POSITIONING AUSTRALIA’S CCS DEVELOPMENTS

RISKS, OPPORTUNITIES AND BENCHMARKS

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Accelerating the deployment of CCS for a net-zero emissions future.

WHO WE ARE
International CCS think tank with offices around the world.

Over 200 members across governments, global corporations, private companies, research bodies and NGOs, all committed to a net-zero future.

WHAT WE DO
Fact-based influential advocacy, catalytic thought leadership, authoritative knowledge sharing.

Global Snapshot

GLOBAL STATUS OF CCS

Number of facilities in operation rises 54%

77

Number of facilities in operation rises 54% year on year

64 Mtpa

Capture capacity in operation rises 25% year on year

513 Mtpa

Total capture capacity rises 23% year on year

44 Mtpa

Capture capacity in construction in July 2025

Commercial CCS facilities by number and total capture capacity

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Global Snapshot

WHERE THERE IS POLICY, THERE ARE PROJECTS

Notable policy advances over the past 12 months are providing greater certainty for investors

46%

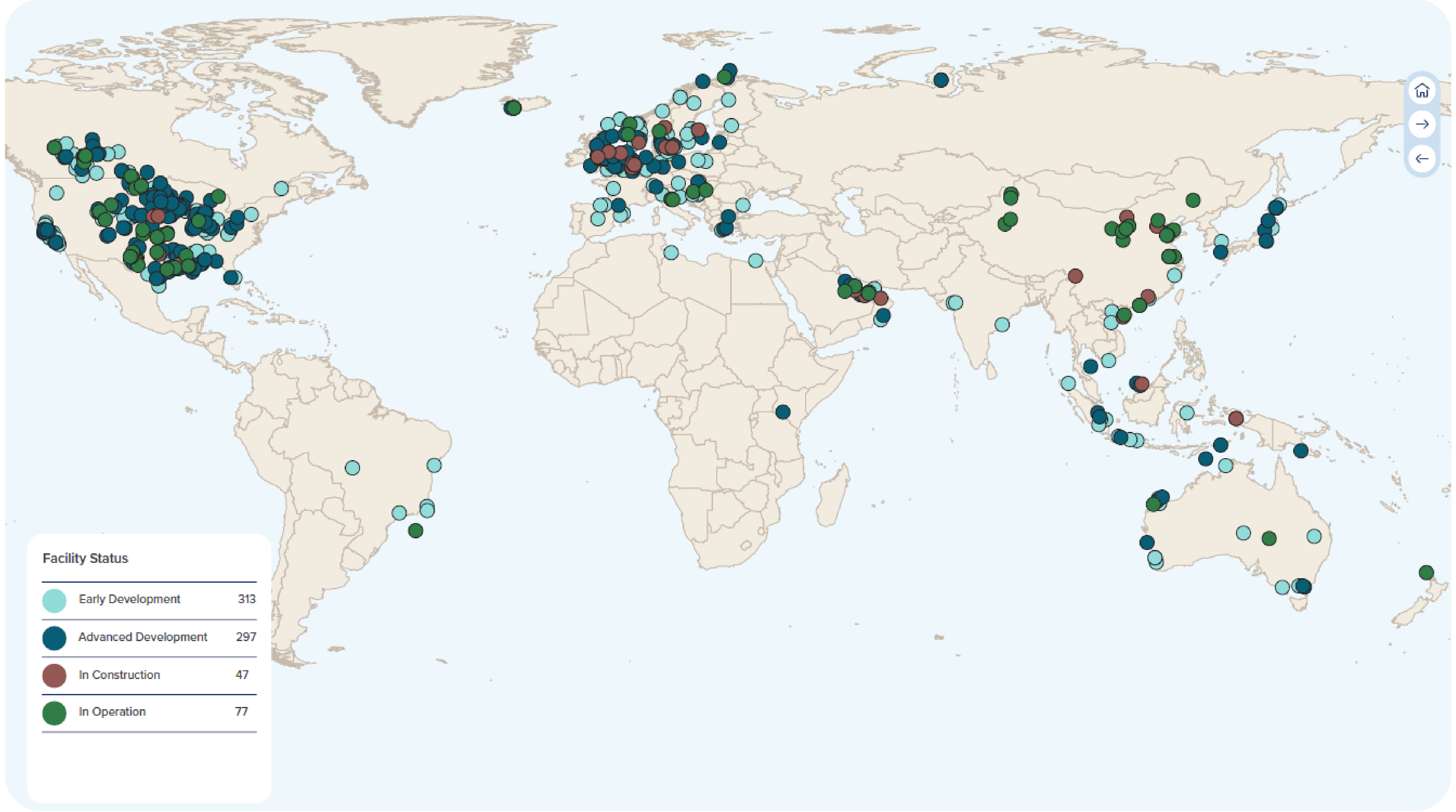
Increase in the capture capacity of facilities in advanced development (FEED) from 180 to 262 Mtpa.

