Building a low emissions future

CCS in challenging energy realities

Australia's CCS Landscape

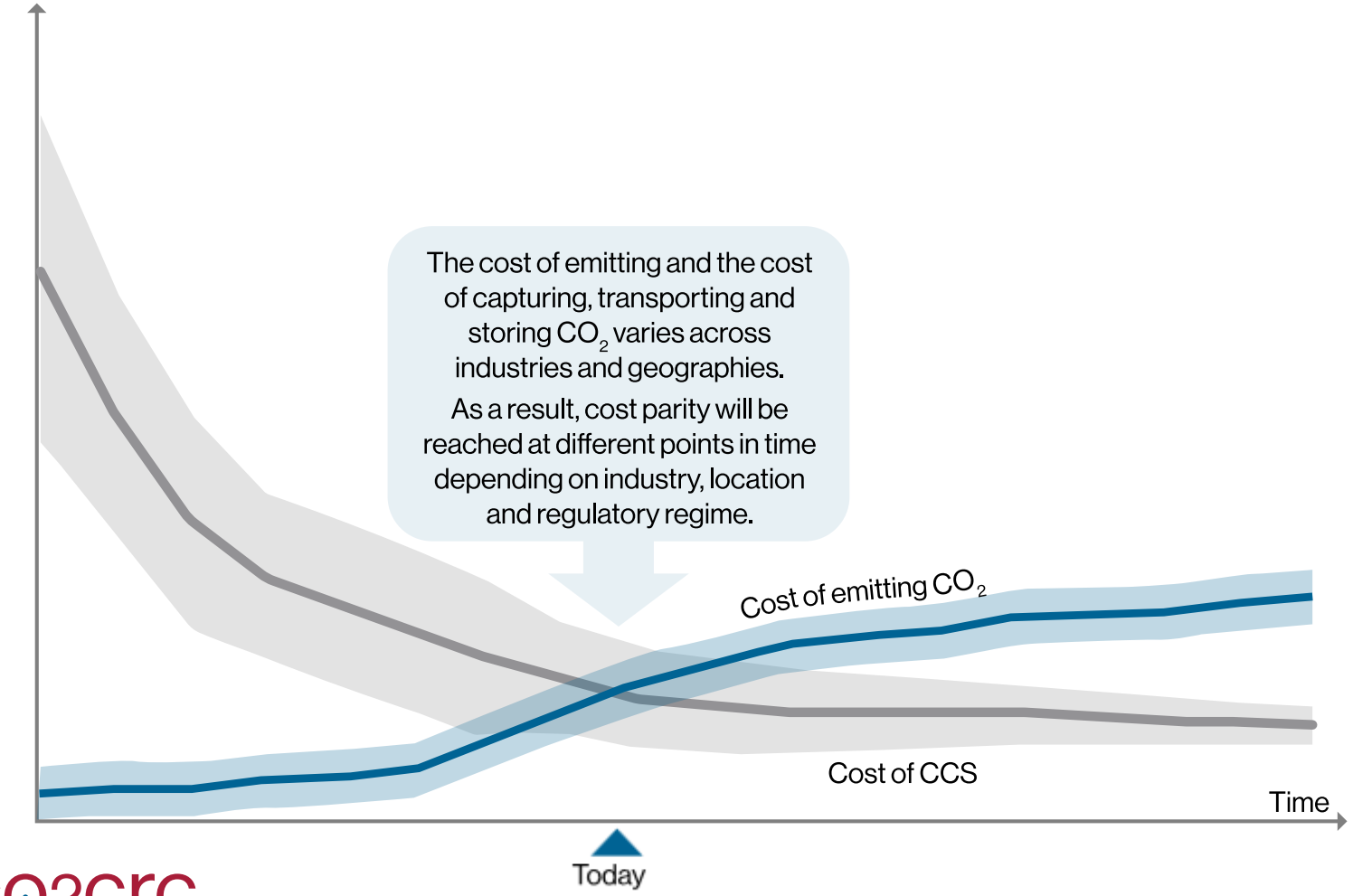
Dr Matthias Raab

Chief Executive Officer

Australian Domestic Gas Outlook 2026
Sydney, Australia
2 April 2026

Recognising economic value of CCS

Cost of emitting CO_2 vs cost of CCS



Cost of emitting

- CO_2 tax, quotas or both
- Regulations and targets
- Indirect costs/ "License to operate"

Cost of CCS

- Cost of capturing
- Cost of transportation
- Cost of storing

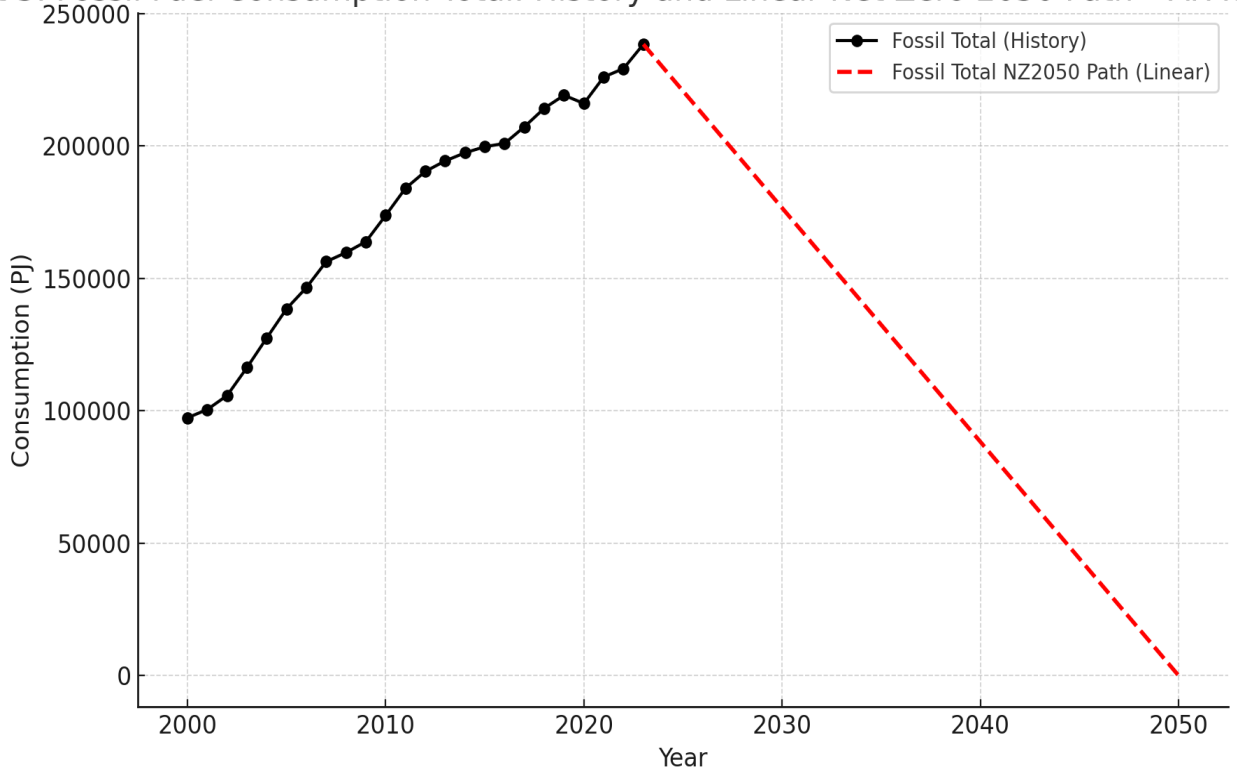
Modified after Rystad Energy and analysis

CO2CRC
Building a low emissions future

APAC ex-Australia

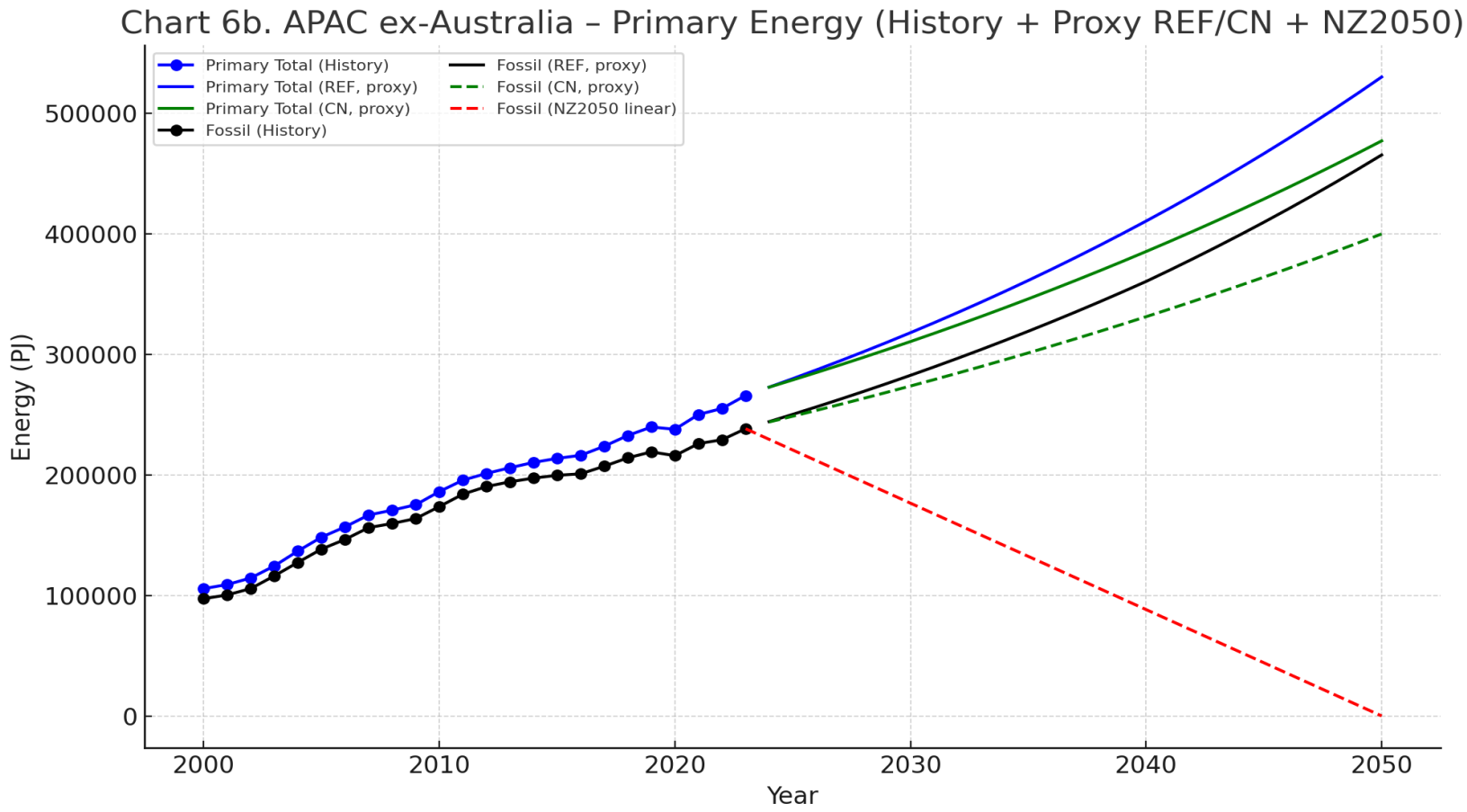
Fossil Fuel Consumption : History and Linear Net Zero 2050 Path – APAC ex-Australia

Chart 5. Fossil Fuel Consumption Total: History and Linear Net Zero 2050 Path – APAC ex-Australia



Source: Energy Institute Statistical Review of World Energy 2024

APAC ex-Australia – Primary Energy (History + Proxy REF/CN + NZ2050)



Building a low emissions future

Production Gap Report 2023

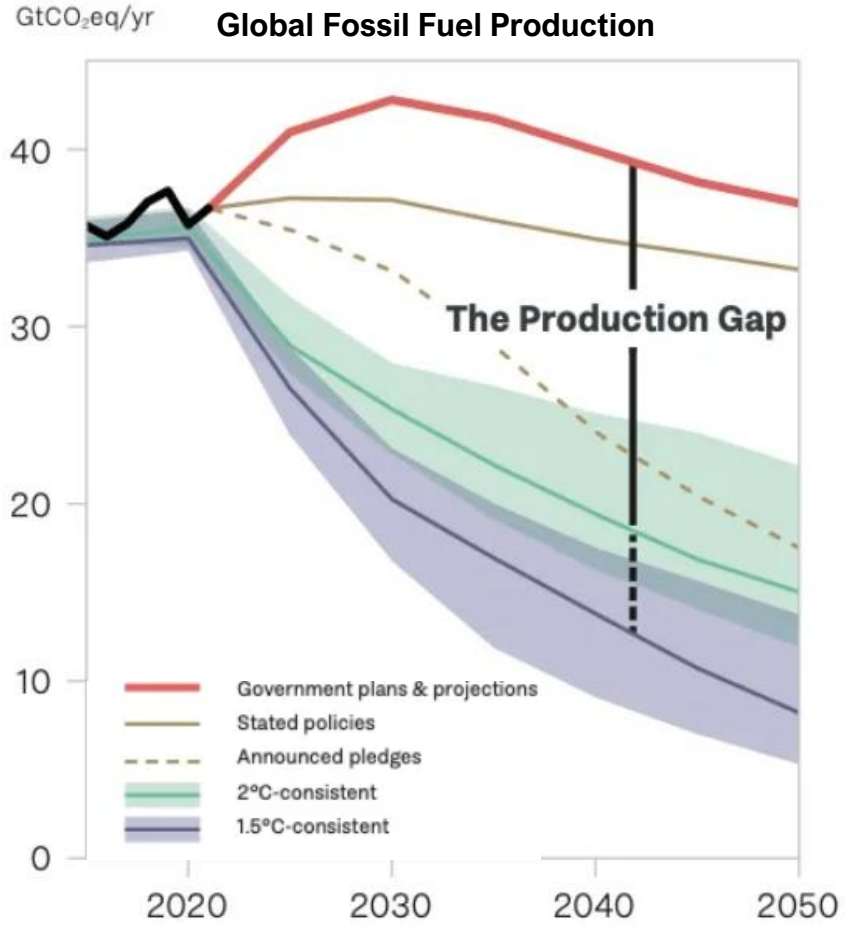


Figure source: Production Gap Report, 2023

The Production Gap is the misalignment between planned and projected production of fossil fuels and the global production paths consistent with warming of 1.5°C.

