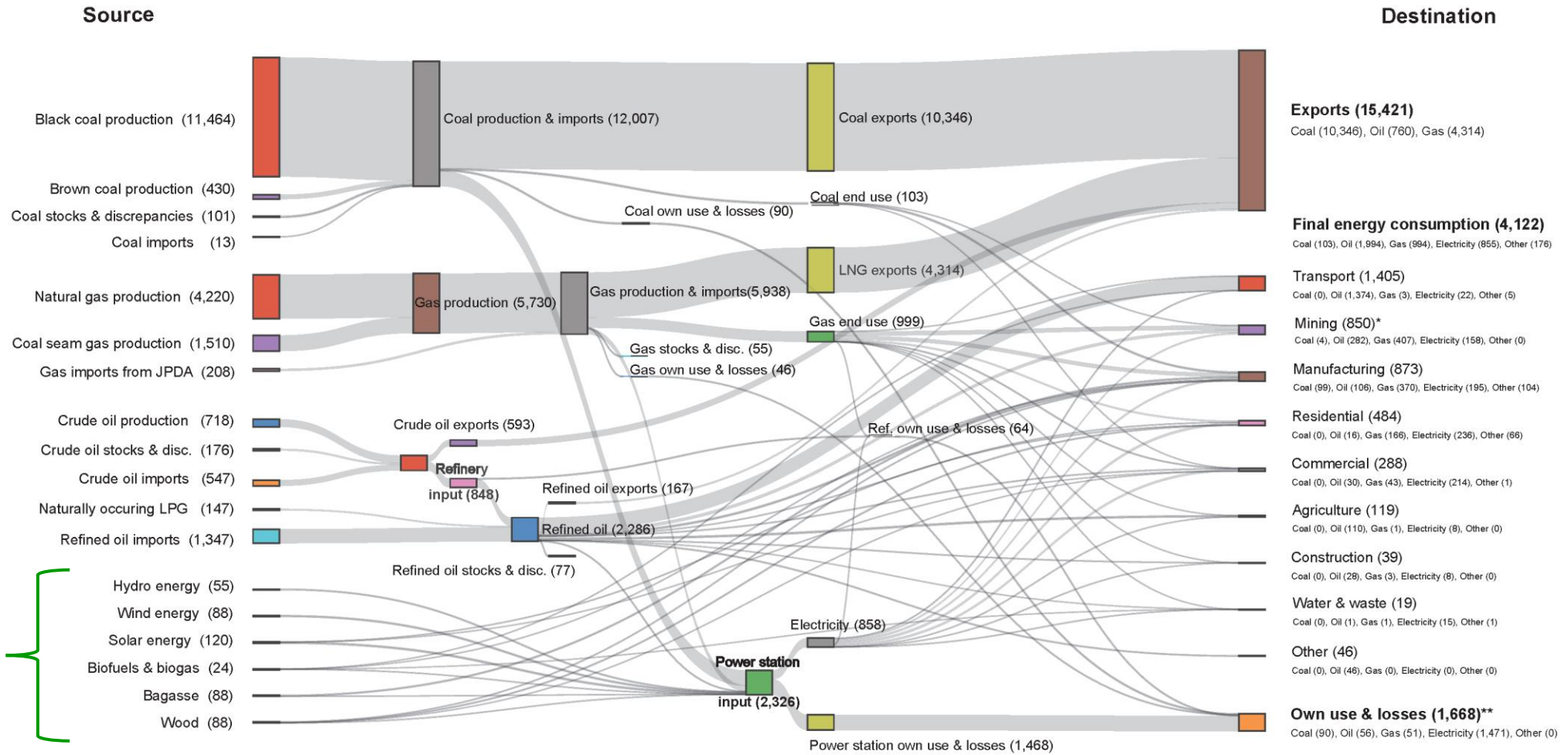
# Australian Emissions Targets

- On 8 September 2022 the Australian Government [legislated](#) emissions reduction targets:
  - 43% below 2005 levels by 2030
  - Net-zero by 2050
- Projections show steady decline, but need more rapid reduction in emissions to meet 2°C scenarios.



Data sourced from Australia's emissions projections 2021 (DISER, 2021)

# Australian Energy Flows 2020-21 (Petajoules)



Primary energy production	+	Imports	-	Exports	-	Stocks change & discrepancies	=	Primary energy supply	-	Own use & losses	=	Final energy consumption
18,952 PJ		2,114 PJ		15,421 PJ		- 145 PJ		5,790 PJ		1,668 PJ		4,122 PJ

NOTES: Numbers may not add due to rounding. JPDA = Joint Petroleum Development Area. \* includes LNG plant own use of gas. \*\* Conversion plants own fuel use & losses, and transmission losses.

# Global Energy Supply

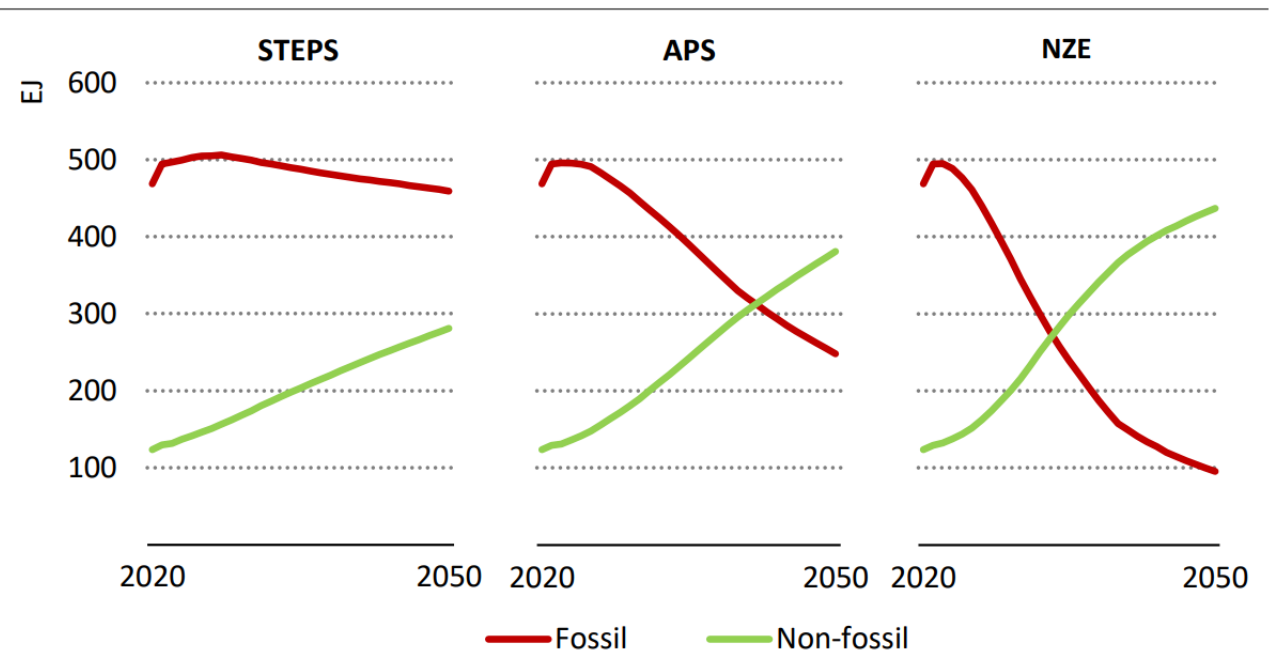
- Fossil fuels projected to remain a significant part of energy supply to 2050.

*Stated Policies Scenario (STEPS) – today’s policy setting trajectory.*

*Announced Pledges Scenario (APS) – assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals.*

*Net Zero Emissions by 2050 (NZE) – International Energy Agency 2021 Scenario*

**Figure 1.17** ▶ Fossil and non-fossil energy supply by scenario, 2020-2050



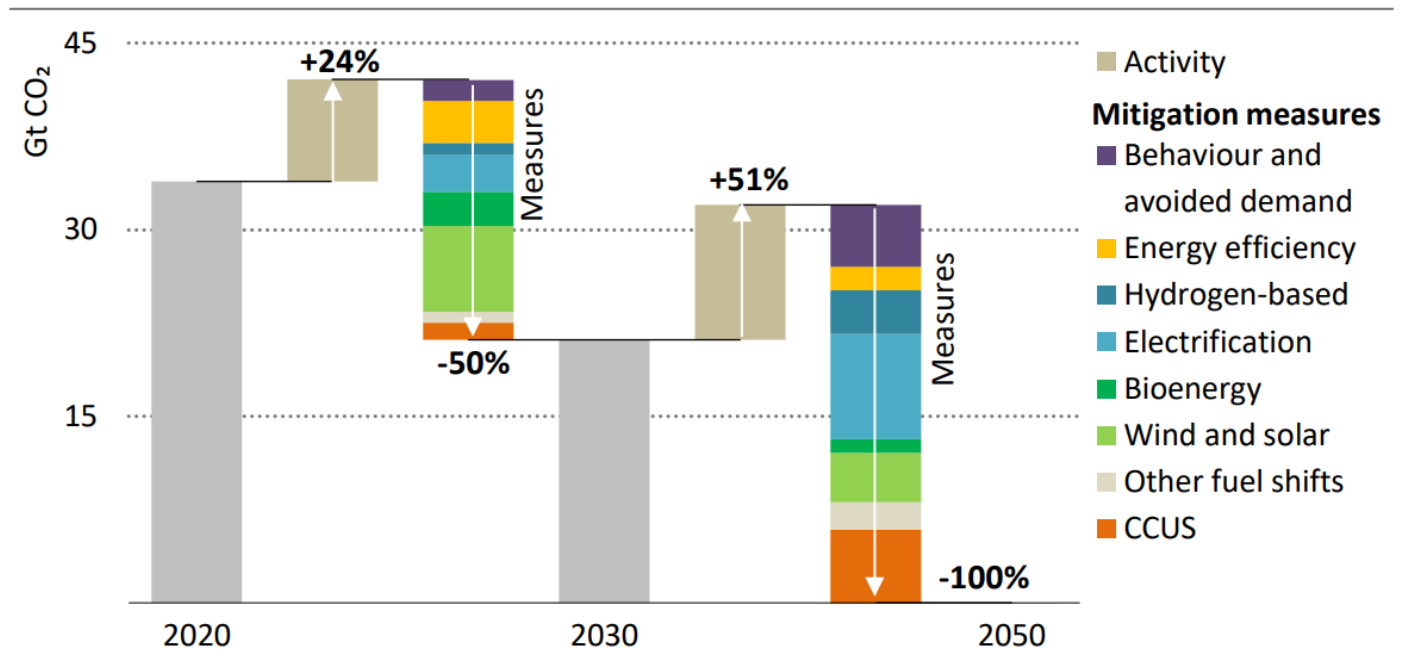
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IEA (2022), World Energy Outlook, IEA, Paris

# IEA Net Zero by 2050 Scenario

- A range of technologies must work together in order to reach net zero by 2050.
- CCUS accounts for approximately 18% of emission reductions to 2050 under the IEA's Net Zero by 2050 Scenario (NZE).