734

Total number of facilities rises 17% year on year

513 Mtpa

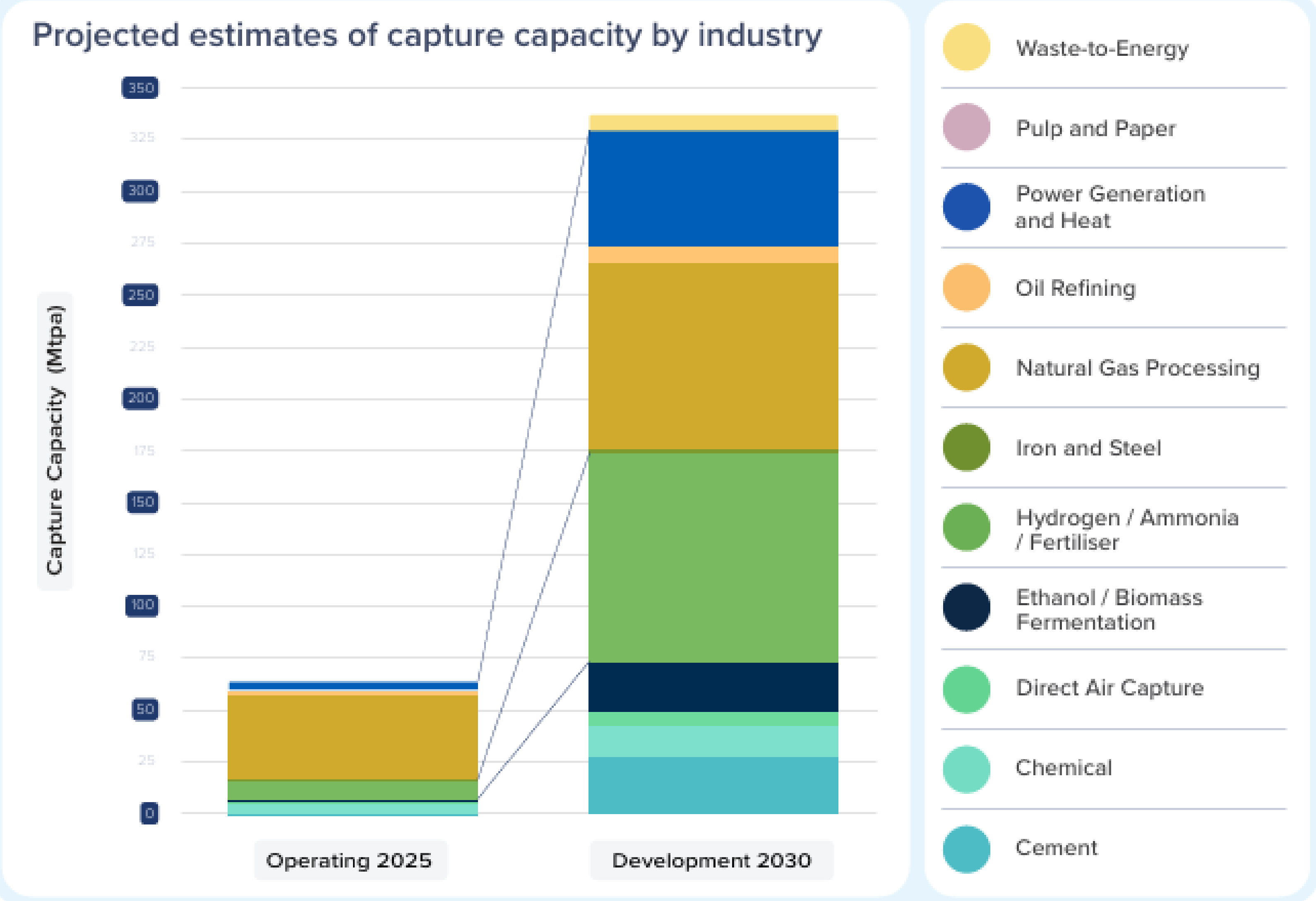
Total capture capacity rises 23% year on year