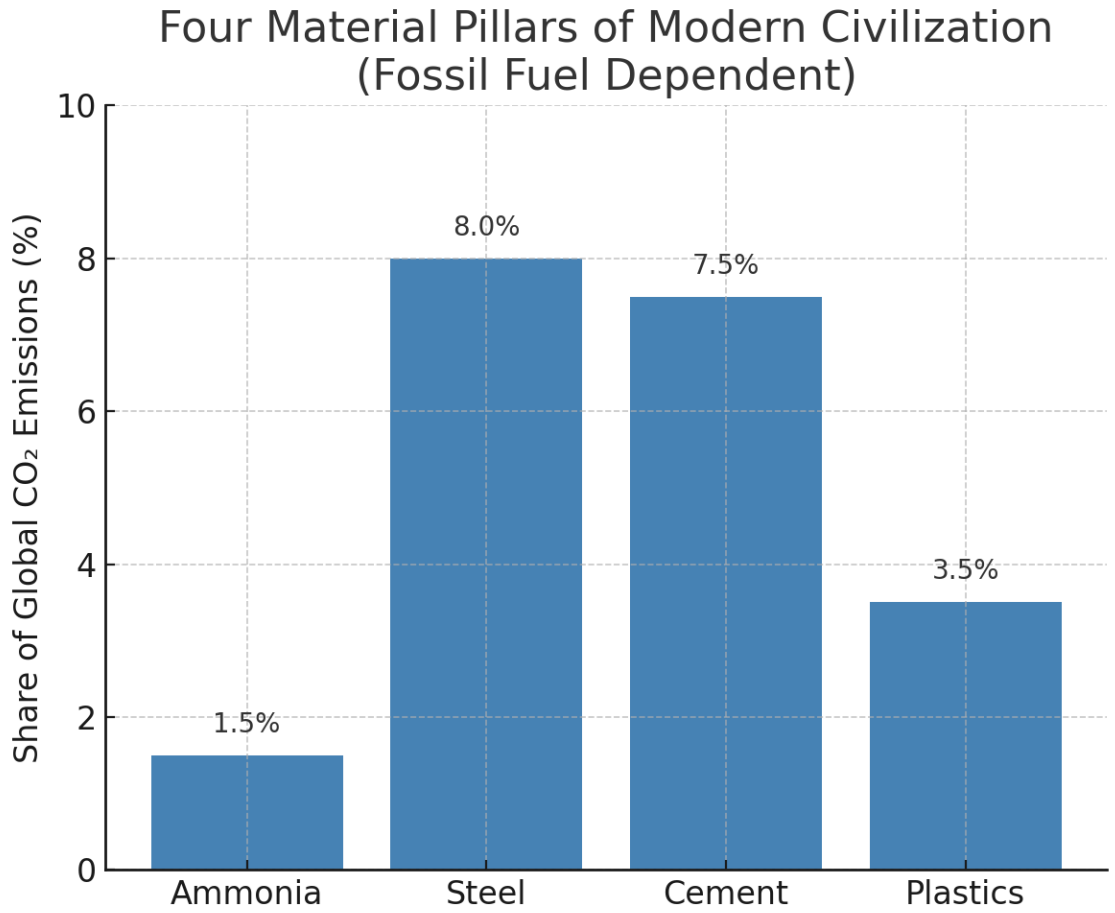
Forecasted production is more than double the amount of fossil fuels in 2030 than what would be consistent with limiting global warming to 1.5°C

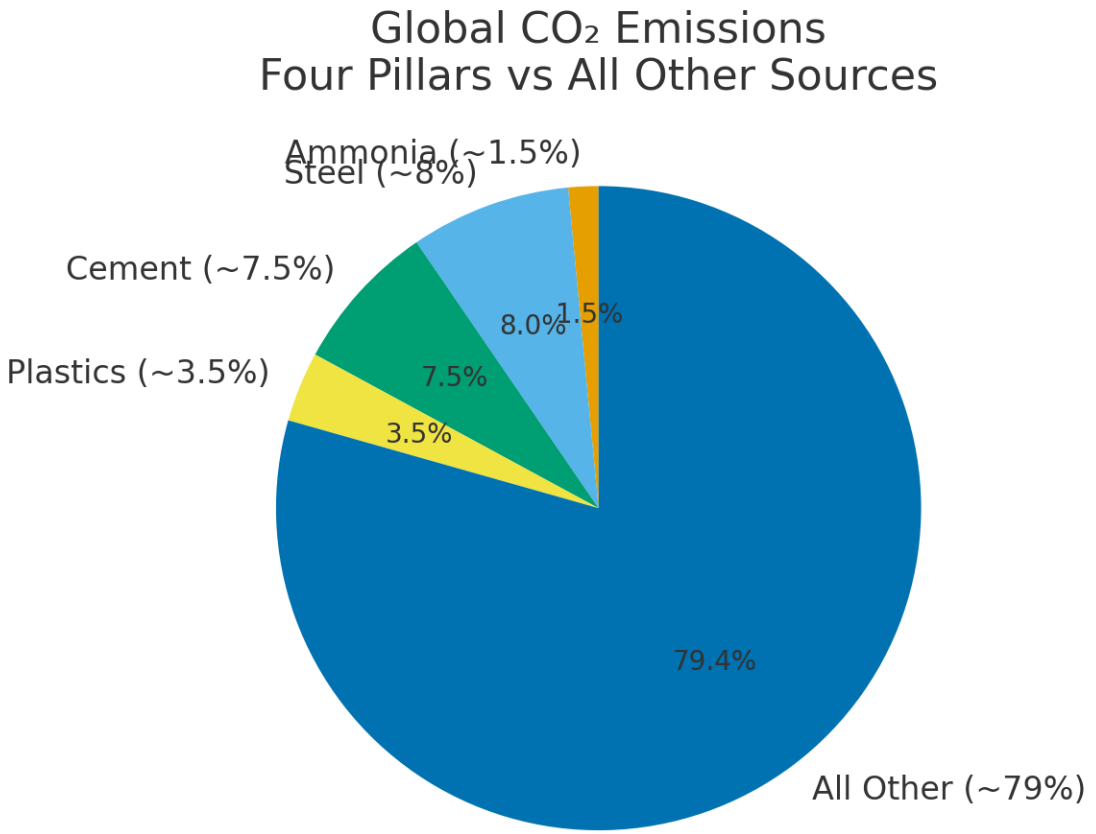
SEI, *Production Gap Report 2023*

CO2CRC
Building a low emissions future

SEI Stockholm Environment Institute · CLIMATE ANALYTICS · E3G · IISD · UN environment programme

The four material pillars in our global society





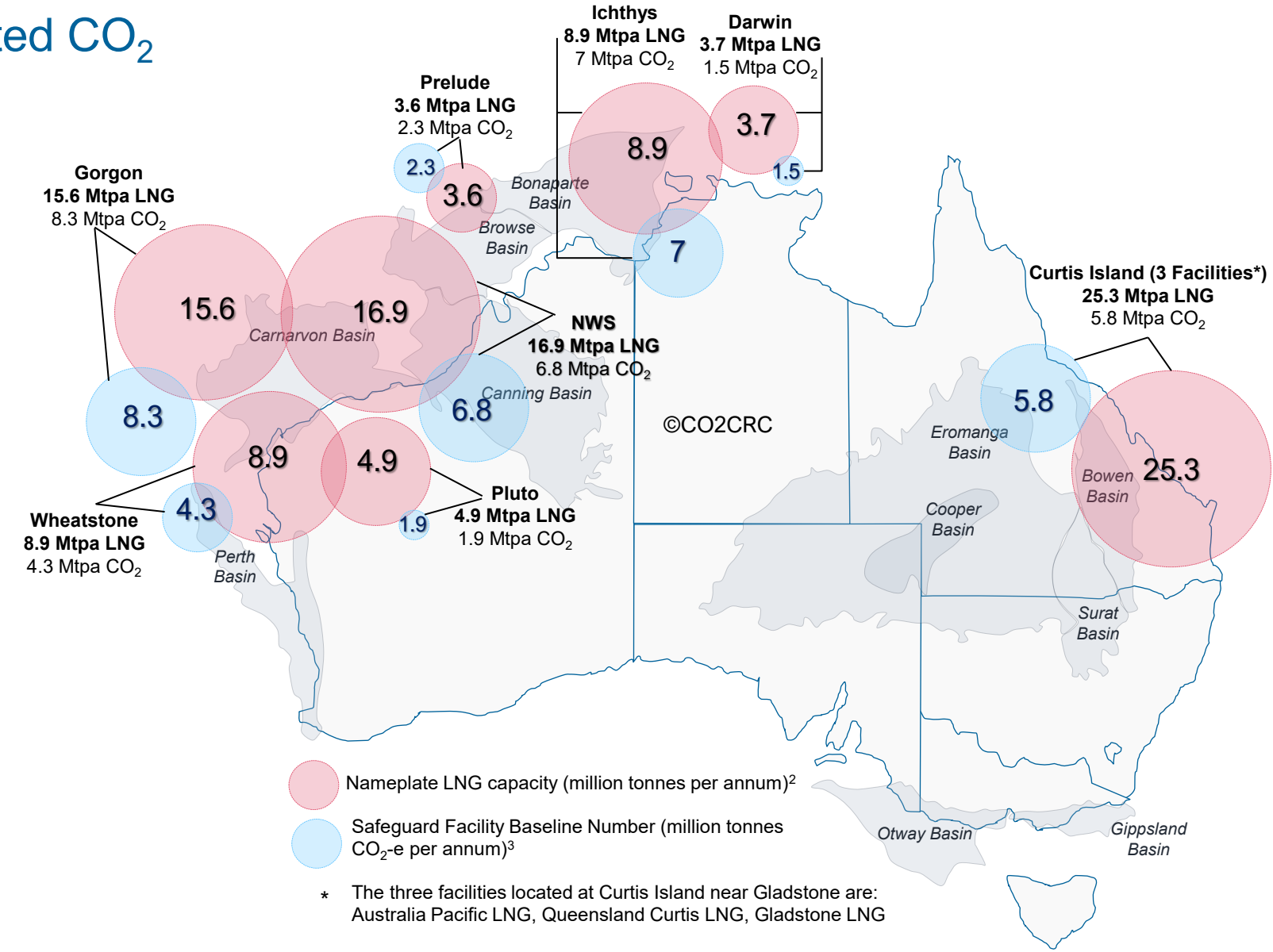
Building a low emissions future

What Makes Australia Unique Regarding Emissions?

- How does it compare with other advanced jurisdictions?
- Implications
- A unique opportunity – the size of the (short-term) Australian CCS prize

Major LNG projects and associated CO_2 Emissions

- In Australia, natural gas processing facilities are a significant source of CO_2 emissions
- Natural gas processing and LNG facilities across Australia contributed ~ 40Mtpa[1] CO_2-e of scope 1 reported covered emissions in the 2022-23 safeguard reporting period
- CCS is the key technology for these facilities to decarbonise and ensure they are compliant with the Safeguard Mechanism

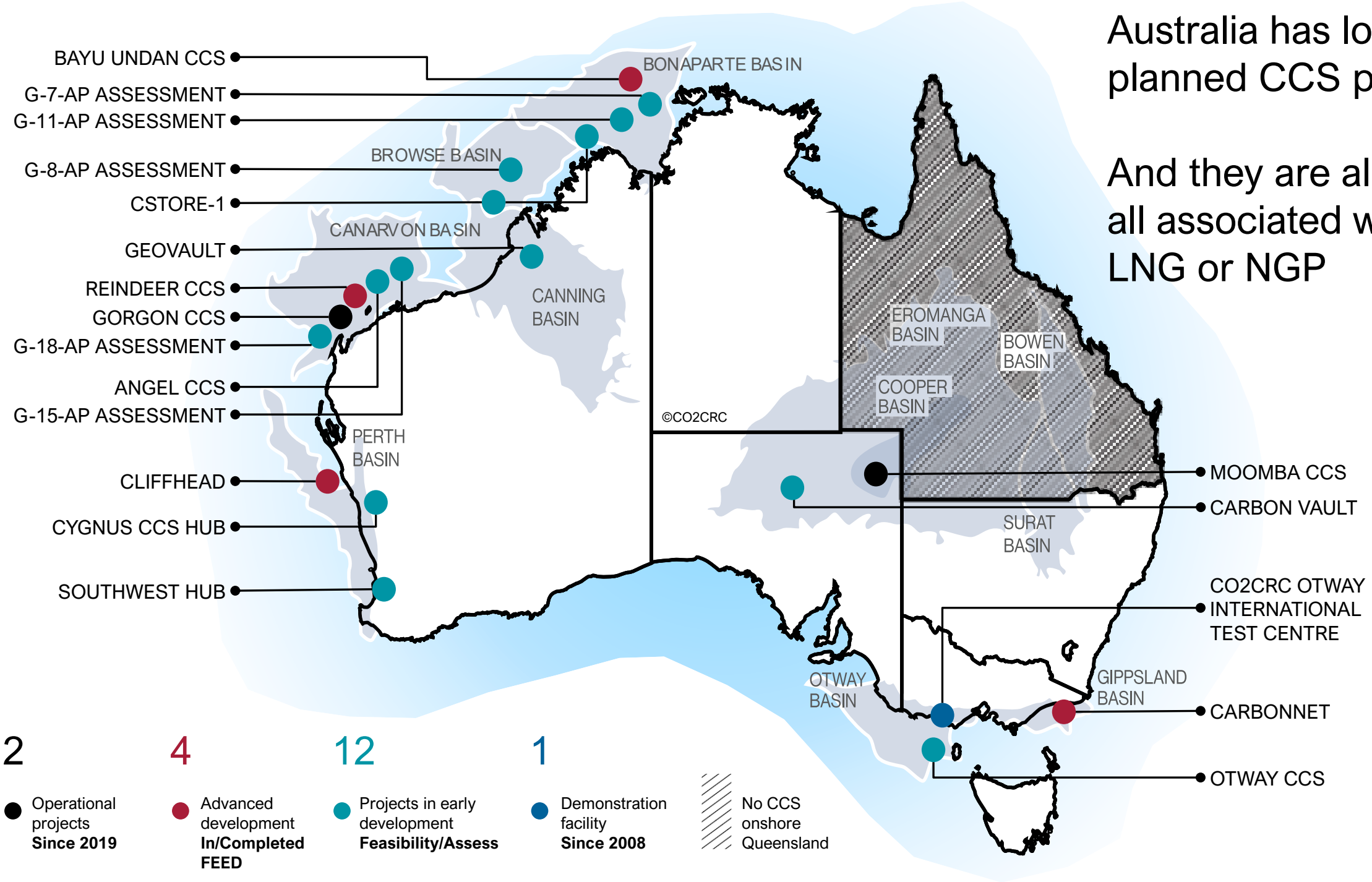


CO2CRC
Building a low emissions future

[1] 40Mtpa includes natural gas processing facilities that do not export LNG
[2] **Source:** *Global Resources Strategy Commodity Report: Liquefied Natural Gas* accessed from: https://www.industry.gov.au/sites/default/files/2022-09/grs-commodity-report-lng.pdf
[3] **Source:** *Safeguard facility reported emissions data*. accessed from: https://cer.gov.au/markets/reports-and-data/safeguard-facility-reported-emissions-data