**Figure 2.12** ▶ Emissions reductions by mitigation measure in the NZE, 2020-2050



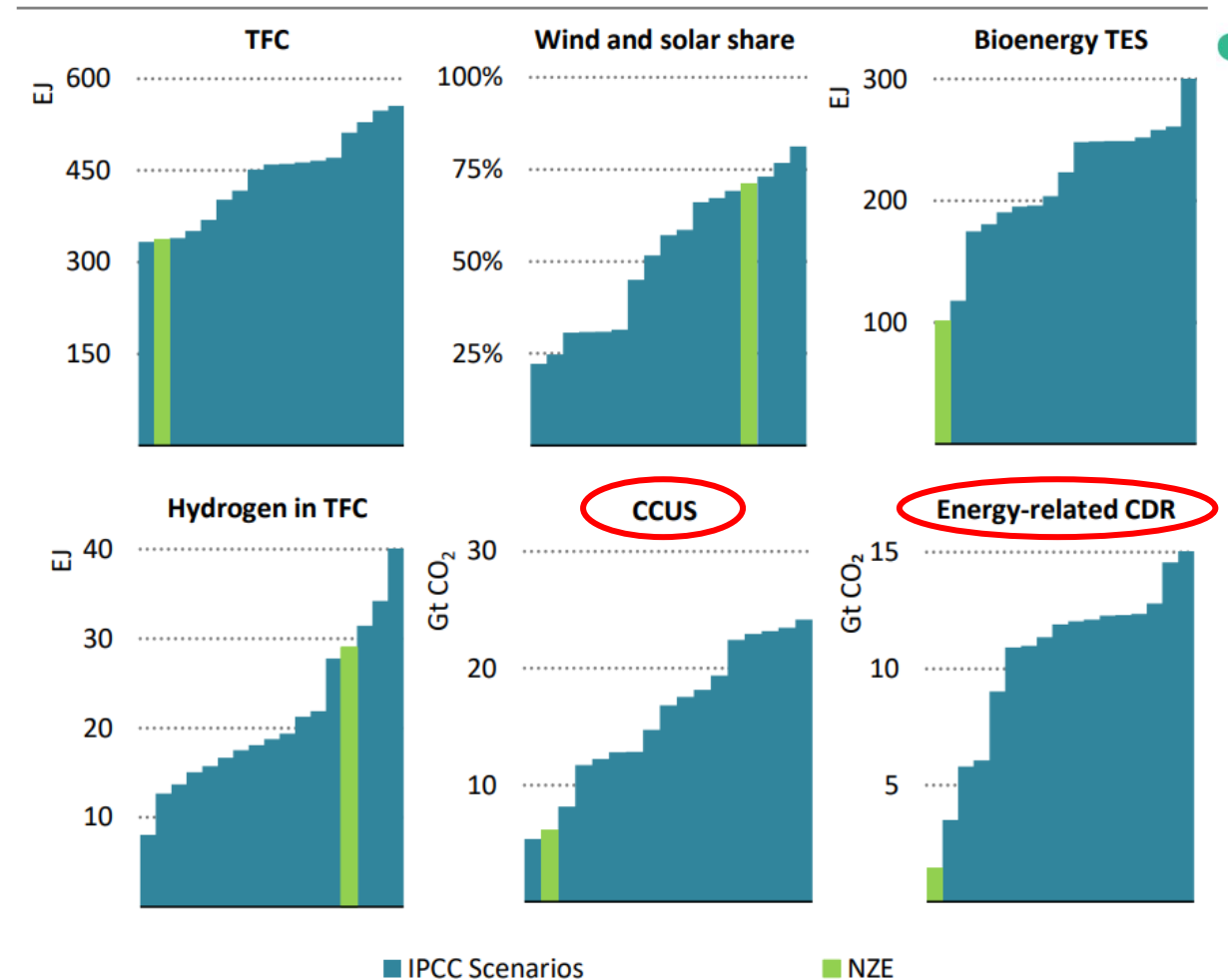
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IEA (2021), Net Zero by 2050, IEA, Paris

# IPCC Scenarios

- CCUS – the scenarios assessed by the IPCC have a median of around 17 Gt CO<sub>2</sub> captured using CCUS in 2050, more than double the level in the NZE.
- CDR (Carbon Direct Removal) – CO<sub>2</sub> emissions captured and stored from BECCS and DACS in the IPCC scenarios have a median of 12 Gt CO<sub>2</sub> captured in 2050, compared to 1.5 Gt CO<sub>2</sub> in NZE.

**Figure 3.6** ▶ Comparison of key indicators for the selected IPCC scenarios and the IEA NZE Scenario in 2050



Notes: IPCC = Intergovernmental Panel on Climate Change. CCUS = carbon capture, utilisation and storage; CDR = carbon direct removal; TES = total energy supply; TFC = total final consumption. Energy-related CDR includes CO<sub>2</sub> captured through bioenergy with CCUS and direct air capture with CCUS and put into permanent storage. Wind and solar share are given as a percentage of total electricity generation. Only 17 of the 18 scenarios assessed by the IPCC report hydrogen use in TFC. BECCS = bioenergy equipped with CCUS; DACS = direct air capture and storage.

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IEA (2022), World Energy Outlook, IEA, Paris

# Importance of CCUS



*“A delay in the development of other CCUS technologies would have a major impact on the prospect of getting to net-zero emissions in 2050. For example, CCUS is the only scalable low-emissions option to remove CO<sub>2</sub> from the atmosphere and to almost eliminate emissions from cement production. If progress in these technologies were delayed and could not be deployed at scale, then achieving net-zero emissions by 2050 would be vastly more difficult.”*

[International Energy Agency \(IEA\), 2021](#)

*“Carbon capture, use and storage (CCUS) technology is an essential step towards mitigating climate change”*

*“Countries need to include CCUS in long-term strategies and commence retrofitting existing infrastructure.”*

*“CCUS allows UNECE member States to establish a pathway to carbon neutrality and stay within their emission targets.”*

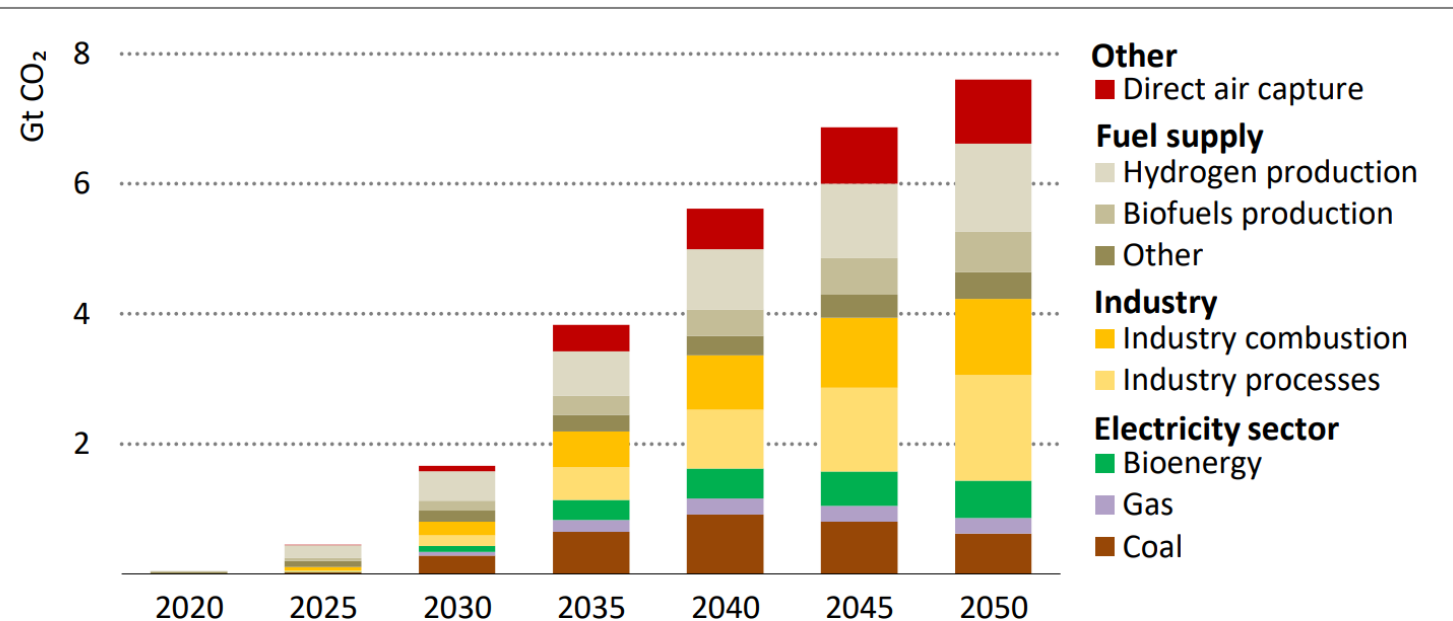
[United Nations Economic Commission for Europe \(UNECE\), 2021](#)



# Growth in CCUS

- Under updated 2022 NZE, by 2030 **1.2 Gt** CO<sub>2</sub> per year is captured globally, rising to **6.2 Gt** CO<sub>2</sub> in 2050 (of which 95% is geologically stored and 5% used for synthetic fuels).
- Negative emission technology (DAC and BECCS) account for **1.5 Gt** CO<sub>2</sub> by 2050.
- In 2022, only **0.045 Gt** CO<sub>2</sub> per year is captured and stored from ~35 commercial CCUS facilities.