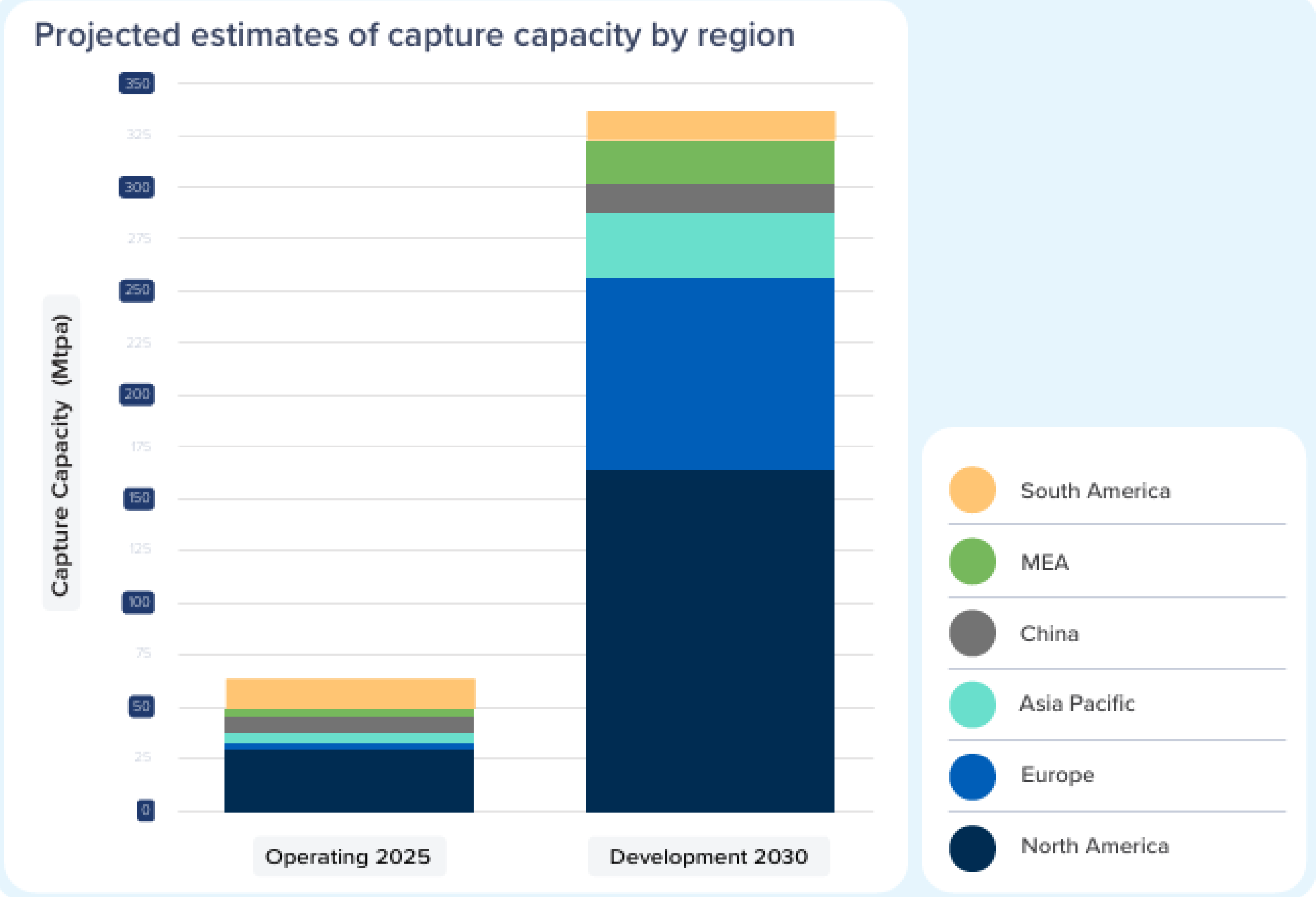


OUTLOOK TO 2030

Expansion across all industries gaining pace.