Australia has lots of planned CCS projects

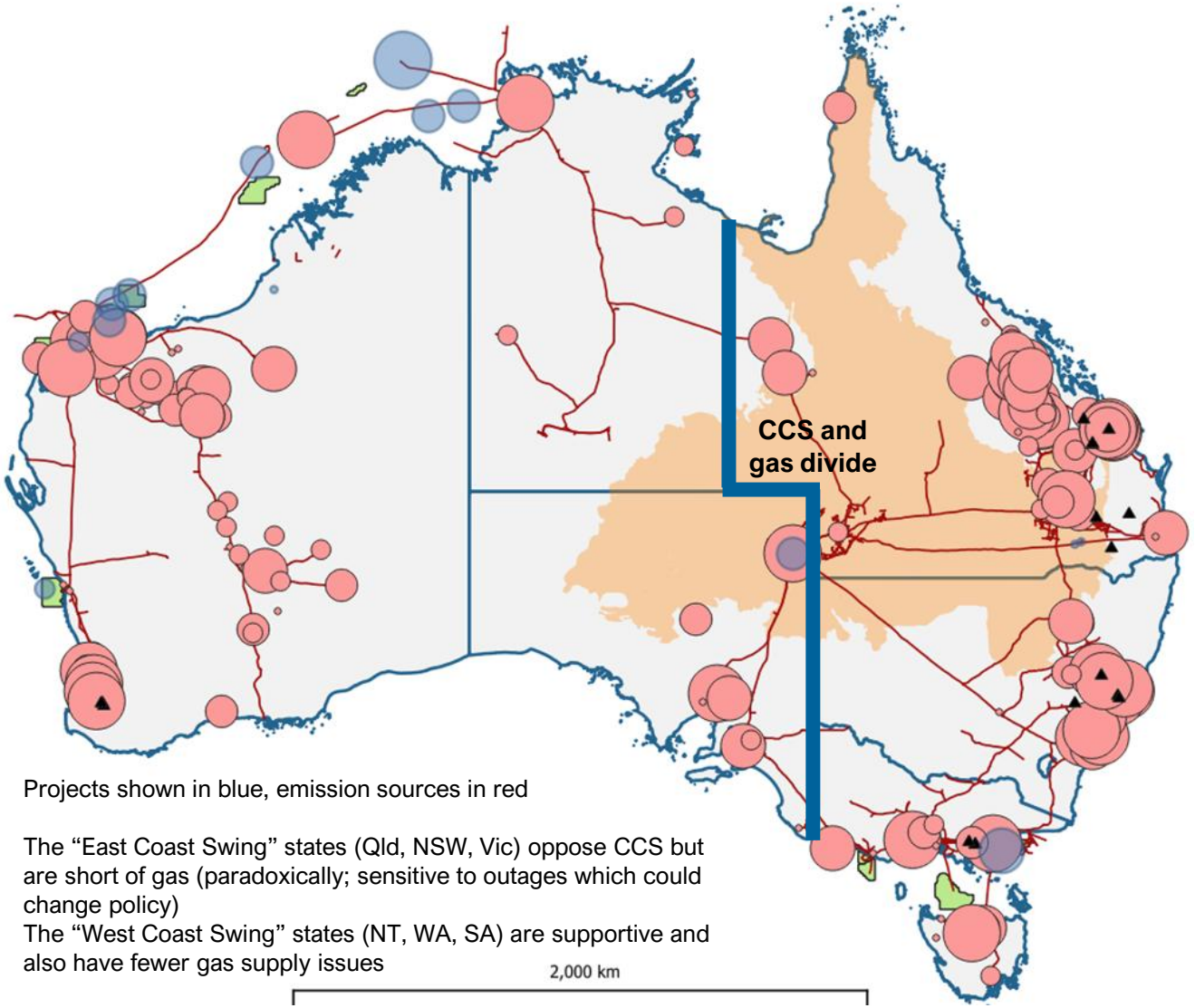
And they are almost all associated with LNG or NGP



Status of Existing and Planned Large Australian CCS Projects

Project (Operator)	JV Partners	Mtpa	Status	Comment
Gorgon (Chevron)	EM, Shell, Osaka Gas, JERA MidOcean Energy	1.7-4	🟢	Injection due to ramp up to boilerplate injection following major recent investment
Browse (Woodside)	Bp, Mimi, PetroChina	4.5	🟡	DOSF awarded
Bonaparte (Inpex)	Total, Woodside	2.5-10	🟡	Targeting 2030 injection, just received Major Project Status by the Commonwealth
Bayu Undan (Santos)	SK, Inpex, Eni, Tokyo TSR	5-10	🟡	London Protocol complexities
Moomba (Santos)	Beach	1.7-2.5	🟢	Online
SEA CCS (Exxon)	Woodside	?	🟡	Status unclear
CarbonNet (DJSIR)	DJSIR	1-5	🟡	Currently holds two GHG assessment permits
CTSCo & Moonie	Glencore	0.3	🔴	Cancelled due to environmental concerns
Cliff Head CCS (Pilot)	Pilot	1	🟡	DOSF awarded
GHG permits		0	🟢	There are currently 21 GHG Assessment Permits in Commonwealth waters (inclusive of the above mentioned projects)

The reality of two Australia's: The states are split on opinion towards CCS. The impact of the QLD decision may already be spreading, with evidence NSW may resist onshore activity in the Darling Basin



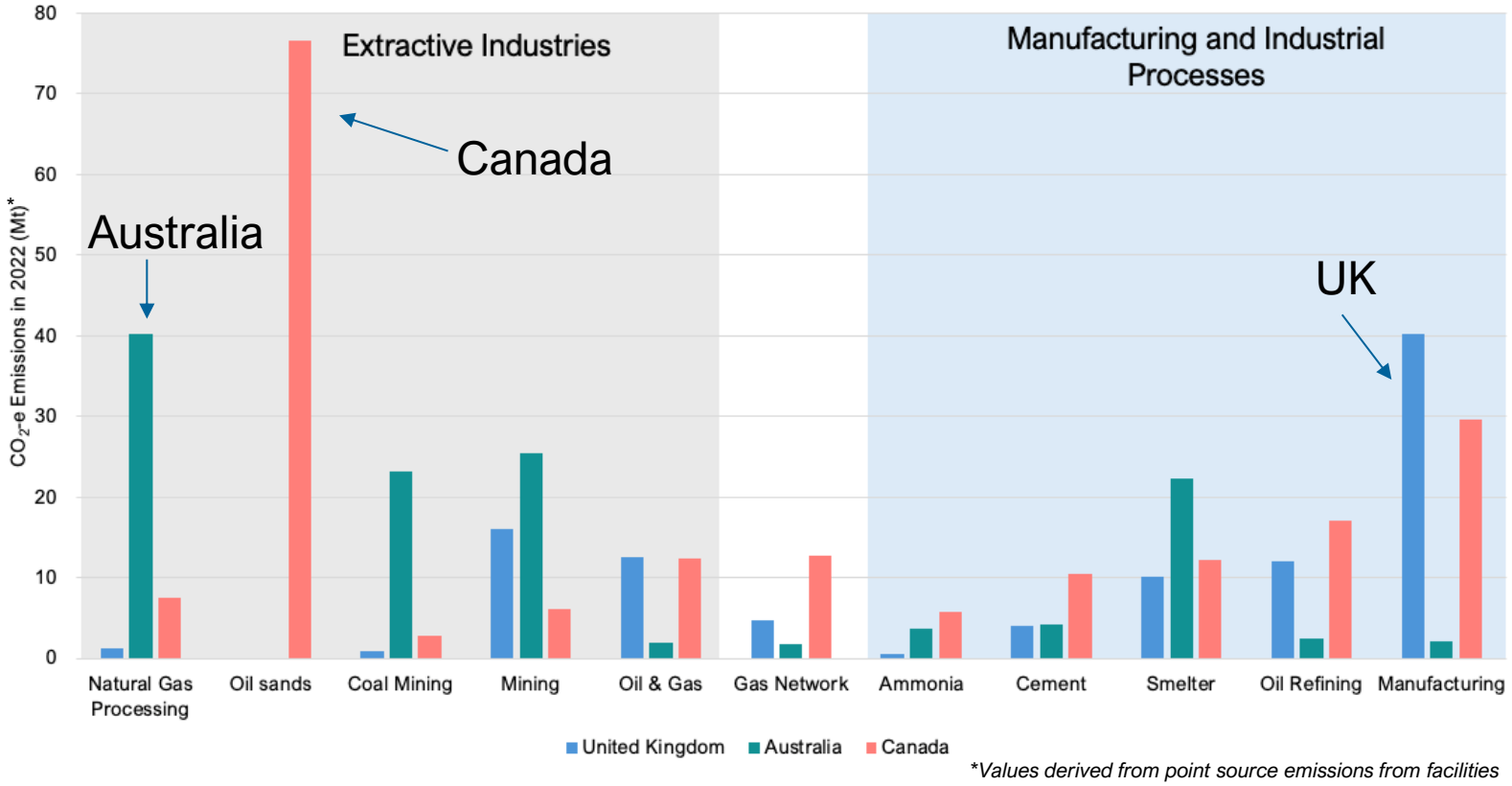
Projects shown in blue, emission sources in red

The "East Coast Swing" states (Qld, NSW, Vic) oppose CCS but are short of gas (paradoxically; sensitive to outages which could change policy)
The "West Coast Swing" states (NT, WA, SA) are supportive and also have fewer gas supply issues

State/Territory	CCS position
Western Australia	●
Queensland	●
South Australia	●
Northern Territory	●
New South Wales	●
Victoria	●
Tasmania	●

CCS and Emissions Sources: Australia Versus Global

- Australia's emissions are largely related to its extractive industries with **LNG-natural gas processing contributing ~40-45 Mtpa**
- In Canada, high emissions are associated with **oil sand production**
- In the UK and Europe, **hard-to-abate manufacturing** is a major source of emissions
- These **differences in emission sources clearly necessitate different policy responses**



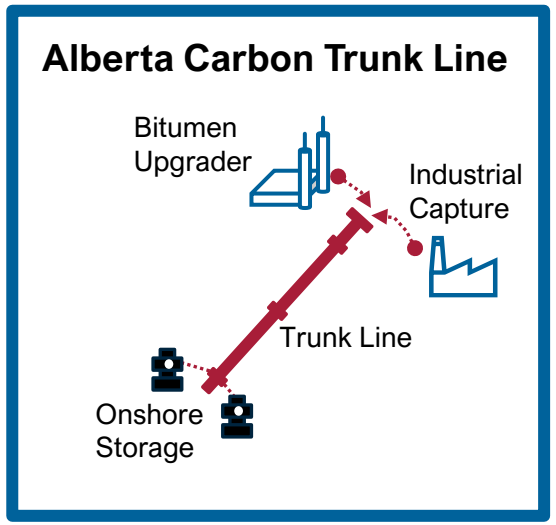
*Values derived from point source emissions from facilities

Source: United Kingdom (UK Government, 2023), Australia (Clean Energy Regulator, 2023) and Canada (Government of Canada, 2023).

CO2CRC
Building a low emissions future

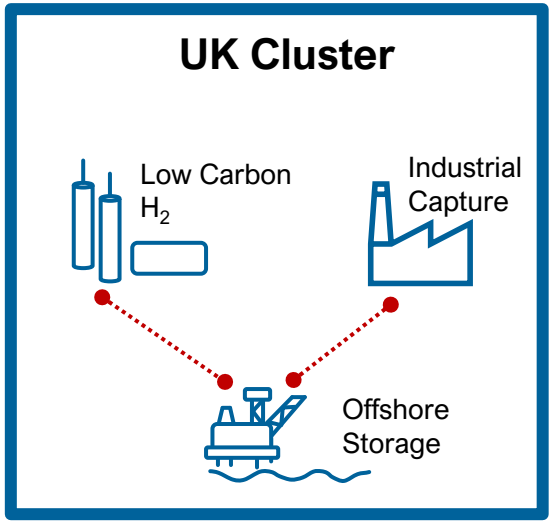
Jurisdictional Approaches to CCS

Canada

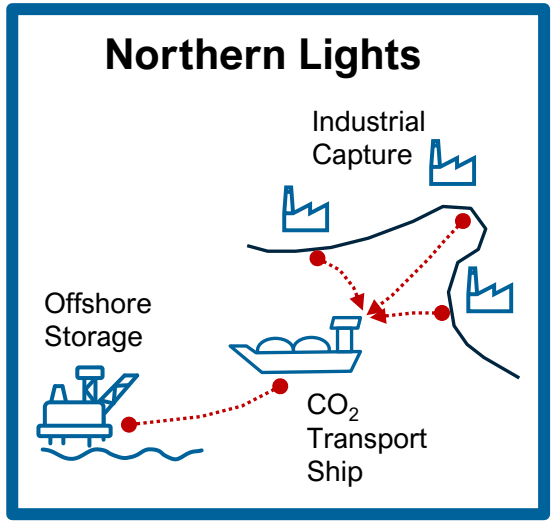


In Canada, government tax incentives are encouraging the CCS project roll-out and a foundation infrastructure CO_2 pipeline (240 km long; 14 Mt/a) was funded by the government

United Kingdom



Europe



CCS projects in the UK and Europe are focused around decarbonising the industrial-manufacturing sectors, with multi-billion-dollar investments made to “kick-start” the CCS industry

Policy and Incentives Follow Emissions: Each government is facilitating CCS where it matters most – with its decarbonisation reality

CO2CRC
Building a low emissions future

A Tale of Two Approaches… CCS's Ying & Yang?