**Figure 2.21** ▶ Global CO<sub>2</sub> capture by source in the NZE

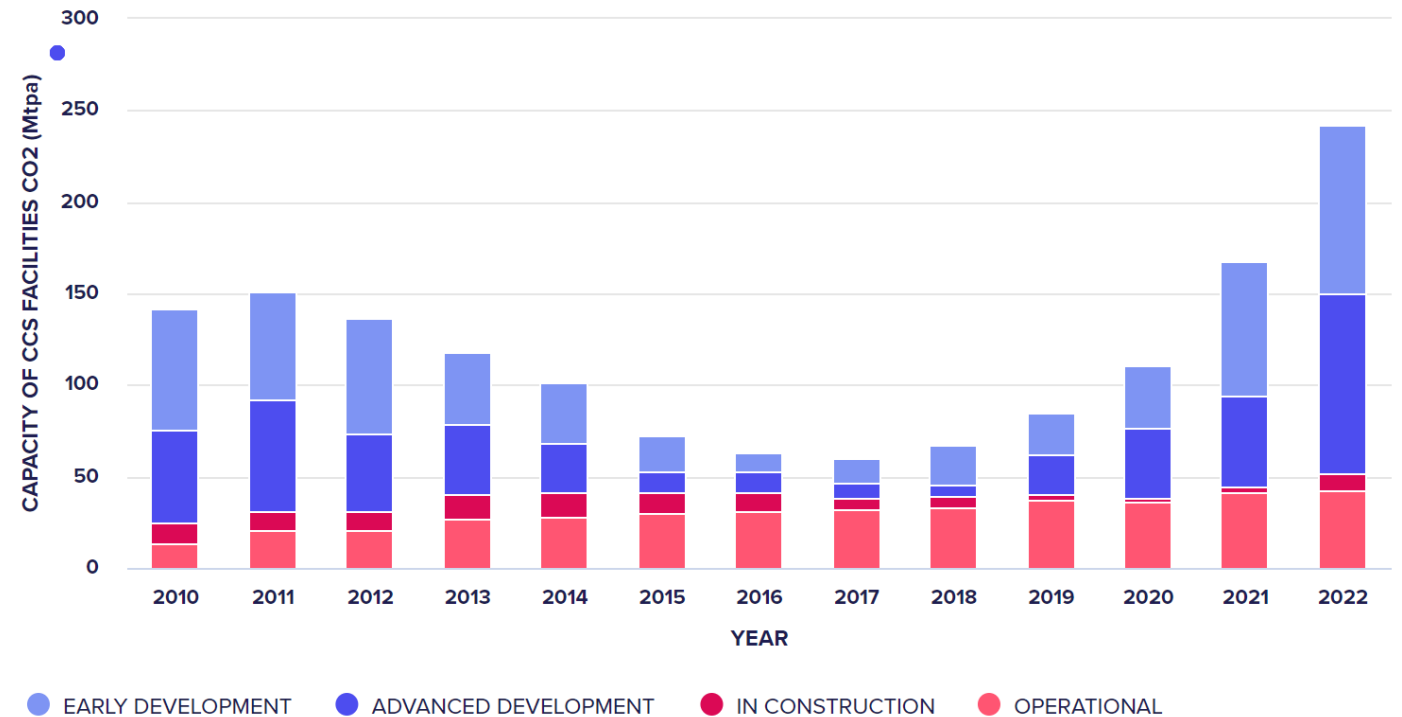


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IEA (2021), Net Zero by 2050, IEA, Paris

# CCUS Facilities Worldwide

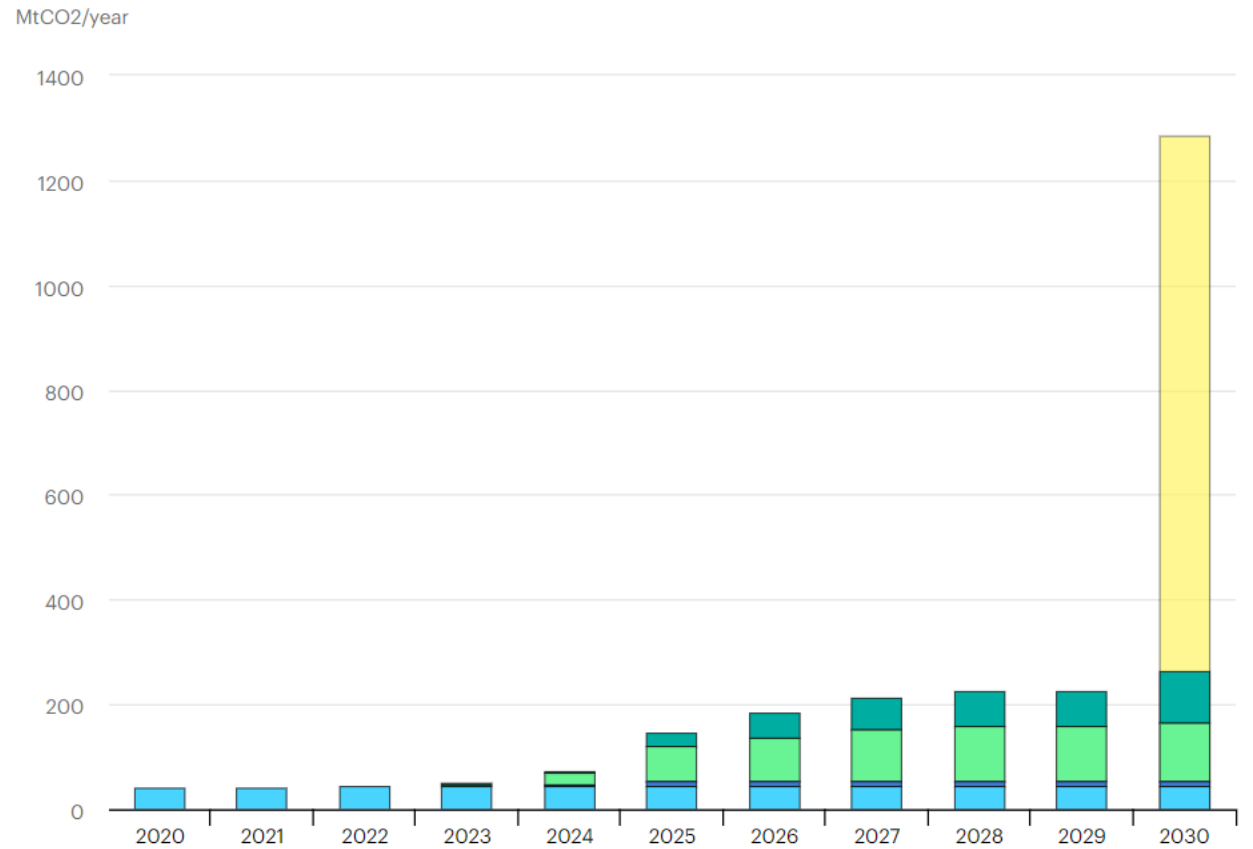
- Approximately 4x increase in capacity of all CCUS facilities in development, under construction and operating since 2017.



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# CCUS Facilities Worldwide

- Approximately 4x increase in capacity of all CCUS facilities in development, under construction and operating since 2017.
- However, need almost 30x increase in current operating capacity under the NZE scenario by 2030.