Continued growth in CCS in natural gas processing (mostly reservoir CO_2)





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Challenges & opportunity for gas sector

Alignment with National Net Zero Plan and ongoing social license will depend on continuing, verifiable cuts to GHG emissions.

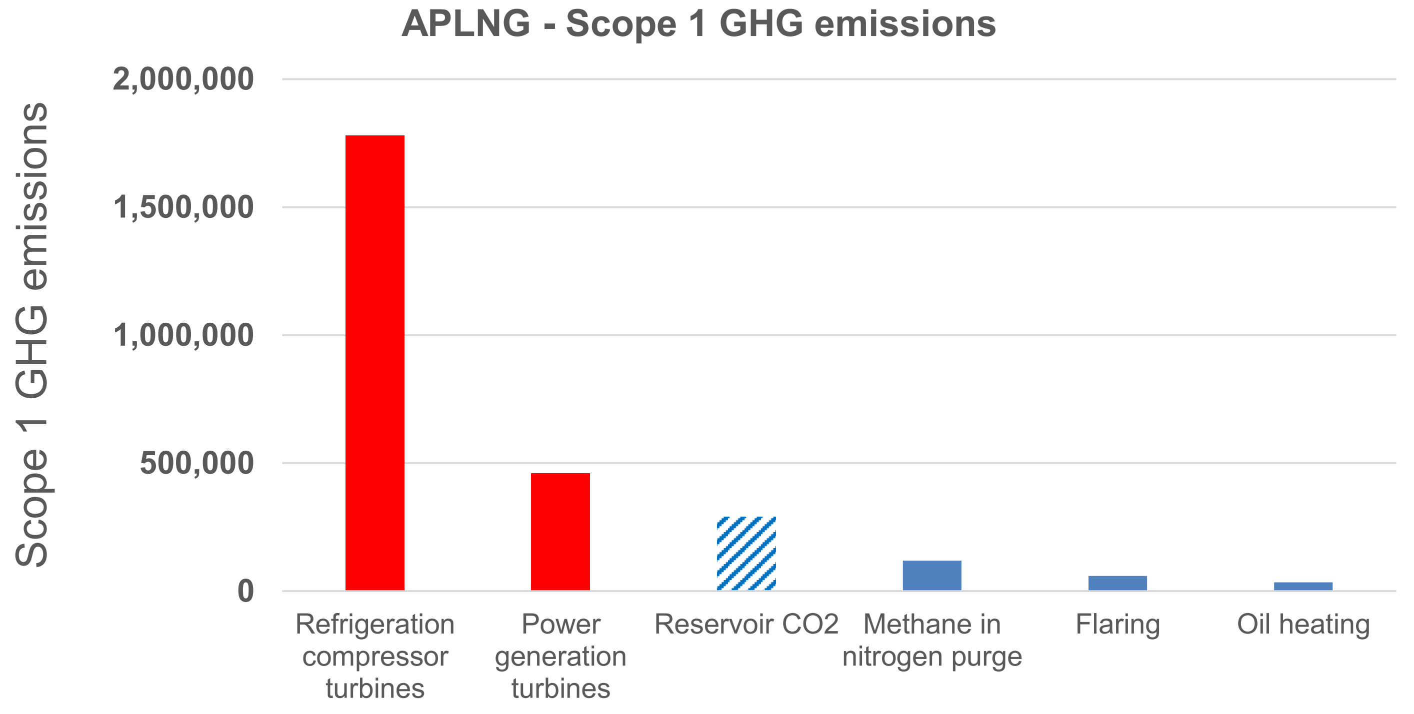
Key sources across sector where CCS plays a key role:

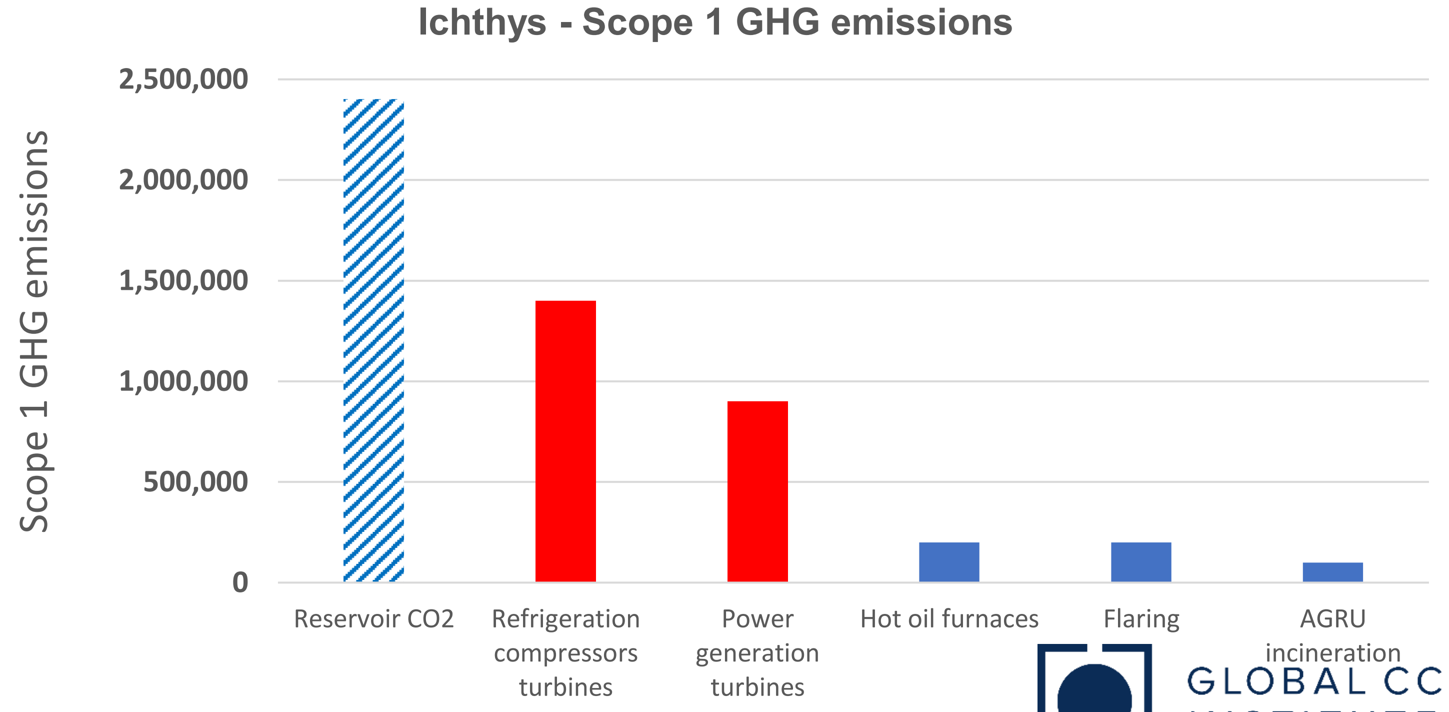
Current sources:

- Venting of reservoir CO_2 – lowest-hanging fruit for larger gas plants and LNG plants. CCS is only realistic option. AGRU already doing capture – these projects are about CO_2 compression, transport and storage.
- Combustion of natural gas in gas turbines (refrigeration + power generation) at upstream / LNG facilities – more challenging, higher cost per tonne of CO_2. Require dedicated additional capture units. Fundamentally higher cost than reservoir CO_2.
- CO_2 emissions from gas-fired power generation (not in scope today). Biggest CO_2 contributor in natural gas value chain.

Future sources (revenue opportunities for CCS Network Operators)

- Imported CO_2 brought in by ship, combined with local CO_2 transport and storage networks. Competition emerging in APAC region, especially from Indonesia and Malaysia.
- Taking CO_2 from adjacent facilities in other sectors (e.g. chemicals), helping with economies of scale.





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Australian CCS progress will be centred on the gas sector

Two world-scale vertically-integrated CCS projects: Gorgon (2019) and Moomba (2024). High scale and low unit cost made these possible.