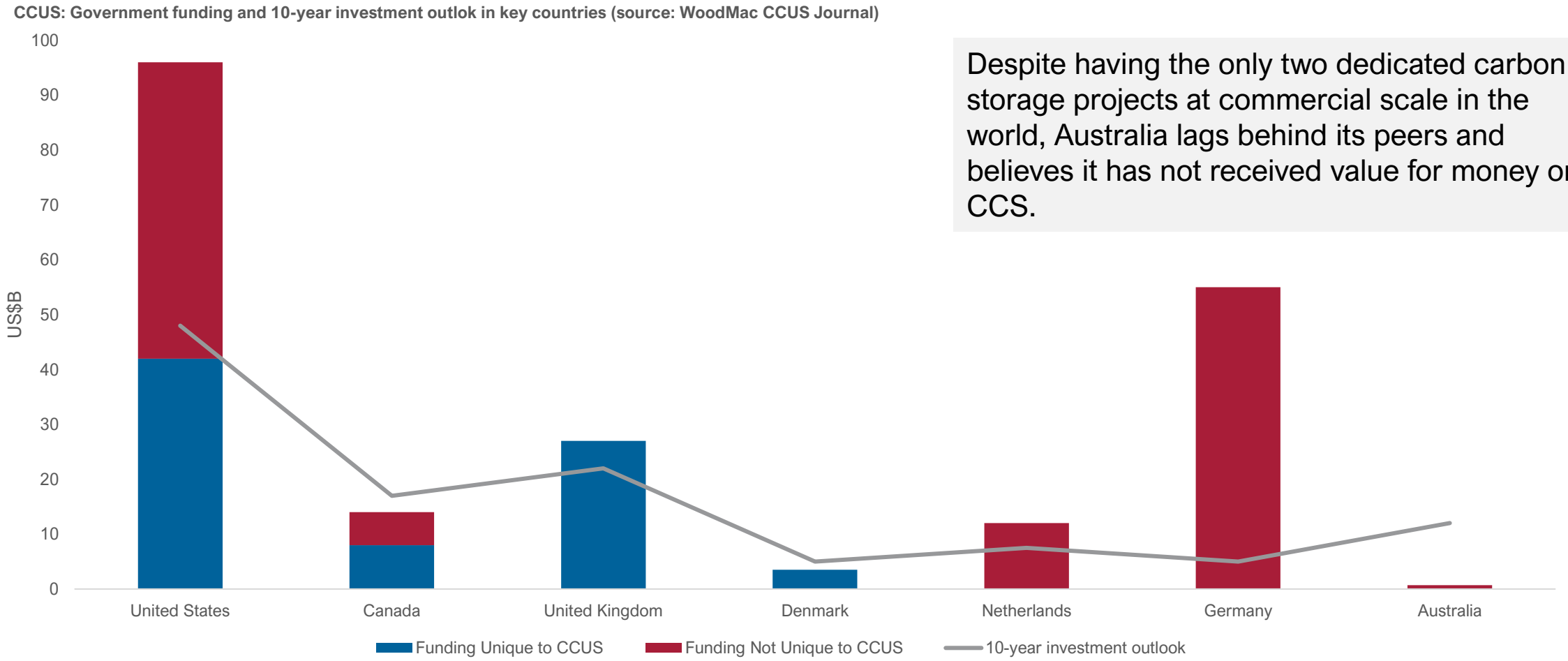
Canada, UK, EU etc

- Targetted and in some cases direct (tax and other) Government support and investment reflects project realities and emission sources
- Large scale Government investment where necessary (e.g., EU and UK)
- Infrastructure investment where appropriate (Canada) to facilitate future shared usage
- Regulatory reform to deliver "one-stop" regulatory approvals
- Strong research support

Australia

- No Government financial support for CCS
- No tax incentives, with CCS excluded from ACCU system (apart from Moomba)
- Projects treated a series of independent variables, with **no consideration of shared or targetted infrastructure investment** (e.g., CO_2 pipelines) to encourage or future proof emerging, multi-storage project CCS hubs
- Labyrinthine, duplicative and **worsening regulatory approvals process** across multiple departments
- No research support

However, even Denmark is out-funding Australia…



Despite having the only two dedicated carbon storage projects at commercial scale in the world, Australia lags behind its peers and believes it has not received value for money on CCS.

CO2CRC
Building a low emissions future

What Is Needed To Realise Australia's CCS Potential?

1) **SUPPORT CCS THROUGH POSITVE MINISTERIAL COMMUNICATION:** The LNG-NGP industries is a key part of the solution

2) **POLICY CHANGE:** Clarify full PRRT deductibility for CCS and widen ACCU accrual for CCS

3) **MAKE INVESTMENTS:** Make targeted shared (common use) infrastructure investments to future proof CCS projects, leading to multi-project hubs

4) **UNDERTAKE GENUINE REGULATORY REFORM:** Accelerate regulatory reforms and eliminate duplication across legislative suites

5) **INVEST IN RESEARCH:** Secure national research assets such as the Otway International Test Centre and to develop next-generation CCS human and research capabilities in support of the nation's CCS projects

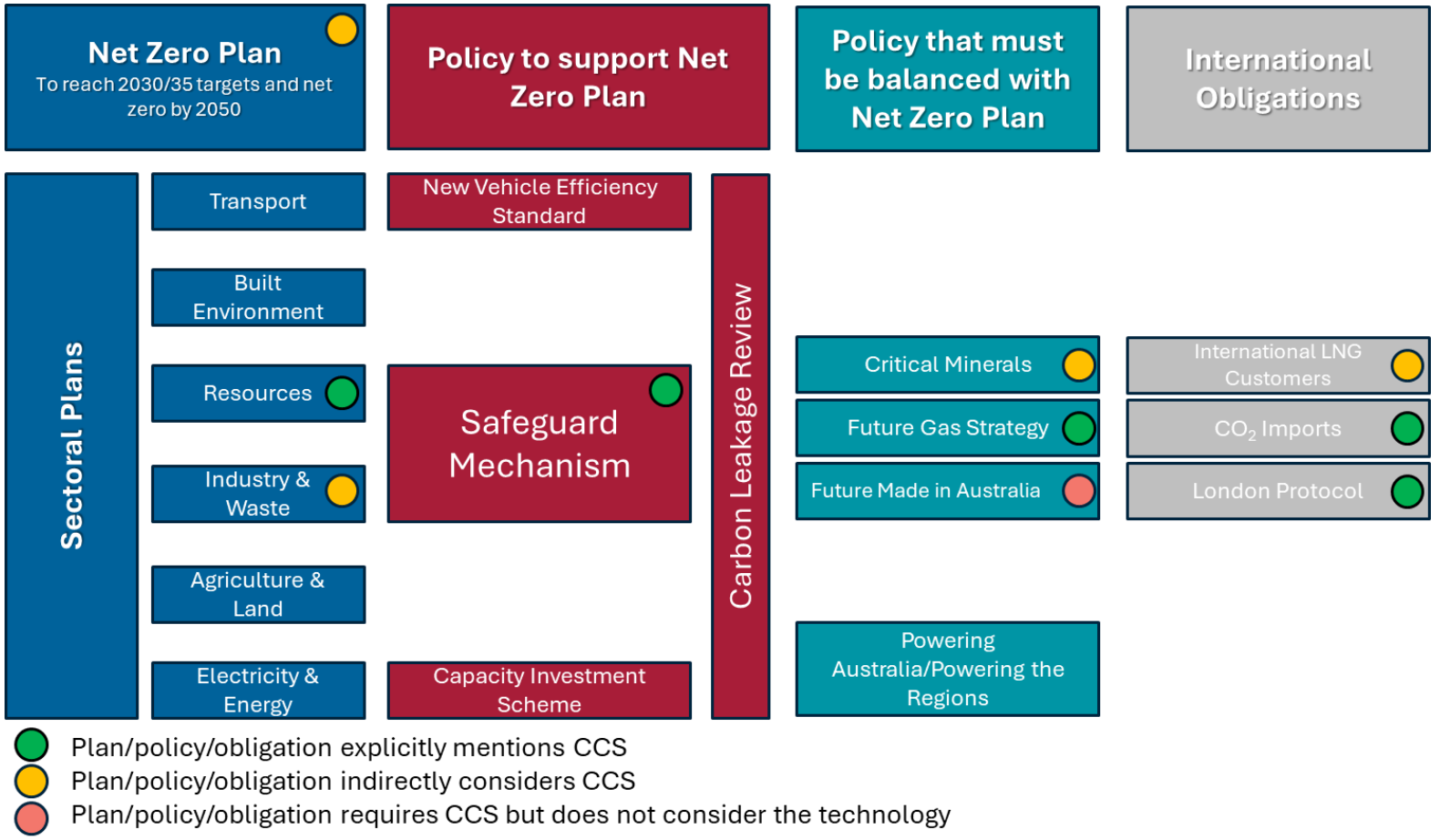
Why Government Support Matters

CCS is required under Policy Drivers in Australia

Safeguard Mechanism
The best-practice benchmark for new gas fields is zero reservoir CO_2 emissions meaning all new gas fields with reservoir CO_2 will require CCS

Future Gas Strategy
Continued supply of LNG while reducing the emissions intensity of LNG and gas production presents opportunities to scale CCS

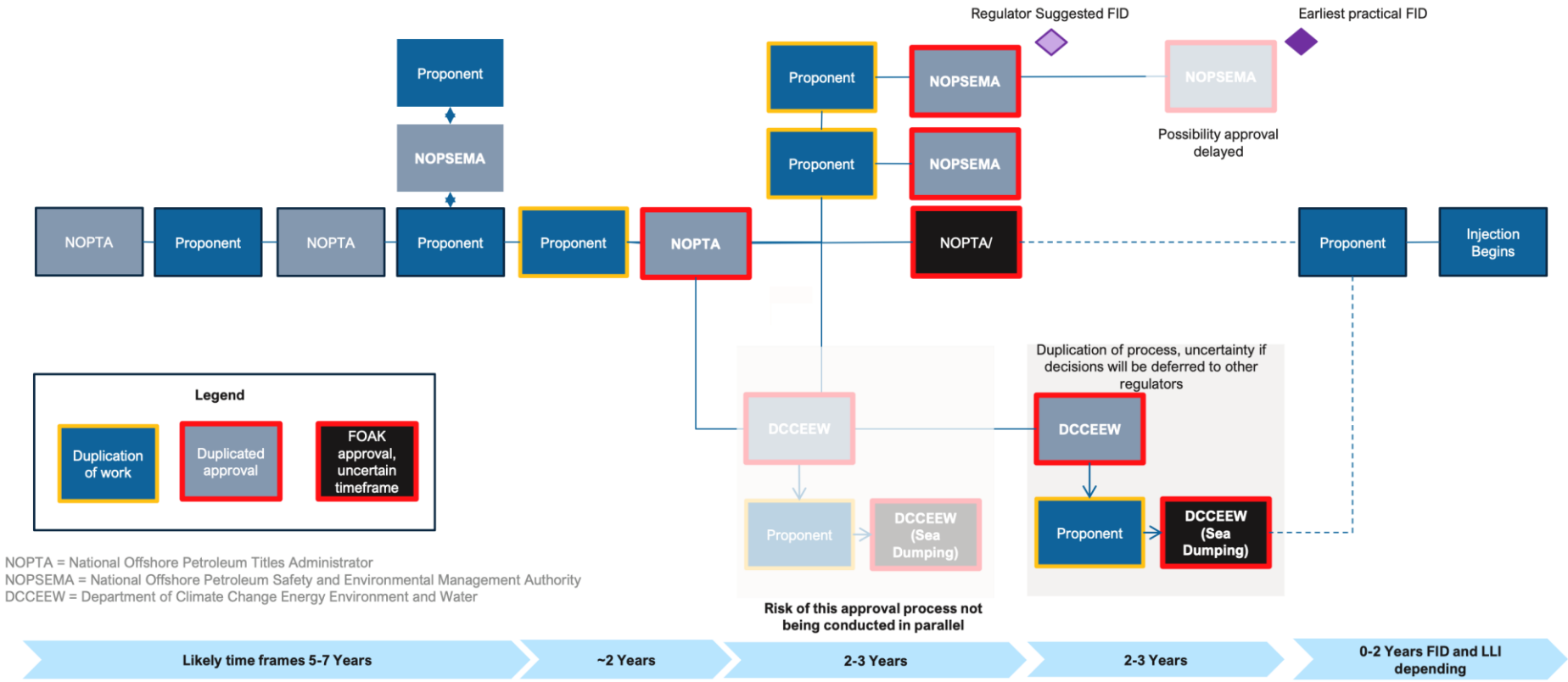
London Protocol
Ratification of the 2009 amendment to the London Protocol allows for the sequestration of imported CO_2 offshore Australia