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● Operating ● Under construction ● Advanced development ● Concept and feasibility ● NZE

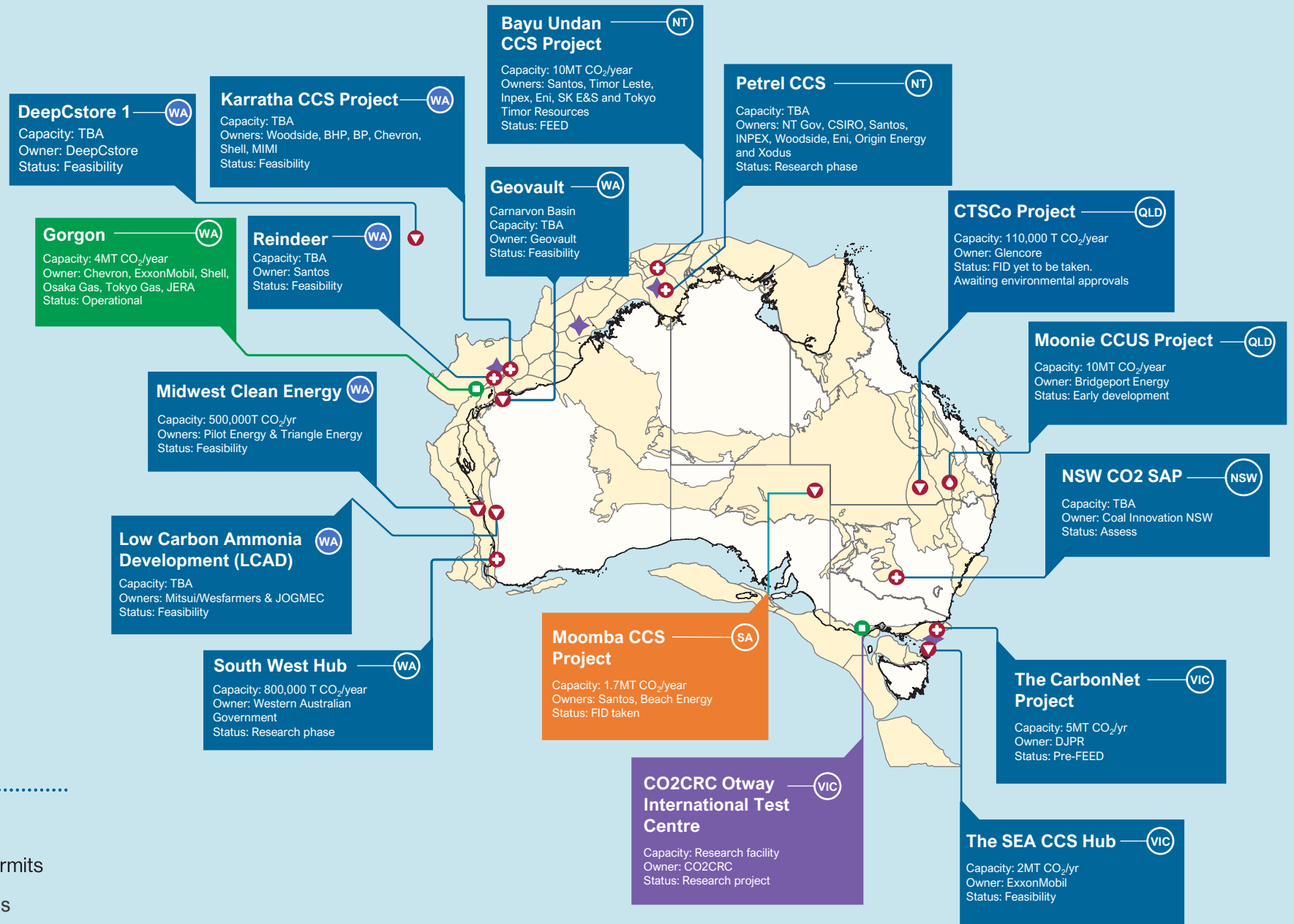
# Australia

## CCUS Projects 2022

- 1 Operational Project
- 1 Under Construction
- 14 Projects in feasibility

### Legend

- Operational
- + Storage hub
- ⬇ CO2-EOR
- ◆ Offshore CCS permits
- ⬇ CCS
- Geological Basins



# CCUS Facilities – Top Operational or in Construction



FACILITY	COUNTRY	FACILITY STATUS	OPERATIONAL DATE	FACILITY INDUSTRY	CAPTURE CAPACITY (Mtpa CO2)	FACILITY TYPE
<b>SHUTE CREEK GAS PROCESSING PLANT</b>	USA	Operational	1986	Natural Gas Processing	7	Enhanced Oil Recovery
<b>PETROBRAS SANTOS BASIN PRE-SALT OIL FIELD CCS</b>	Brazil	Operational	2011	Natural Gas Processing	7	Enhanced Oil Recovery
<b>LOUISIANA CLEAN ENERGY COMPLEX CENTURY PLANT</b>	USA	In Construction	2026	Various	5	Dedicated Geological Storage
<b>GORGON CARBON DIOXIDE INJECTION</b>	Australia	Operational	2019	Natural Gas Processing	4	Dedicated Geological Storage
<b>GREAT PLAINS SYNFUELS PLANT AND WEYBURN-MIDALE</b>	USA	Operational	2000	Synthetic Natural Gas	3	Enhanced Oil Recovery
<b>QATAR LNG CCS</b>	Qatar	Operational	2019	Natural Gas Processing	2.2	Dedicated Geological Storage
<b>SANTOS COOPER BASIN CCS PROJECT</b>	Australia	In Construction	2024	Natural Gas Processing	1.7	Dedicated Geological Storage
<b>ALBERTA CARBON TRUNK LINE (ACTL) WITH NORTH WEST REDWATER PARTNERSHIP'S STURGEON REFINERY CO2 STREAM</b>	Canada	Operational	2020	Oil Refining	1.6	Enhanced Oil Recovery
<b>NORTHERN LIGHTS - STORAGE</b>	Norway	In Construction	2024	Various	1.5	Dedicated Geological Storage
<b>QUEST</b>	Canada	Operational	2015	Hydrogen Production	1.3	Dedicated Geological Storage
<b>NORTH FIELD EAST PROJECT (NFE) CCS</b>	Qatar	In Construction	2025	Natural Gas Processing	1	Under Evaluation
<b>SLEIPNER CO2 STORAGE</b>	Norway	Operational	1996	Natural Gas Processing	1	Dedicated Geological Storage
<b>AIR PRODUCTS STEAM METHANE REFORMER</b>	USA	Operational	2013	Hydrogen Production	1	Enhanced Oil Recovery
<b>BOUNDARY DAM 3 CARBON CAPTURE AND STORAGE FACILITY</b>	Canada	Operational	2014	Power Generation	1	Various
<b>ILLINOIS INDUSTRIAL CARBON CAPTURE AND STORAGE</b>	USA	Operational	2017	Ethanol Production	1	Dedicated Geological Storage
<b>SINOPEC QILU-SHENGLI CCUS</b>	China	Operational	2022	Chemical Production	1	Enhanced Oil Recovery
<b>COFFEYVILLE GASIFICATION PLANT</b>	USA	Operational	2013	Fertiliser Production	0.9	Enhanced Oil Recovery
<b>UTHMANIYAH CO2-EOR DEMONSTRATION</b>	Saudi Arabia	Operational	2015	Natural Gas Processing	0.8	Enhanced Oil Recovery
<b>ABU DHABI CCS (PHASE 1 BEING EMIRATES STEEL INDUSTRIES)</b>	United Arab Emirates	Operational	2016	Iron and Steel Production	0.8	Enhanced Oil Recovery
<b>SNOHVIT CO2 STORAGE</b>	Norway	Operational	2008	Natural Gas Processing	0.7	Dedicated Geological Storage

# Gorgon Carbon Capture and Storage

- 7 million tonnes injected since start-up in August 2019 to October 2022.
- Injection capacity of 4 Mtpa from the Gorgon LNG plant.
- Predicted lifespan of more than 40 years.

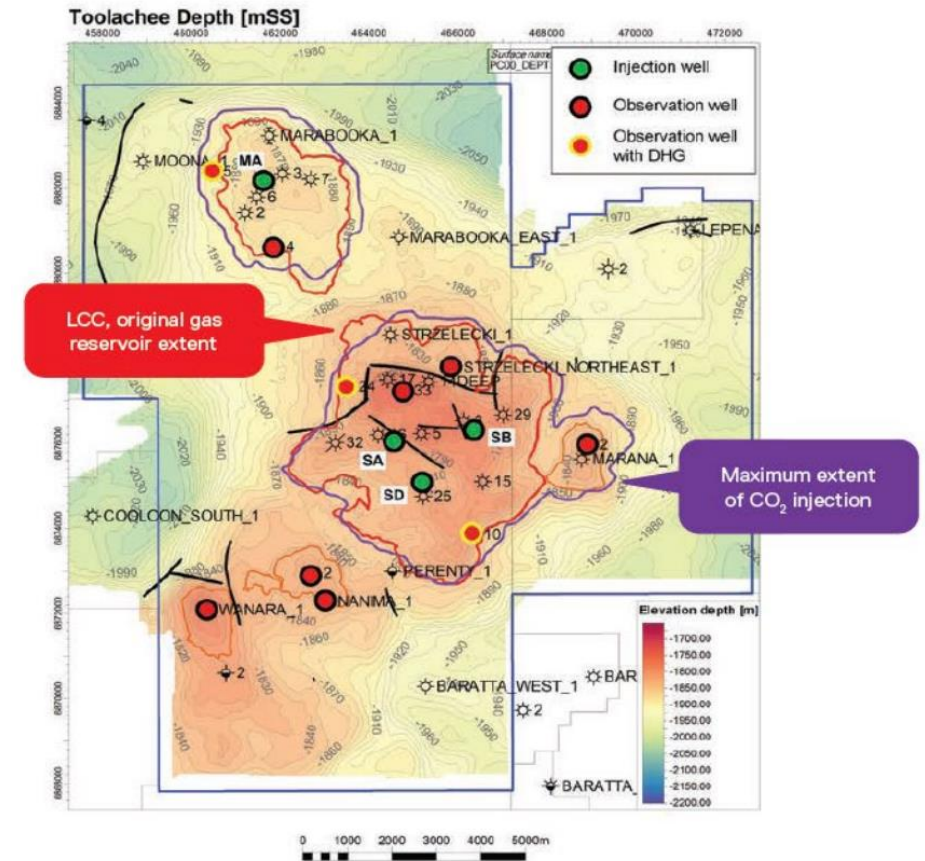
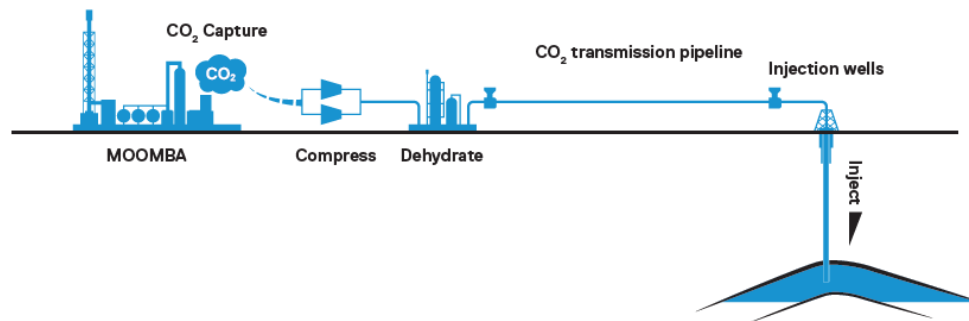
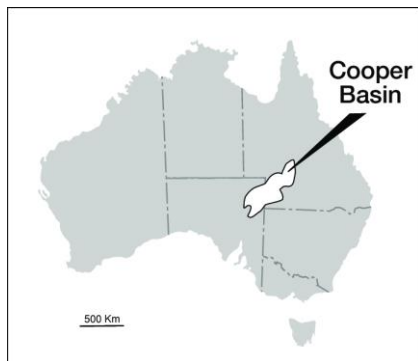
- Injection into the Dupuy saline aquifer 2.5km below Barrow Island.
- Pressure management via water production and injection into overlying Barrow Group formation.