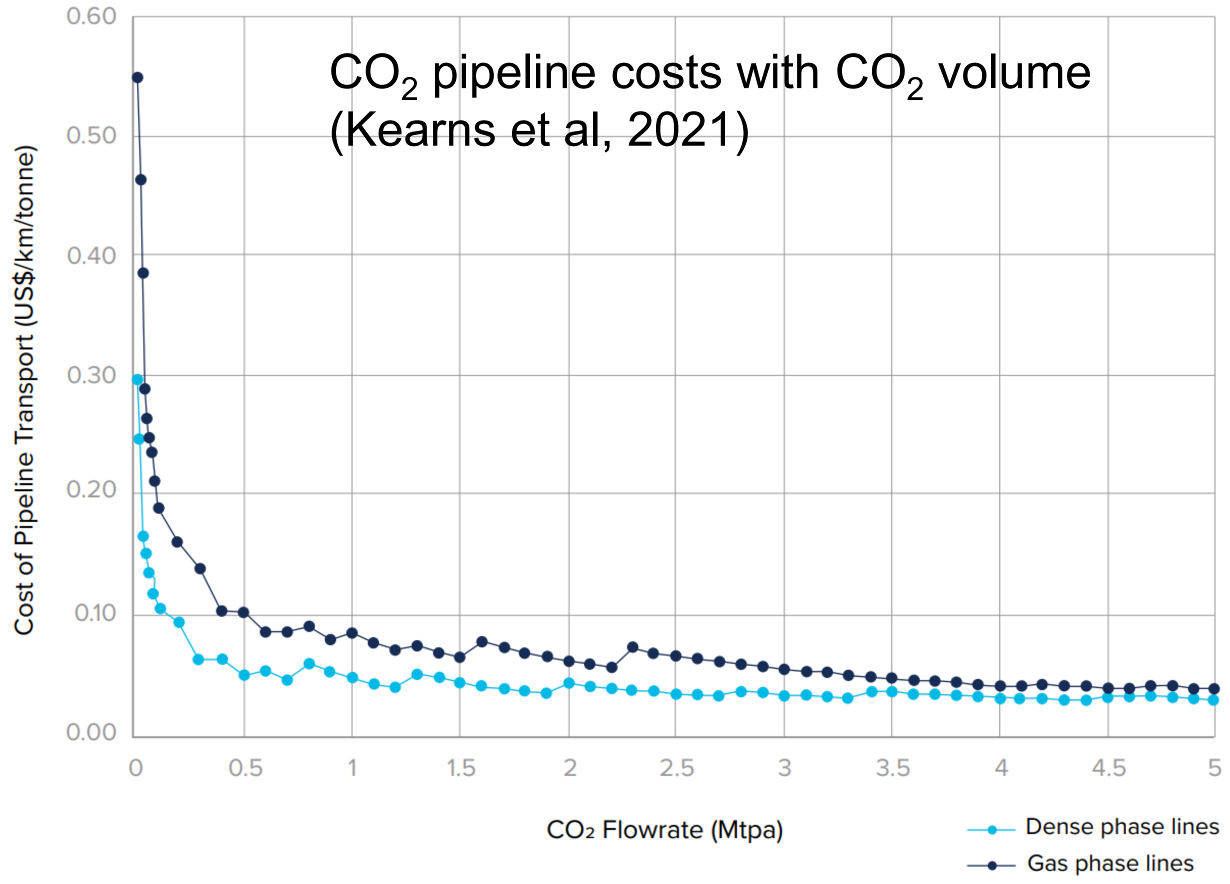
On current policy settings, deployment will be limited. Even with increased incentives, cost will be a primary consideration in which projects proceed.