CO2CRC
Building a low emissions future

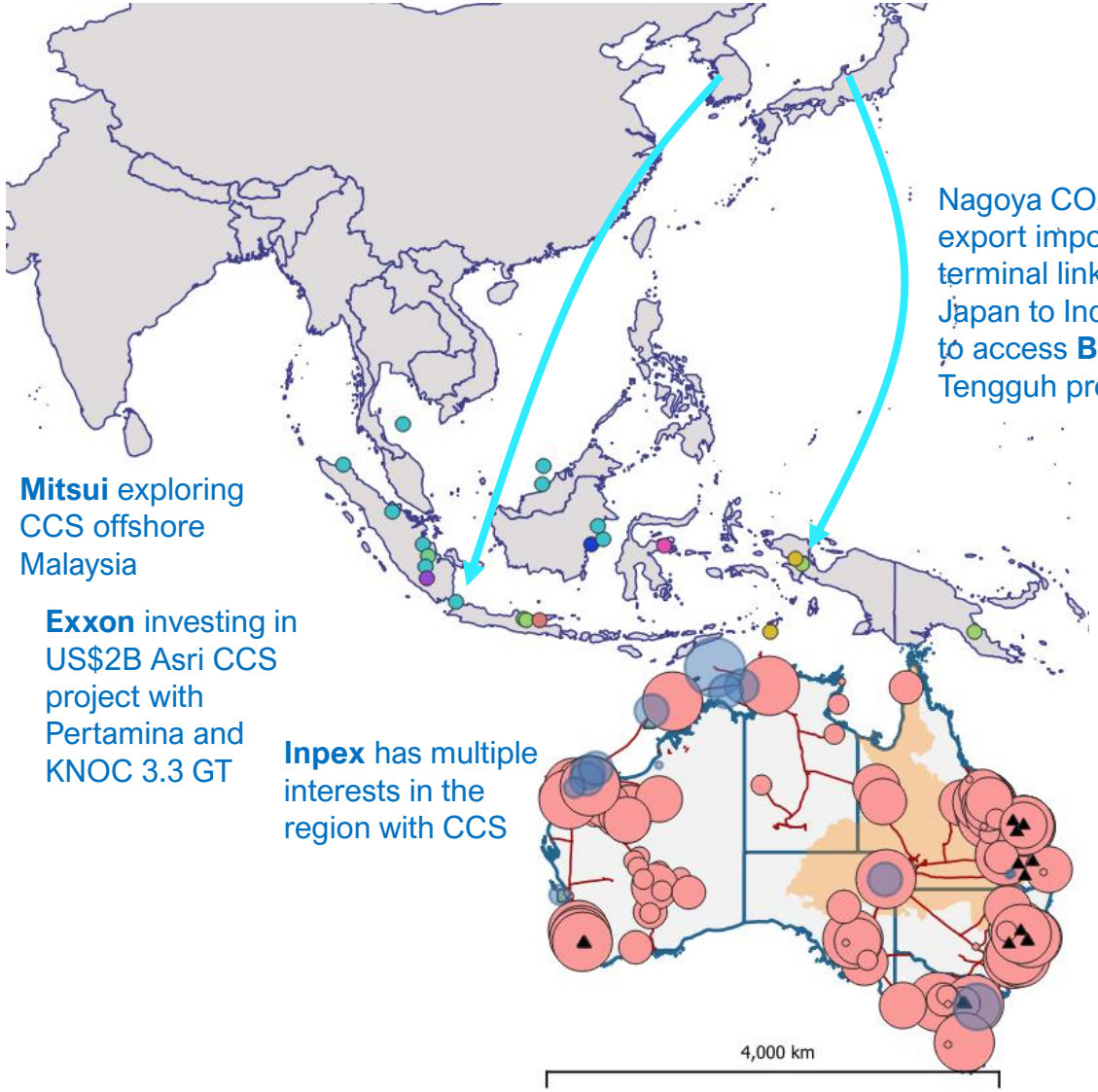
Regulatory pathway (offshore) and process map

showing complexity and intra-governmental overlap



CO2CRC
Building a low emissions future

Australia could be losing its competitive edge - SE Asia could strangle CO_2 import prospects. **Oil and gas majors invest heavily in CCS in Asia instead of Australia.**



There is an embarrassing outcome where Australia exports CO2 for sequestration to Indonesia

Presidential Regulation No. 14 of 2024 regarding Implementation of Carbon Capture and Storage (CCS) Activities

- BP Tengguh
- INPEX Abadi

National Energy Policy (NEP) 2022-2040

- Petronas Kasawari
- PTTEP Arthit Gas field

	Brunei	Indonesia	Malaysia	Thailand	Vietnam	Australia
Domestic CO2 storage potential	●	●	●	●	●	●
Legal and regulatory frameworks for CCUS in place	●	●	●	●	●	●
Targeted policies to support CCUS	●	●	●	●	●	●

Nuancing the energy transition with CO_2-EOR

co2crc
Building a low emissions future

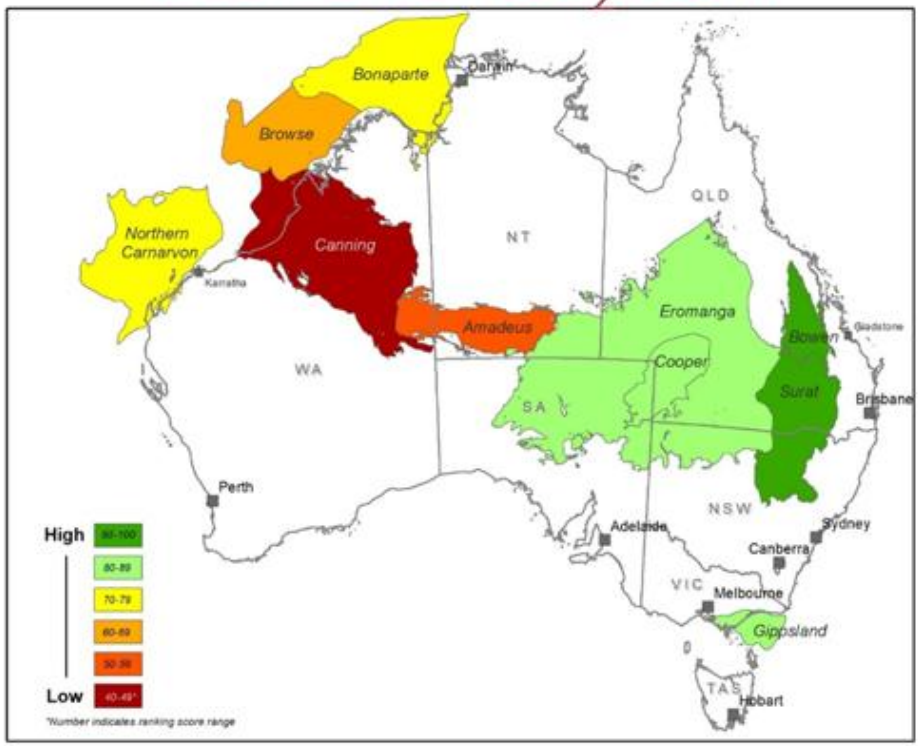
CO_2 Utilisation : CO_2-EOR Potential in Australia

CO_2 EOR potential in Key Australian basins

Basin	PRO (mmbbl)	PR Condensate (mmbbl)	kgCO_2/bbl oil 300	600	900
			million tonnes of CO_2 required		
Cooper/Eromanga	145	32	53	106	160
Bowen/Surat	13	2	5	9	14
Gippsland	945	80	308	615	923
Carnarvon	809	340	345	690	1035
Bonaparte	209	120	99	198	296
Canning	11	6	5	10	16
Amadeus	9	1	3	6	8
Browse	11	243	76	152	228

The ranking above is based on subsurface and infrastructure properties and recoverable oil and associated CO_2 storage is not included

Ranking of Australian basins for CO_2 EOR

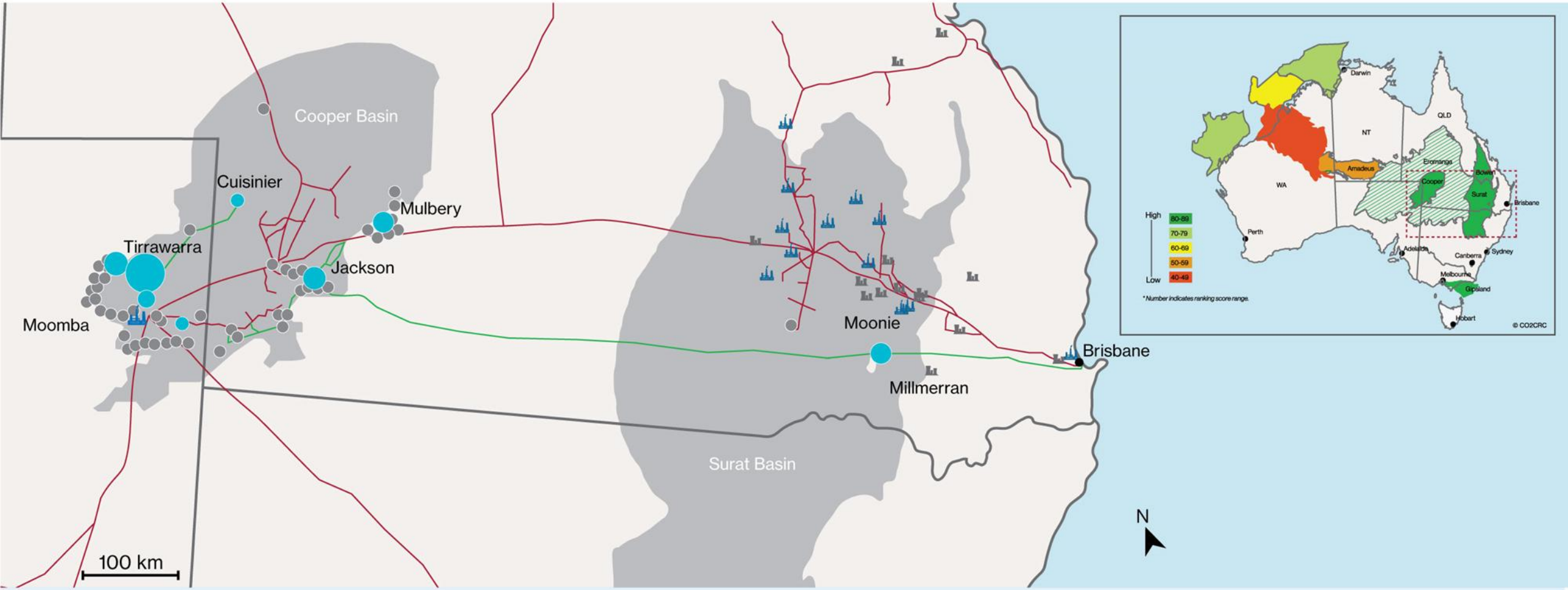


Building a low emissions future

Low Emission Technology Australia

Australian Government
Geoscience Australia

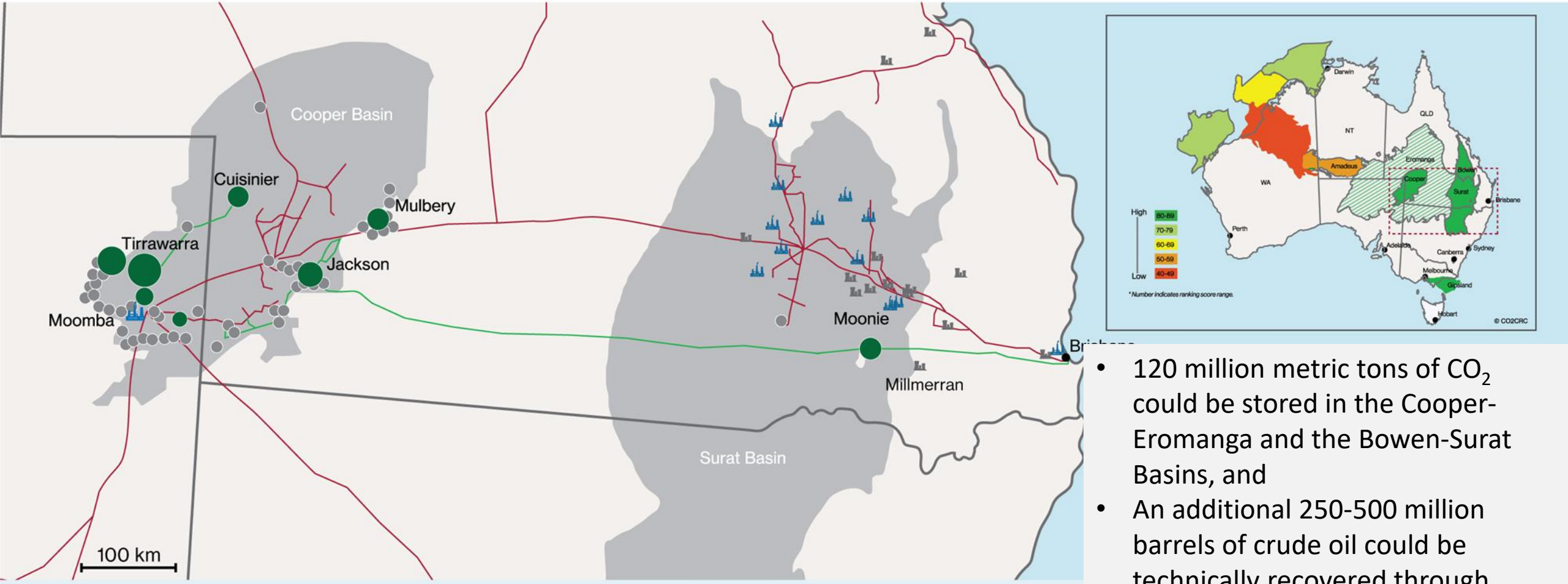
CO_2 storage potential during EOR



Key

- 15 million tonnes CO_2
- Reservoirs
- Onshore gas pipeline
- Onshore oil pipeline
- Gas plant
- Power station

Potential of enhanced oil recovery using CO_2

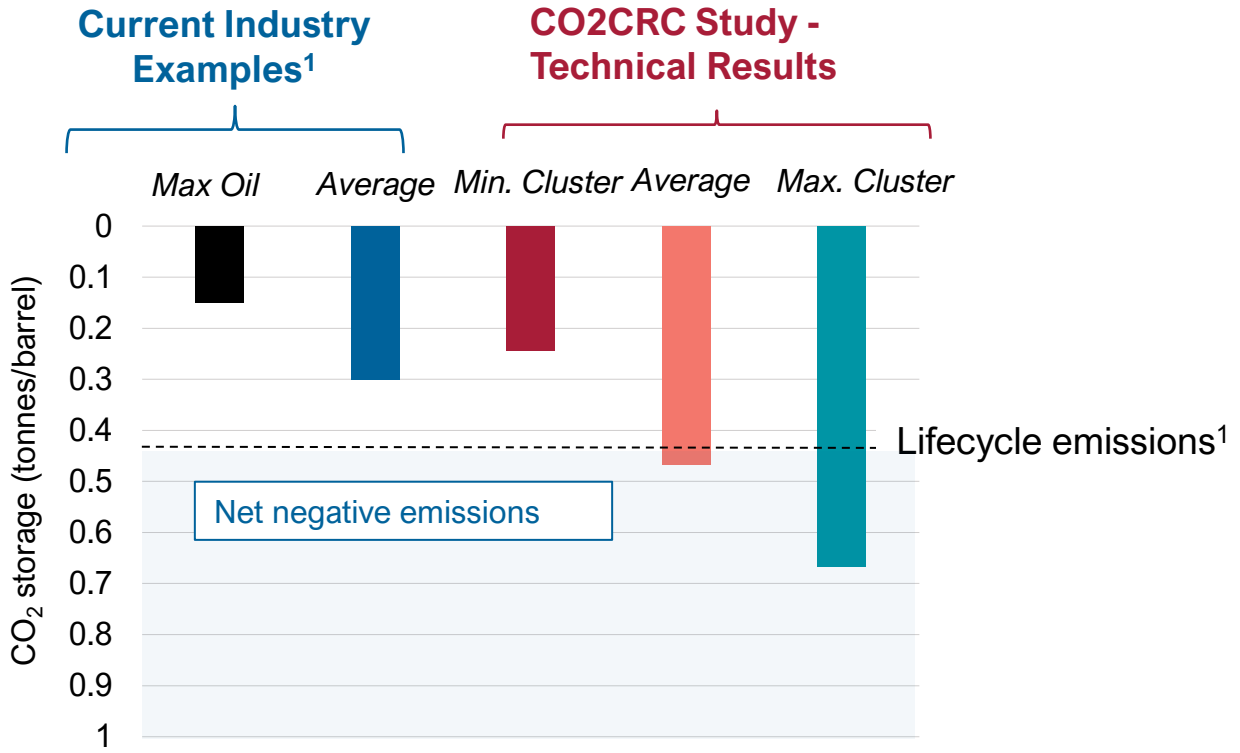


- 120 million metric tons of CO_2 could be stored in the Cooper-Eromanga and the Bowen-Surat Basins, and
- An additional 250-500 million barrels of crude oil could be technically recovered through applying CO_2-EOR.