Source: Chevron Australia Pty Ltd.

# Moomba Carbon Capture and Storage

- First phase operational in 2024 with injection rate of 1.7 Mtpa from processing plant into depleted fields.
- 1.7 Mtpa represents approximately **7% of South Australia's total emissions**.
- Future phases target injection of 20 Mtpa from other industrial sources.
- Direct air capture trials planned at Moomba.
- Potential for low-carbon hydrogen production.

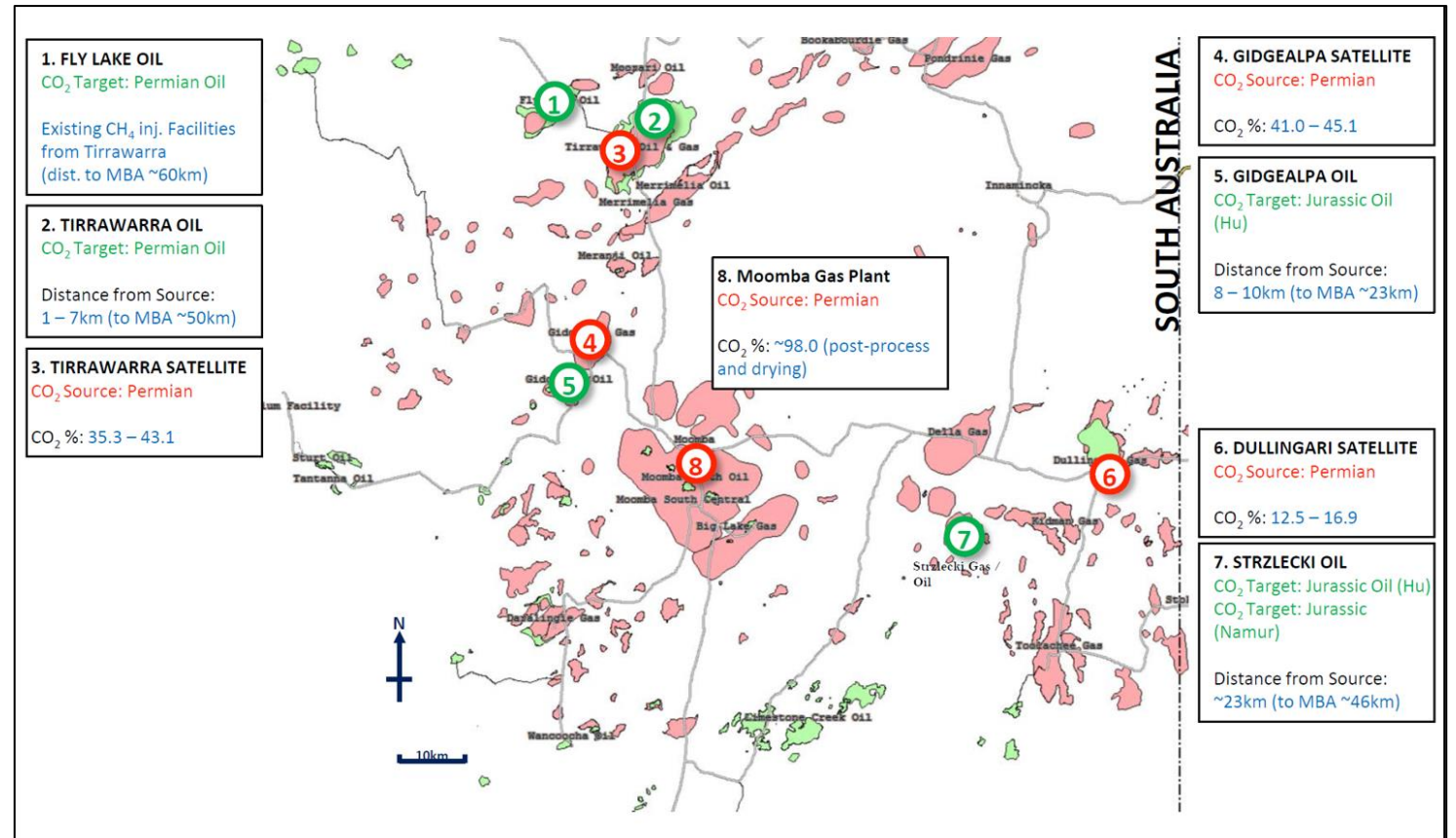


Source: Santos Ltd.

# Cooper Basin CO<sub>2</sub> EOR Potential



- Cooper and Eromanga basins well suited to CO<sub>2</sub> EOR.
  - Deep reservoirs and light oil.
- Co-located with high CO<sub>2</sub> gas fields.
- [Report published](#) on department website analysing oil miscibility with CO<sub>2</sub>.

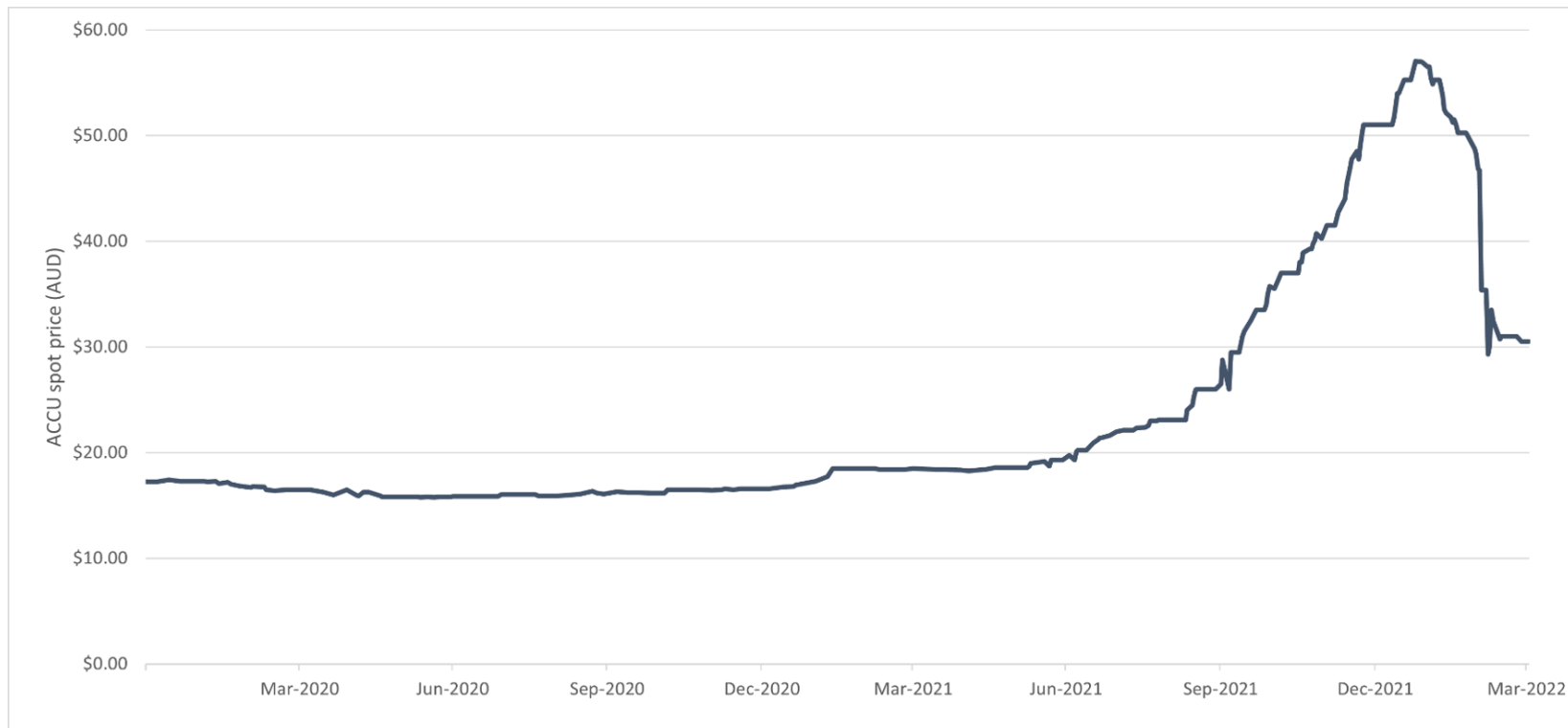


Source: Santos Ltd.