CO_2EOR Net Negative Emissions Potential

Lifecycle emissions[1]

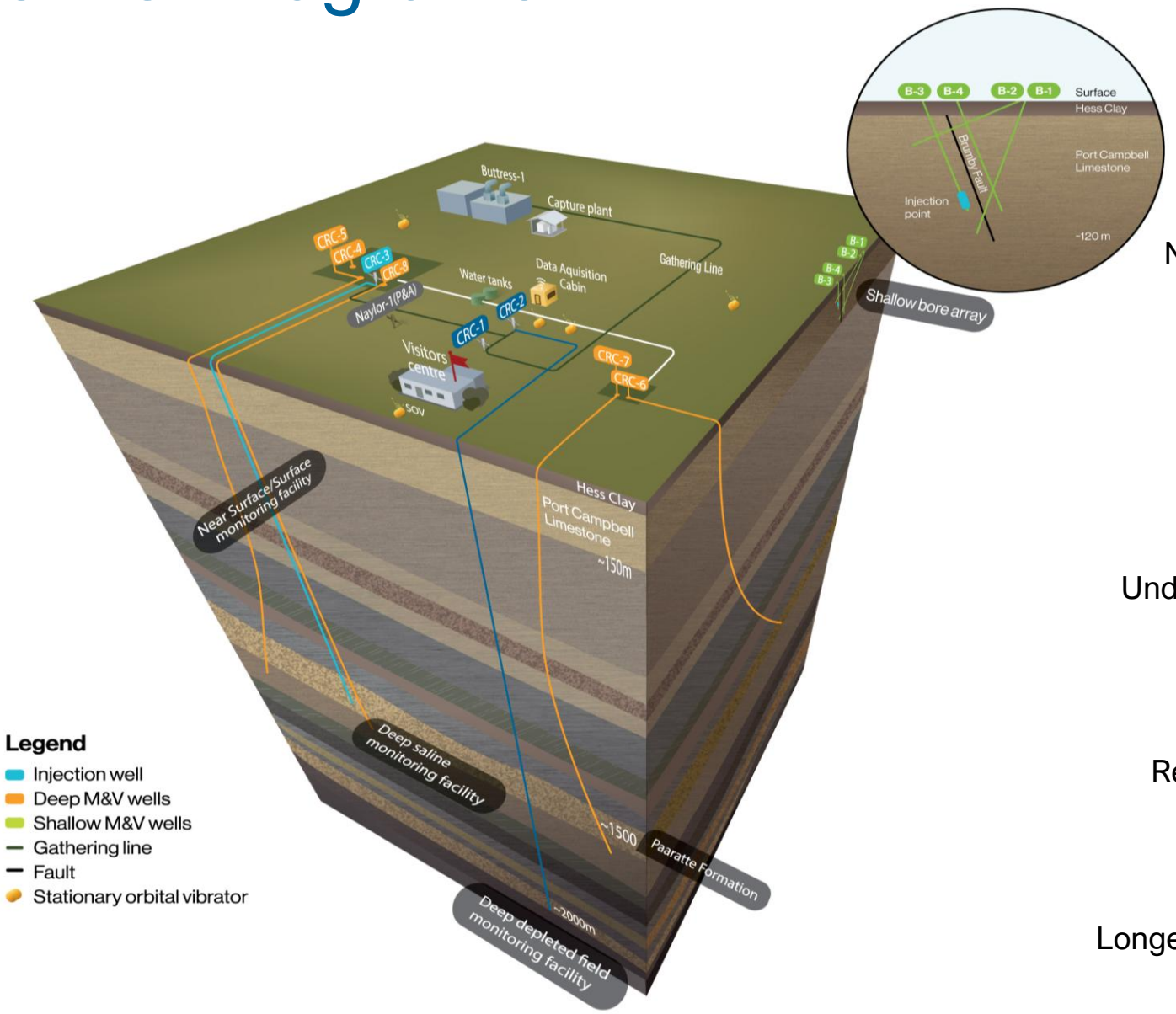
Emissions stage	Typical CO_2 (t/bbl)
Transport plant to gate	~0.00-0.01
Compression/injection/recycle	0.01-0.02
Storage/flaring/transport market	0.03
Distribution and final consumption	0.38
Total	0.42-0.44



[1] *Tenthorey et al., CO2-EOR+ in Australia: achieving low-emissions oil and unlocking residual oil resources (2021)*

CO2CRC
Building a low emissions future

OITC Programs



Otway Stage 1: 2004 – 2009

Transport, injection, storage and monitoring of CO_2 into a depleted gas reservoir.

Otway Stage 2: 2009 – 2019

Near well residual trapping characterisation, and seismic monitoring performance in saline formation.

Otway Stage 3: 2015 – 2022

Reliable and cost-effective subsurface monitoring and verification of stored CO_2.

Otway Shallow Fault Project: 2017 – 2025+

Understand role of faults in fluid flow and near surface M&V capability

Otway Stage 4: 2020 – 2027

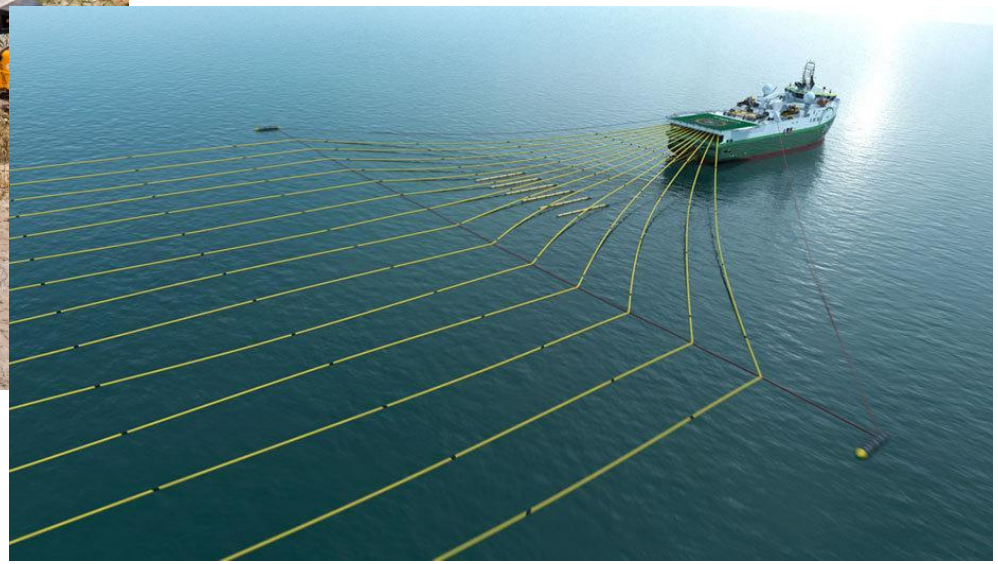
Reservoir management technologies to improve injection, storage and monitoring efficiencies.

Otway Future Program: 2026 +

Longer term storage system response, threshold analysis and monitoring approaches.

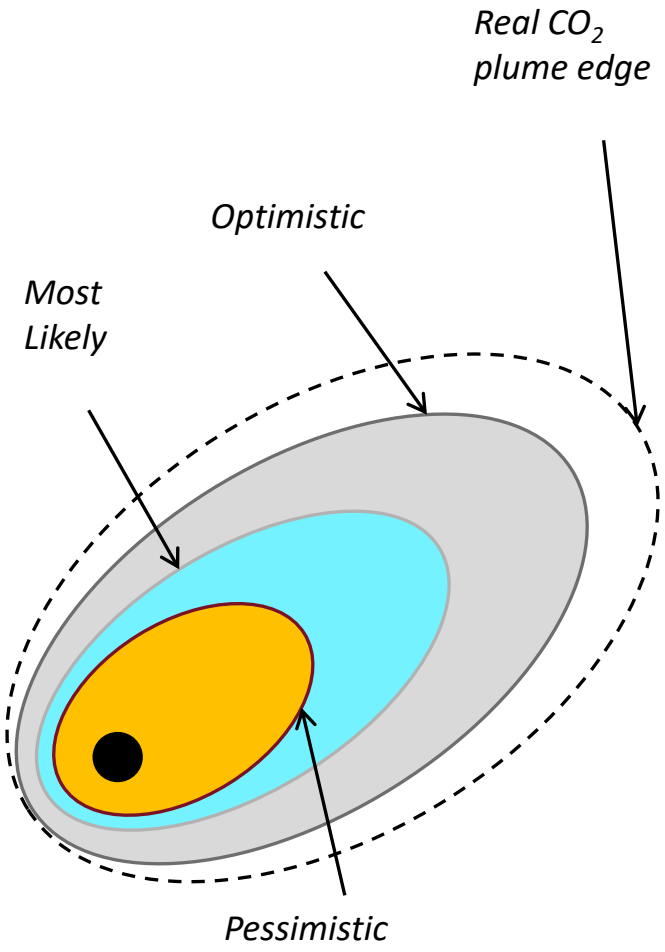
Breakthrough technologies

In order to see, the industry needed:



co2crc
Building a low emissions future

What do we actually need to monitor?



Well Instrumentation

Injection Well

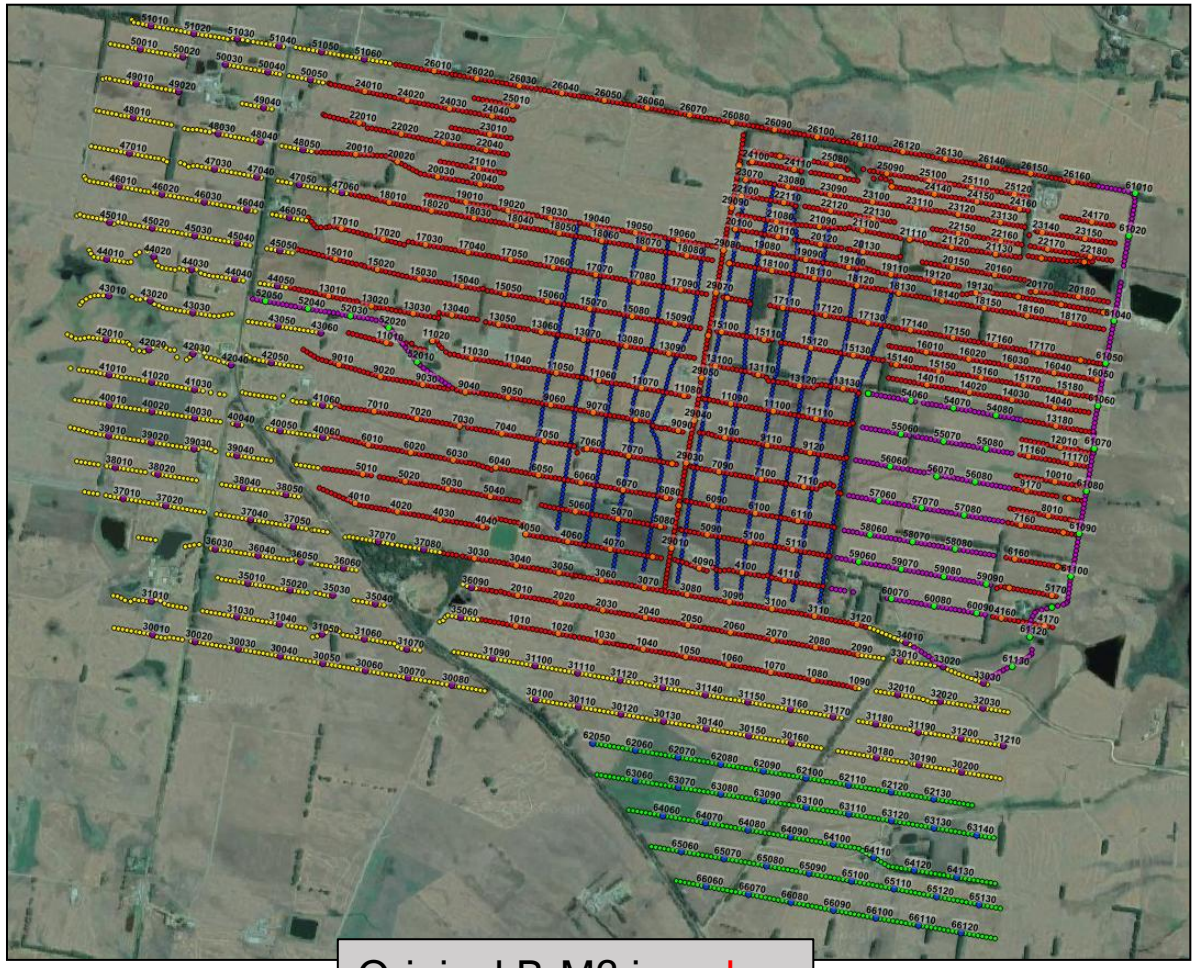
- 2 x Engineered TEF* cemented outside of casing and looped at TD
- 1 x Engineered TEF clamped to tubing and looped at TD
- P&T gauges at reservoir depth (positioned above and below injection zone)
- Wellhead P&T
- Injection line P&T