# Australian Policies

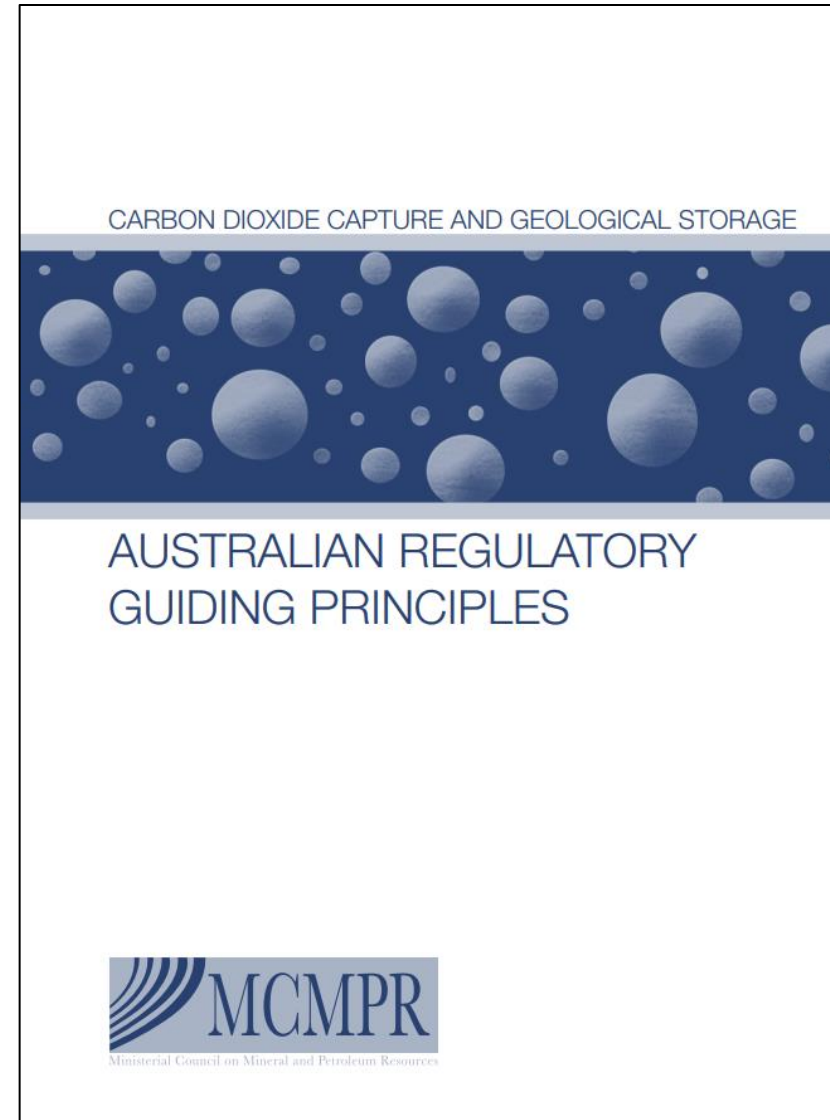
- CCS eligible for Australian Carbon Credit Units (ACCUs) from 1 October 2021.



Clean Energy Regulator (2022), Australian Government

# Australian Legislation

- The Australian Government developed regulatory guiding principles for CCS in 2005.
- In 2022, jurisdictions including South Australia, Queensland, Victoria and offshore Commonwealth waters have legislation in place to licence and regulate CCUS, with other states and territories currently developing legislation.



# Regulatory Framework

- Underground resources in Australia belong to the Crown.
- Objective/risk based regulatory framework.
  1. Licensing
  2. Environmental assessment (including consultation)
  3. Activity assessment and approval
- Adopt relevant international and national standards.



## ISO/TC 265 standards portfolio

### Carbon capture

**ISO/TR 27912** CO<sub>2</sub> capture systems, technologies and processes

**ISO 27919-1** Performance evaluation methods for post-combustion CO<sub>2</sub> capture integrated with a power plant

**ISO 27919-2** Evaluation procedure to assure and maintain stable performance of post-combustion CO<sub>2</sub> capture plant integrated with a power plant

**ISO/TR 27922** Overview of CO<sub>2</sub> capture technologies in the cement industry

**ISO XXXX** Performance evaluation of CO<sub>2</sub> capture connected with a CO<sub>2</sub> intensive plant

**ISO XXXX** Performance index and standard test method of absorption solvent performance for CO<sub>2</sub> capture

### Transportation

**ISO 27913** Pipeline transportation systems [proposed for revision]

**ISO/TR XXXX** CO<sub>2</sub> shipping and trans-shipping

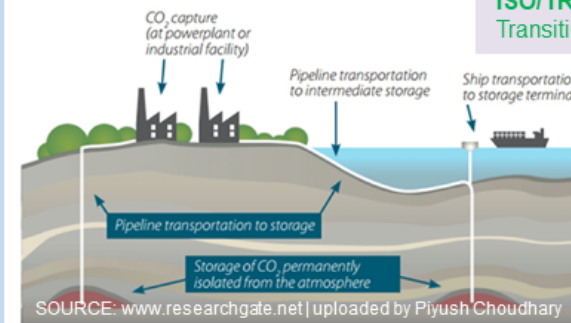
### Underground storage

**ISO 27914** Geological storage [proposed for revision to include quantification and verification]

**ISO 27916** CO<sub>2</sub> storage using enhanced oil recovery (CO<sub>2</sub>-EOR)

**ISO/TR 27923** Geologic storage of CO<sub>2</sub> injection operations and infrastructure

**ISO/TR 27926** CO<sub>2</sub>-EOR - Transitioning from EOR to storage



**Key**  
 Black: Published document  
 Green: Document under preparation  
 Grey: New proposed project  
 Red: Project cancelled

Status: June 2021

### Overarching aspects

**ISO 27917** Vocabulary — Cross cutting terms

**ISO/TR 27925** Flow assurance

**ISO/TR 27918** Lifecycle risk management for integrated CCS projects

**ISO/TS 27924** Risk management for integrated CCS projects

**ISO/TR 27915** Quantification and verification

**ISO 27920** Quantification and verification

**ISO/TR 27921** CO<sub>2</sub> stream composition

# Monitoring and Verification



Santos


South Australia - Moomba



Statement of Environmental Objectives:  
Carbon Storage

March 2021

South Australia - Moomba



Environmental Impact Report:  
Carbon Storage

March 2021

- Demonstration of long term containment via a monitoring and verification plan that is project specific.
- Developed in accordance with recognised standards.
- Required for:
  - Ongoing compliance.
  - Closure and licence relinquishment.
  - Federal Australian Carbon Credit Units (ACCUs).

<https://www.energymining.sa.gov.au/industry/energy-resources/regulation/projects-of-public-interest/cooper-basin-carbon-storage>

WORKING DRAFT - VER\_1.02 AS TS 5373:2022

Designation: SA TS 5373  
Committee: EE-002, Carbon dioxide capture, transportation and geological storage

**Carbon dioxide capture, transportation  
and geological storage (CCS):  
quantification and verification of emission reductions**

Stage: Committee Draft

# Conclusions

- Australia requires more rapid emission reductions to meet net-zero by 2050.
- CCUS will play an important role among a range of technologies that must work together to meet 2°C scenarios.
- CCUS requires a step-change in growth to meet capacity required by IEA and IPCC net-zero scenarios.
- Australia contains the largest dedicated carbon storage project in the world (Gorgon) and by 2024 will also have the 3<sup>rd</sup> largest (Moomba).
- Australia will continue to enable CCUS through policy and leading practice regulation.