Monitoring Well

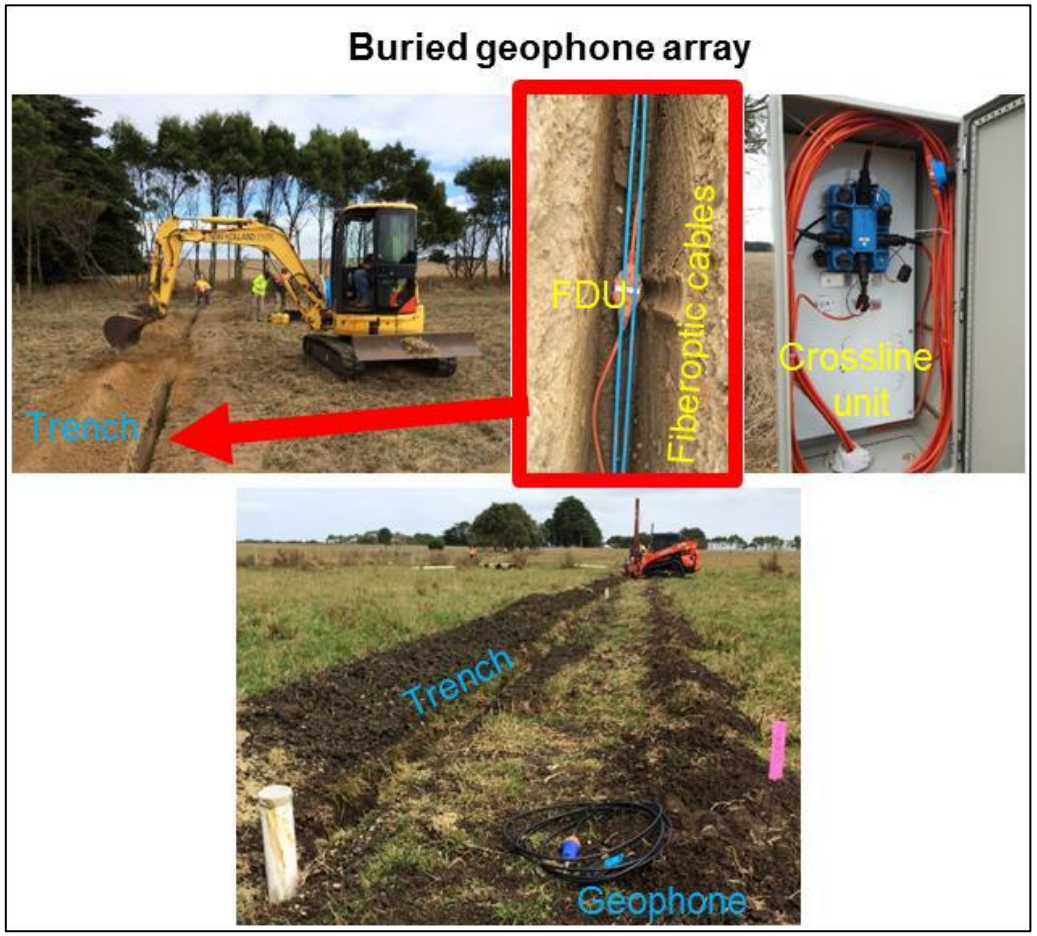
- 2 x Engineered TEF* cemented outside of casing and looped at TD
- P&T gauge at reservoir depth suspended from wellhead (TEC clamped to suspension cable)
- CRC-4: 1 x SM/MM TEF suspended from wellhead (clamped to suspension cable)
- Wellhead Pressure

**TEF: Tubing Encapsulated Fibre – a multi-core hybrid fibre combination of EF, SM and MMF housed in an Inconel sheath*

Seismic infrastructure



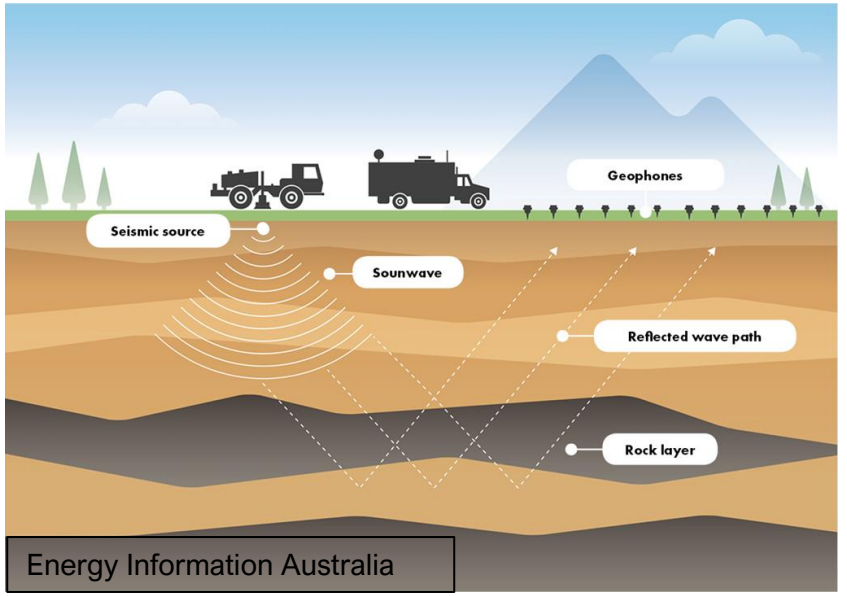
Original B-M3 is red, M4 is red + yellow. M5 is red+yellow+purple



CO2CRC
Building a low emissions future

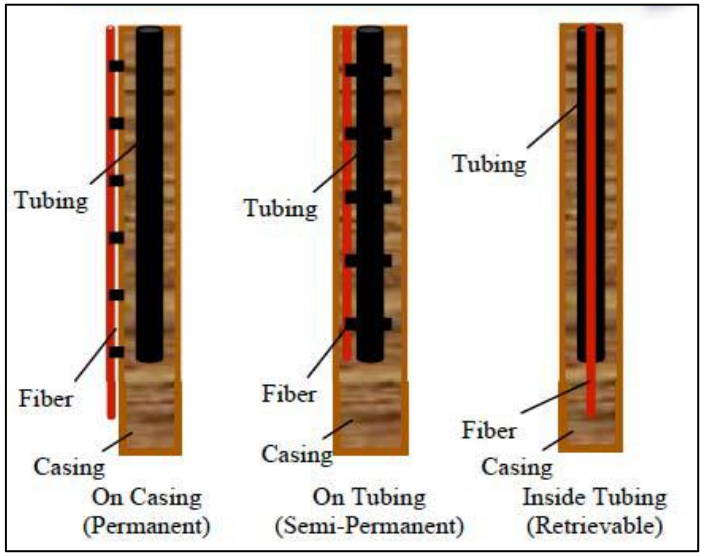
Fibre Optics

- What are they?
  - Commonly known for their role in the comm. Industry (internet)
  - Carrier of information…OR…a sensing system
- What do they have to do with the reservoir, seal, etc?
  - What do we need in our monitoring system?
  - Sources & receivers
  - Fibre Optics --> Receivers

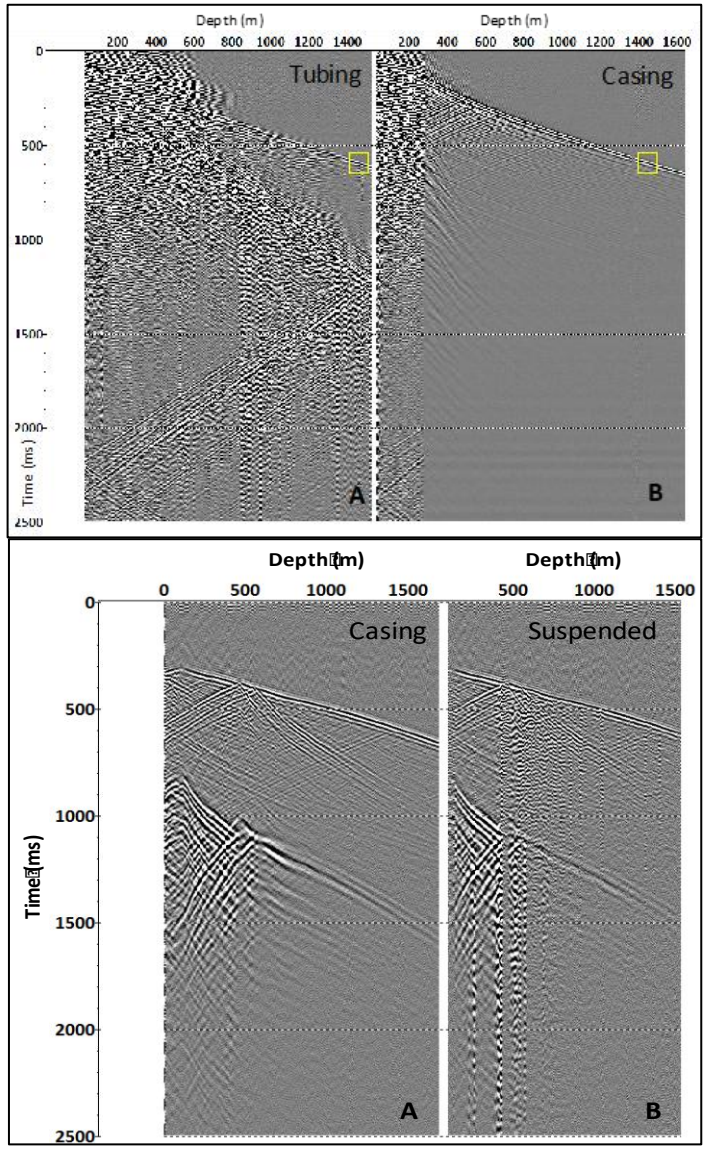


Fibre Optic: Deployment

- Vertical Seismic Profile (VSP)
- Permanent production monitoring
- Modes:
  - Behind the casing
  - On Production Tubing
  - Suspension
- FO mode
  - Single Mode
  - Multi-mode
  - Enhanced Backscatter



Li M. et al (2015), Open Petroleum Journal.



Surface Orbital Vibrators (SOV's)

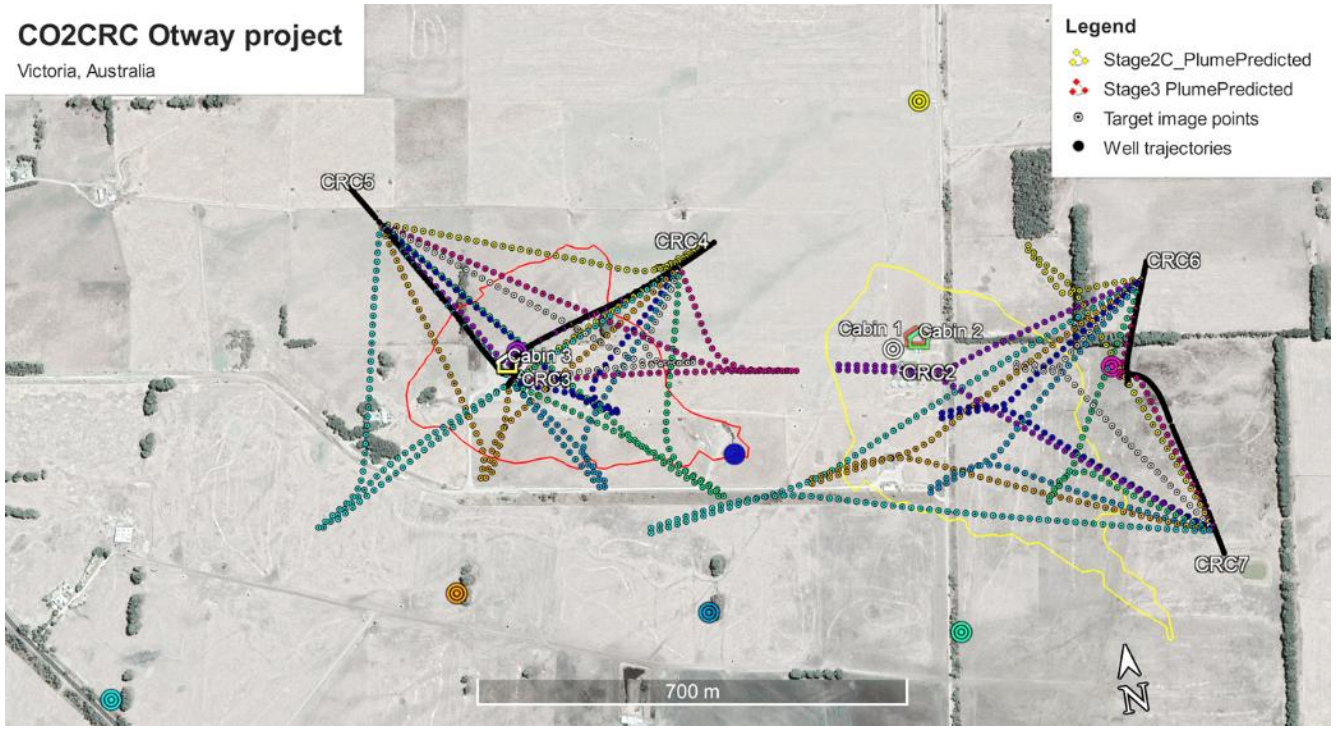
- Installation
- Characteristics
  - Phase
  - Peak Force
  - Sweep Length
  - Frequency
  - P-wave/ S-wave
  - Clock-wise and Counter clock-wise
- Remote Operation
  - Automation

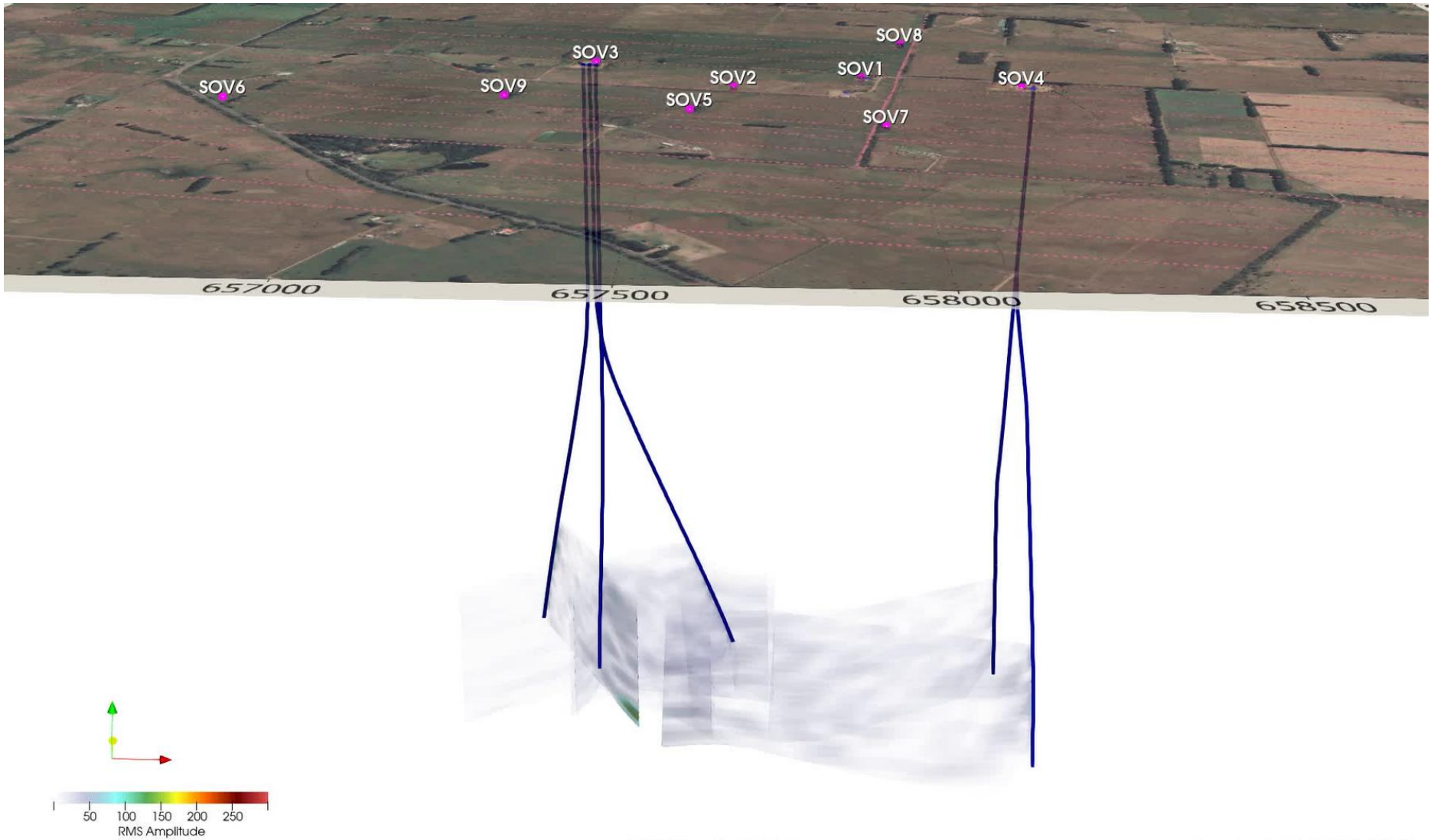
Courtesy of CLASS VI Solutions

Risk based monitoring through downhole seismic and SOV/DAS

- The system was configured to provide a new image of the plume every 2 days.

- It first detected the gas plume on the 2nd day of injection with ~300 tonnes.




SOV8
SOV3
SOV1
SOV2
SOV4
SOV6
SOV9
SOV5
SOV7
657000
657500
658000
658500
50
100
150
200
250
RMS Amplitude
Vintage: 139.000000
Volume: 1.16454626012731

Why Science Matters

Why Australia Should Invest in CCS Research

- **Strategic fit:** Australia has two of the world's largest CCS projects, unique geology for storage, and LNG/NGP industries that *must* deploy CCS to stay viable
- **Global competitiveness:** Without R&D investment, Australia risks losing its competitive edge to Asia, Europe, and North America, which provide strong incentives and research support
- **Economic security:** CCS protects the future of LNG exports (80% of production exported) and underpins energy security for the Asia-Pacific
- **Climate necessity:** CCS is essential to meet both the **2030 emissions reduction target (43%)** and **2050 net zero**; without CCS, pathways are not feasible

Australia's Role in a Carbon-Constrained World

Australia's Domestic Obligation

- Legislated targets:
  - 62 - 70% by 2035; net zero by 2050
- Residual industrial emissions remain (~150 Mt CO_2 p.a.)
  - gas, steel, cement, chemicals
- Policy relies on storage
  - Safeguard Mechanism
  - Future Gas Strategy
- The central challenge
  - Confident, affordable and investable CO_2 storage

Australia's Regional Responsibility & Opportunity

- The Valeriepieris Circle
  - 50% of the world's population, and Australia's key export markets
- Uneven access to storage
- Australia's strategic role
  - Enable lower-carbon exports
  - Provide trusted storage capability
  - Potentially deliver CO_2 storage as a regional service

Storage is proven. Predictable, investable storage will unlock scale

CO2CRC
Building a low emissions future

How CCS Scales in Australia

Foundational Projects

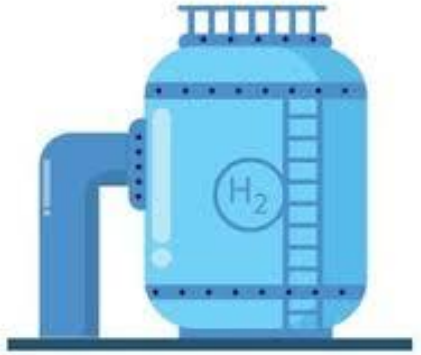
(Gas Processing & LNG)

- Build confidence and scale
- Establish regulatory pathways
- Anchor early wins in storage

Sector Expansion

(Hard to Abate Industries)

- Shared Infrastructure & Hubs
- Infrastructure re-use



System Integration

(Low-Carbon Fuels & CDR)

- Blue hydrogen
- DACC & BECCS integration

Regional Expansion

- Transboundary CO_2
- Storage as a service

Key Enablers

- Investor and regulatory confidence in (start – operate – close)
- Cost effective project (and hub) development
- Scaling up storage volumes
- Regional-scale storage coordination
- Sovereign capability

CO2CRC
Building a low emissions future

Scaling Geological CO_2 Storage: The Delivery Challenge

Scale

- Multi-million tonne injection rates
- Mixed CO_2 sources
- Cold injection
- Onshore complexities
- Offshore uncertainty

Cost

- High upfront capex
- Monitoring burden
- Pressure to reduce $/t
- Avoiding stranded pore space

Regulator & Closure Expectations

- Demonstratable containment
- Measurable performance
- Defining operational limits
- Credible closure pathways
- Minimal longer-term liability

Decision Pressure

- Faster project timelines
- Limited skilled subsurface workforce
- Increasing data volumes
- Need for real-time information and decision support

Storage is moving from first-of-a-kind to n^{th}-of-a-kind.
The tolerance for uncertainty is shrinking.

CO2CRC
Building a low emissions future

CO2CRC: Core Research Program - Validated, Effective Storage Operation and Utilisation

THEME 1
Assured CO2 Storage Performance

Improving CO2 injection and reservoir response modelling for next-generation projects for effective operation

THEME 2
Assured geomechanical Integrity

Enhancing the understanding and predictability of geomechanical processes for long-term storage integrity

THEME 3
Effective Monitoring & Verification

Developing advanced techniques for monitoring to ensure regulatory compliance and operational integrity

THEME 4
Basin-scale Modelling

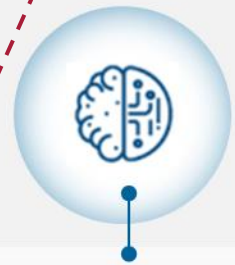
Developing basin-wide appraisal and management tools to optimise pore space using and mitigation risks

THEME 5
GCS Infrastructure Adaptation

Understanding and de-risking technical constraints of re-purposing existing infrastructure for reliable CO_2 storage

THEME 6
AI-Enabled Storage Solutions

Embedding AI to enhance model accuracy, optimise monitoring workflows, and deliver scalable tools



THEME 7
Techno-Economics & Realising Benefit

Analysing the economic viability of CCS technologies to ensure projects deliver financial and environmental benefits

THEME 8
Education, Training and Communication

Building Australia's specialist CCS workforce and facilitating knowledge sharing to maintain sovereign capability

co2crc
Building a low emissions future

As the CCS industry moves to large-scale, multi-million tonne injection projects, operators require greater certainty in long-term storage performance, geomechanical stability, regulatory compliance, and cost-efficiency. Our program delivers the field-validated tools and data to address these challenges directly.

Future Program - Domestic Research Collaboration

Theme 1 – CO2CRC coordinating
- *University of Queensland*
- *University of NSW*
- *University of Adelaide*
- *Edith Cowen University*

Theme 2 – Victorian Geomech Consortium
- *University of Melbourne*
- *Monash University*

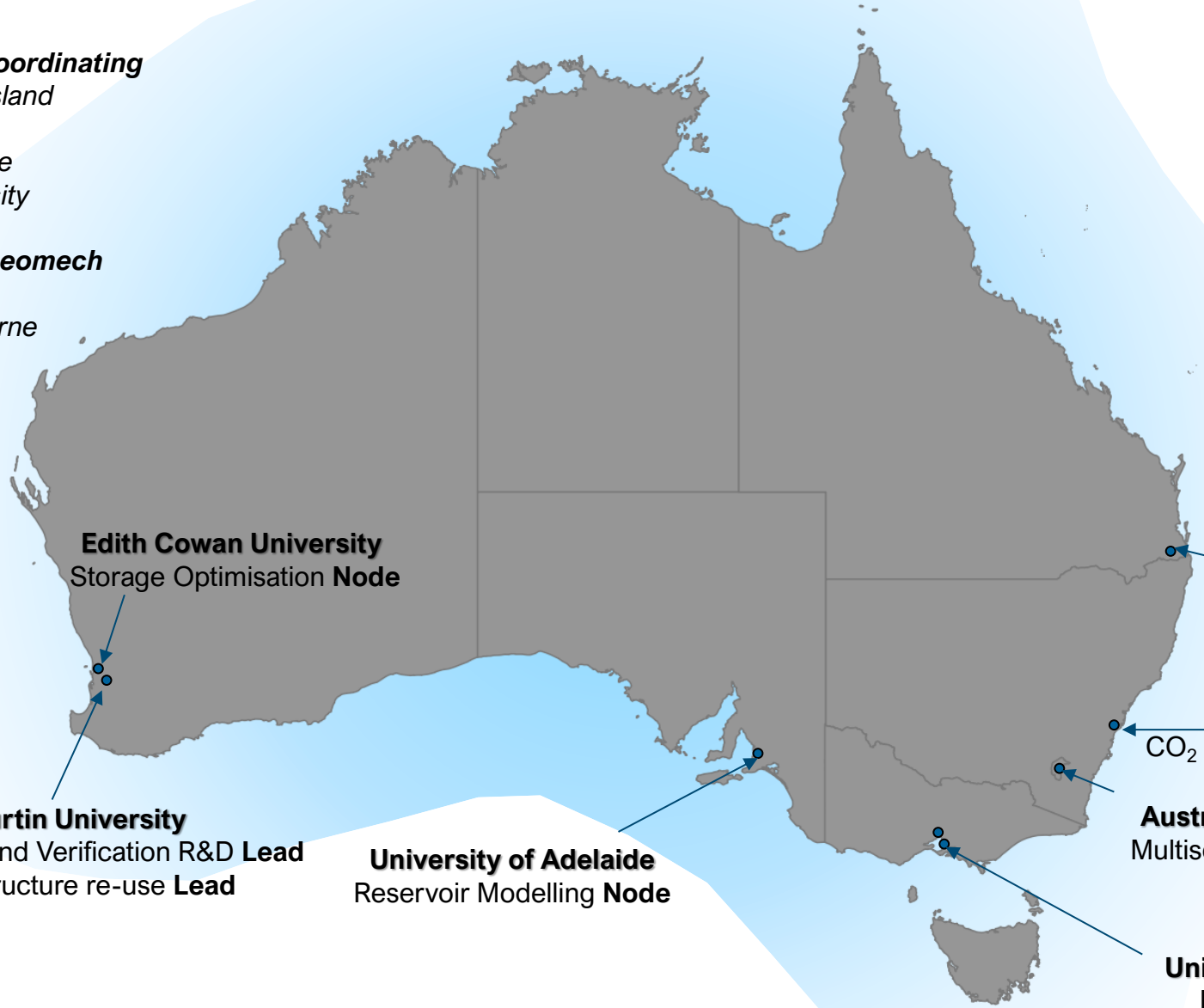
Theme 3 – Curtin University

Theme 4 – GA and CO2CRC collab. with
- *University of Queensland*
- *University of NSW*
- *University of Adelaide*
- *University of Western Australia*
- *University of Melbourne/Monash*

Theme 5 – Curtin University

Theme 6 – CO2CRC with industry driven expertise

***Theme 7 & 8 – CO2CRC**, working with domestic and international partners*



Edith Cowan University
Storage Optimisation **Node**

Curtin University
Monitoring and Verification R&D **Lead**
Infrastructure re-use **Lead**

University of Adelaide
Reservoir Modelling **Node**

University of Queensland
Geochemical R&D **Node**

University of NSW
CO_2 Injection Behaviour R&D **Node**

Australian National University
Multiscale Imaging and Upscaling

University of Melbourne
Monash University
Co-Lead for Geomechanics and Monitoring

CO2CRC
Building a low emissions future

CO2CRC acknowledges and appreciates the strong relationships it has with industry, community, government, research organisations, and agencies in Australia and around the world.

CO2CRC
Building a low emissions future