# Contacts

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Thank you



Enhanced Oil Recovery

Technology  
Collaboration  
Programme  
by IEA

# ITHANKS!

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Enhanced Oil Recovery

Technology  
Collaboration  
Programme  
by IEA

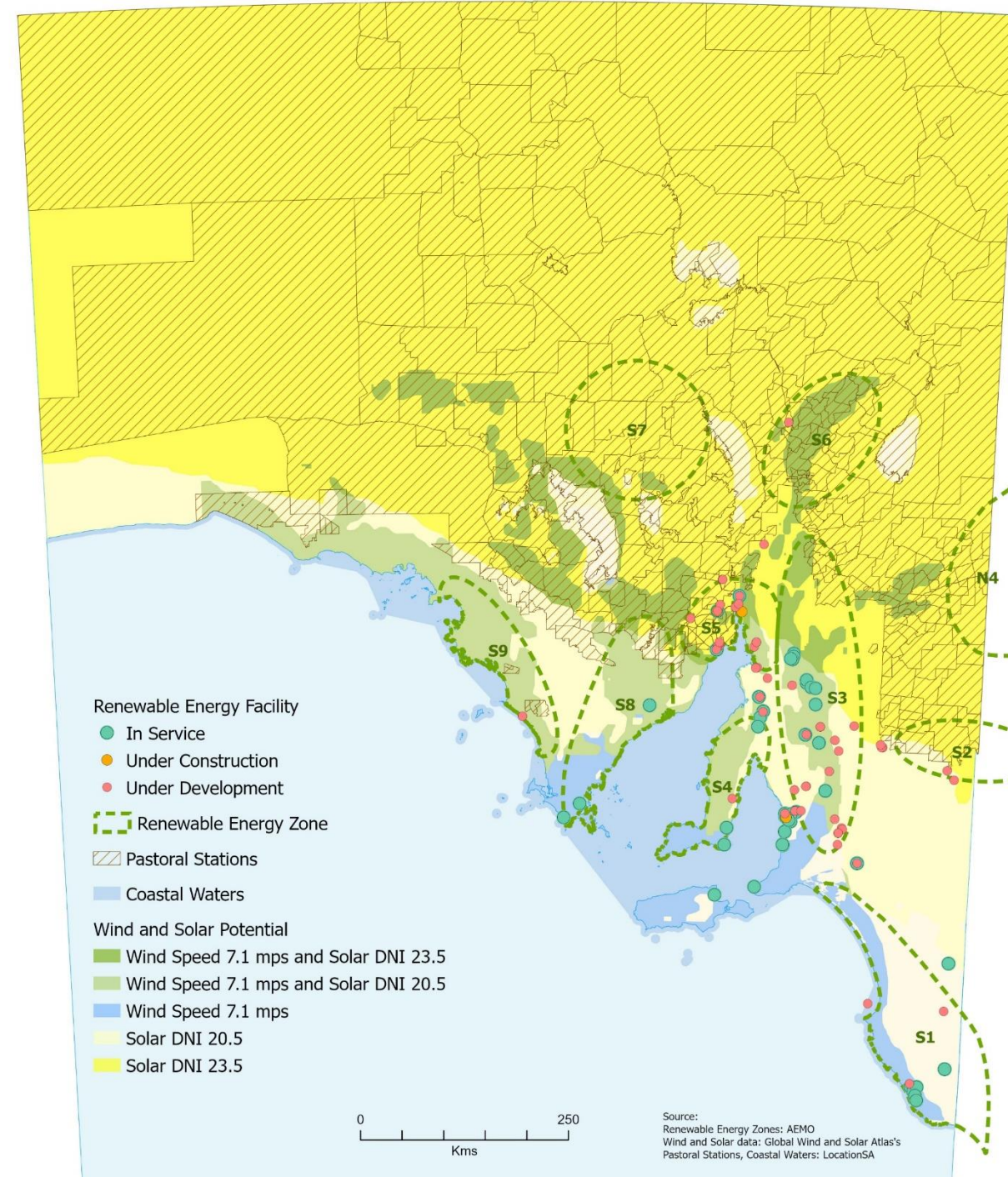
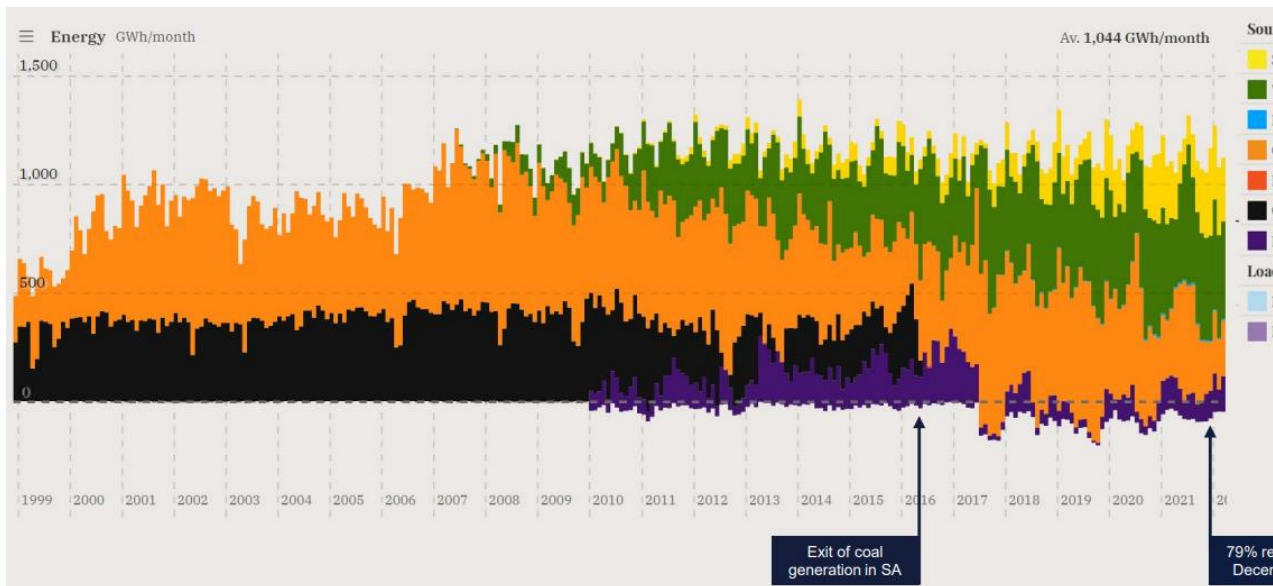


# Backup Slides



# Renewable energy in SA

- 68% electricity from renewable energy
- 22 wind farms, 3 solar farms
- World's highest rooftop uptake per capita
- 4 grid scale batteries
- Australia's largest hydrogen electrolyser

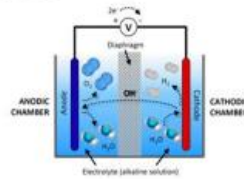


# Hydrogen in SA

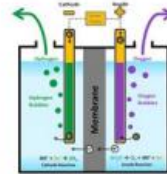
- **South Australian Government's hydrogen power plant commitment:**
  - \$593 million in capital funding
  - 250 MWe electrolyser
  - 200 MW hydrogen fuelled power plant
  - Hydrogen storage facility
  - Operational by Dec 2025
- [Hydrogen and Renewable Energy Generation Act](#) in development.

Hydrogen electrolyser  
250MWe

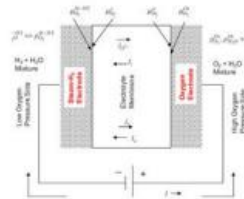
Alkaline:



PEM:



Solid Oxide:



Hydrogen gas storage

Line-packed pipeline:



Gaseous H2 sphere:



Liquified H2 sphere:



Hydrogen power plant  
200MW

Gas turbine:



Fuel Cell:



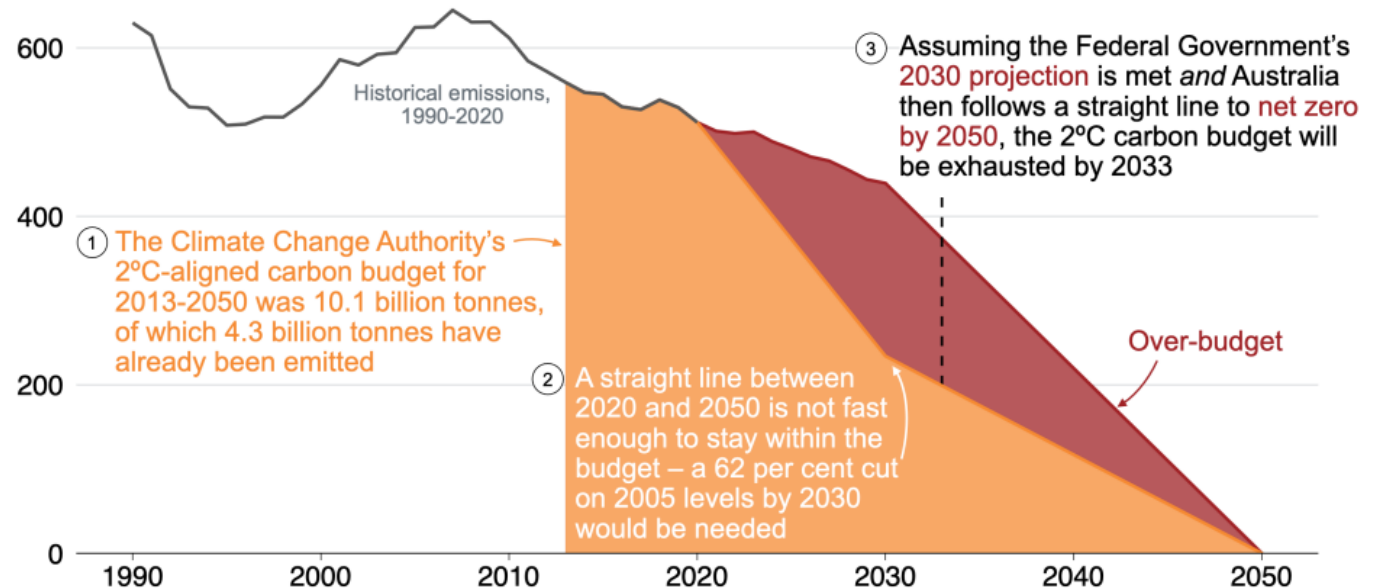
# Australian Emissions Targets

- On 8 September 2022 the Australian Government [legislated](#) emissions reduction targets:
  - 43% below 2005 levels by 2030
  - Net-zero by 2050
- 2°C scenario requires a rapid reduction in emissions.

To stay within a 2°C-aligned carbon budget, Australia would need to cut emissions by 62 per cent by 2030 compared to 2005 levels

GRATTAN  
Institute

Australia's annual emissions (millions of tonnes)

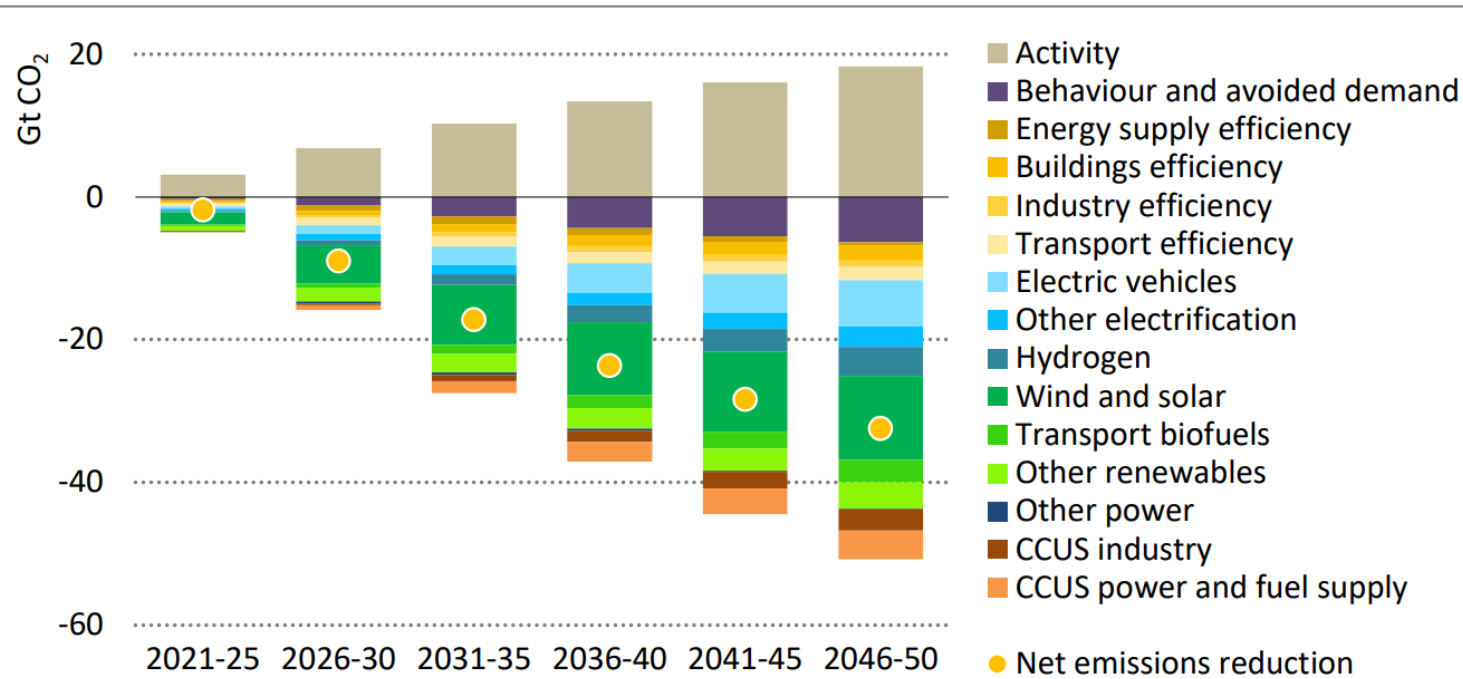


Source: Grattan analysis of Australia's emissions projections 2021 (DISER, 2021) and Targets and Progress Review Final Report (Climate Change Authority, 2014).

# Global Emissions Reductions



**Figure 2.4** ▶ Average annual CO<sub>2</sub> reductions from 2020 in the NZE



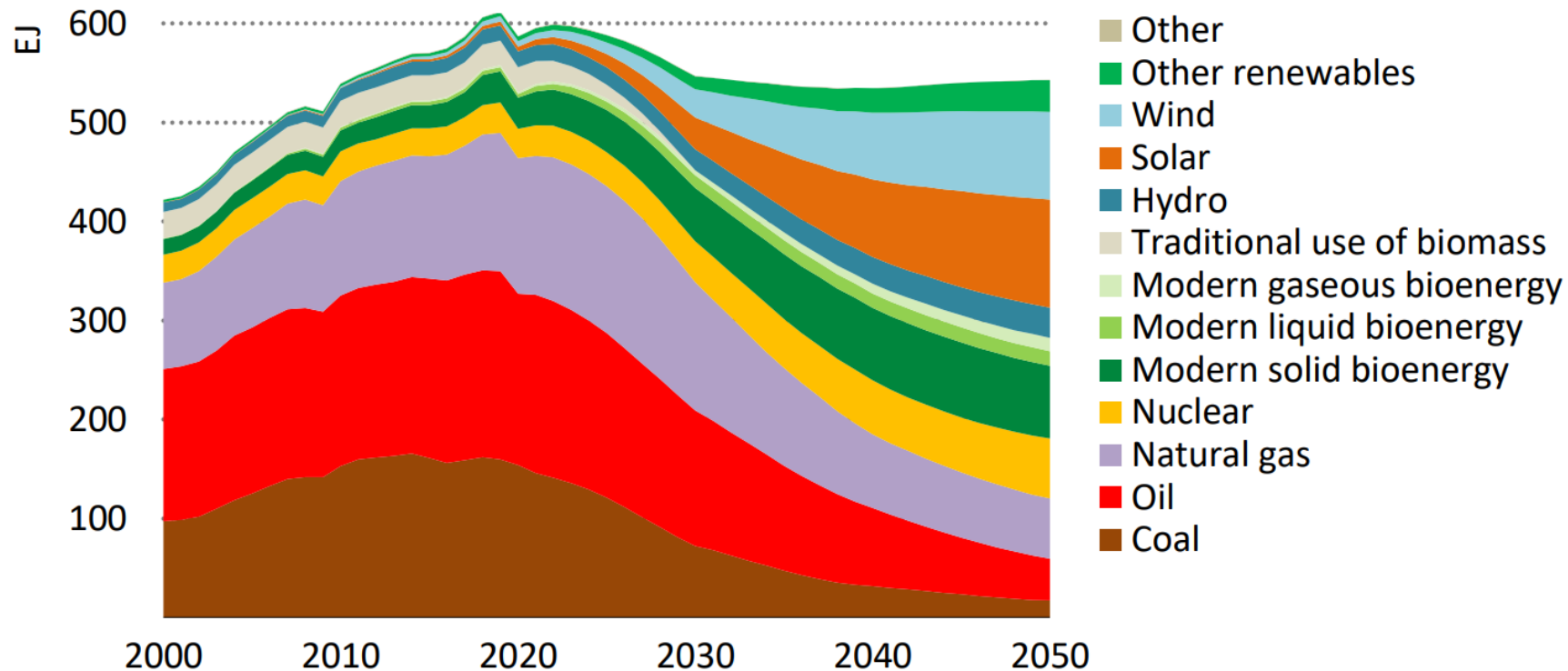
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IEA (2021), Net Zero by 2050, IEA, Paris

# Global Energy Supply



**Figure 2.5** ▶ Total energy supply in the NZE

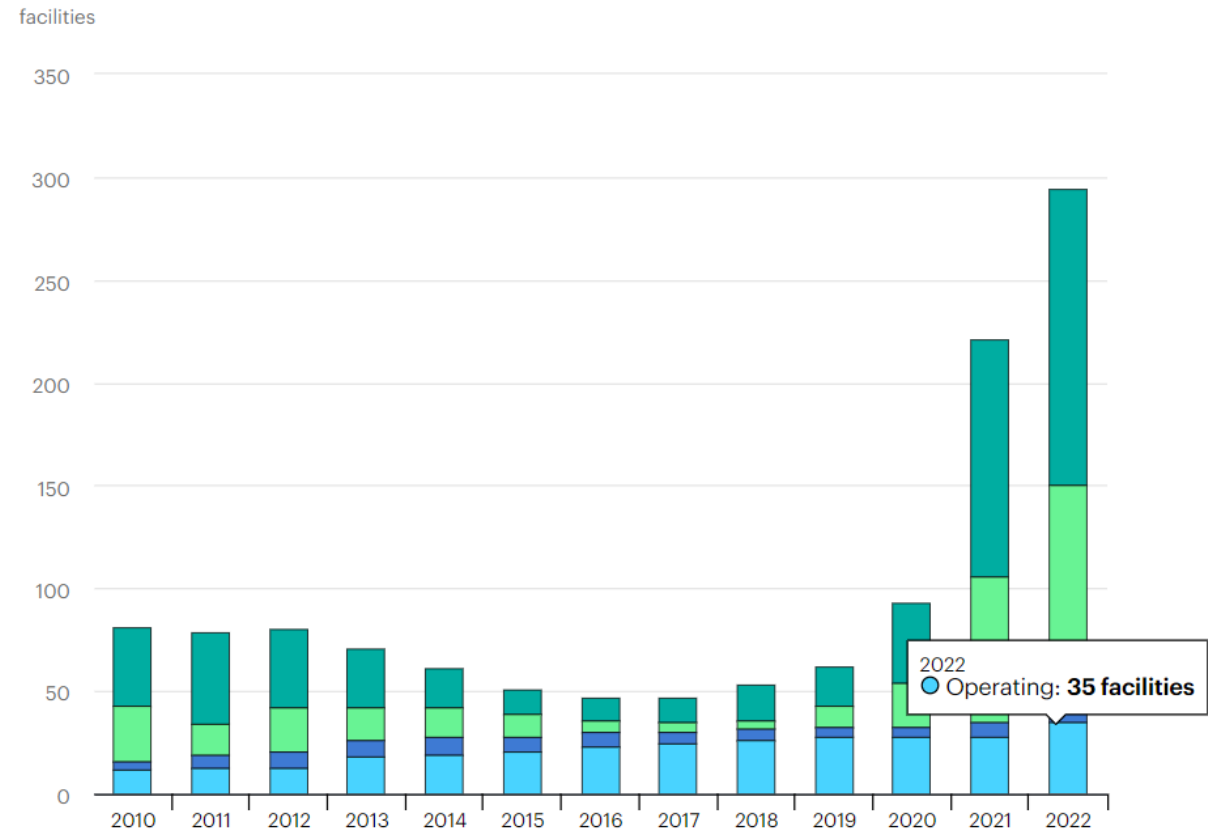


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IEA (2021), Net Zero by 2050, IEA, Paris

# CCUS facilities worldwide

- Approximately 6x increase of proposed, under construction and operating CCUS facilities since 2017.



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● Operating ● Under construction ● Advanced development ● Concept and feasibility

# Australian Policies

- [Australian Carbon Credit Units](#) (ACCUs) for CCS from 1 October 2021.
- IEA Referenced Australian Policies:
  1. [Carbon Capture, Use and Storage Development Fund](#)
  2. [Clean hydrogen and carbon capture investment](#) – discontinued
  3. [Federal government / South Australian Energy and Emissions Reduction Deal](#)