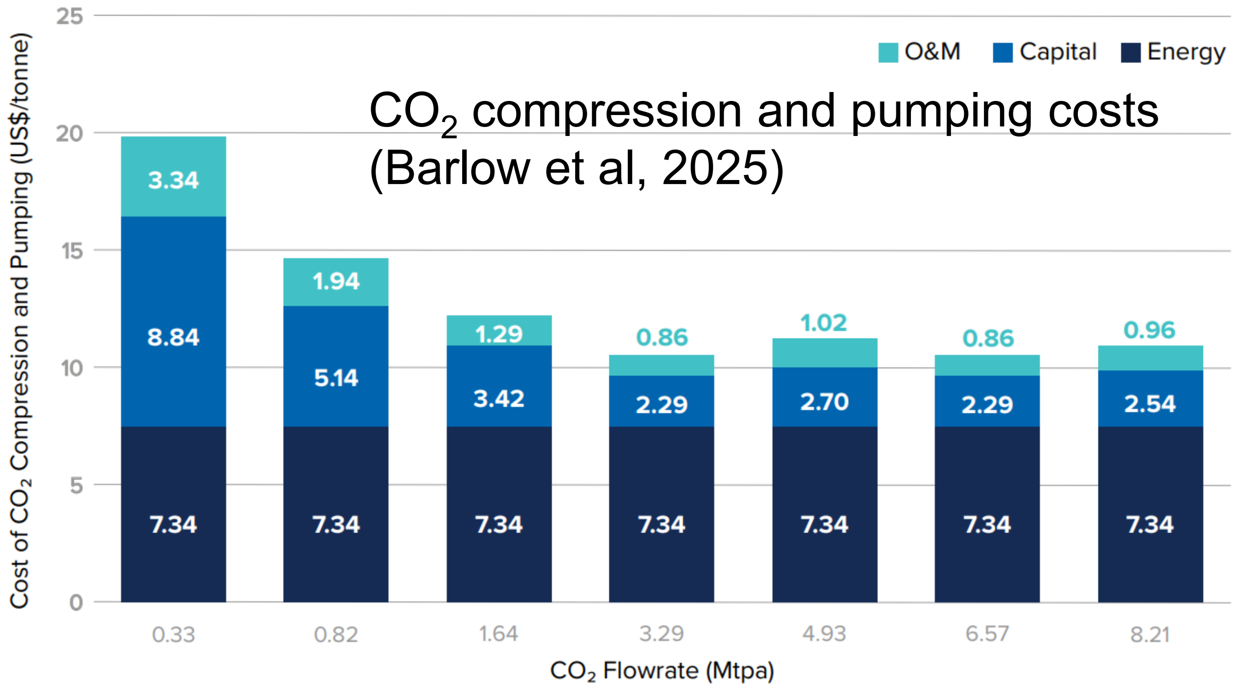
Safeguard Mechanism will increase financial incentives over time, but effect is gradual and may not be sufficient for some CCS projects.

CO_2 network developments reduce cost through economies of scale. Internationally these have become the primary means of developing CCS decarbonising multiple facilities/industries.

Gas sector provides key ingredients for successful CCS Networks:

- Experience in building key elements – pipelines, compression, storage wells, liquid-transporting ships.
- Reservoir CO_2 volumes sufficient to provide required economies of scale to reduce decarbonisation costs for the whole network (reduces unit costs of compression, pumping, pipelines, and storage). CCS can reduce net costs of moving to net zero economy-wide.
- These capability and economic drivers will keep the gas sector as the essential element in most CCS network deployments





INCENTIVES FOR DECARBONISATION & ALTERNATIVE OPTIONS

- Corporate sustainability goals
- Customer expectations re Scope 3 emissions
- Safeguard Mechanism: direct financial implications for major emitters including gas facility operators.

The Safeguard Mechanism is a baseline and credit scheme for Scope 1 (direct) emissions.

Facilities are allocated emissions baselines, and if they exceed these, they must obtain and surrender Australian Carbon Credit Units (ACCUs) or Safeguard Mechanism Credits (SMCs) for their emissions over the baseline.

The 2023 revisions to the Safeguard Mechanism introduced **declining baselines** for facilities.

All facilities (not just gas) will exceed their baselines eventually. This will increase demand for ACCUs, putting upward pressure on prices in the future. Effect limited by cap on ACCU prices (current cap $82.68)

Decarbonising gas operations will reduce the ACCU surrender obligation, and hence reduce costs if CCS costs offset by ACCU savings (plus any other emerging incentives).

Source: Australia Pacific LNG

Zero baseline for reservoir CO2 has made CCS (for new facilities) BAU. Decarbonising gas turbines is not.

Options to decarbonise gas turbines in Australia LNG plants:

(1) Drive refrigeration compressors with electric motors and renewable electricity and cease on-site power generation – this is known as eLNG (see Freeport LNG in the US)

(2) Improve the thermal efficiency of gas turbines

(3) Improve the efficiency of refrigeration compressors and electricity use on-site.

(4) Generate hydrogen from natural gas for use in the gas turbines, while capturing the CO_2 from hydrogen production.

(5) Retrofit carbon capture and storage (CCS) on existing gas turbine installations.

1-3 are expensive or marginal in terms of making deep emissions cuts.

4 can present retrofit issues as GTs not designed to use hydrogen.

5 is remaining pathway to deep decarbonisation in retrofits.

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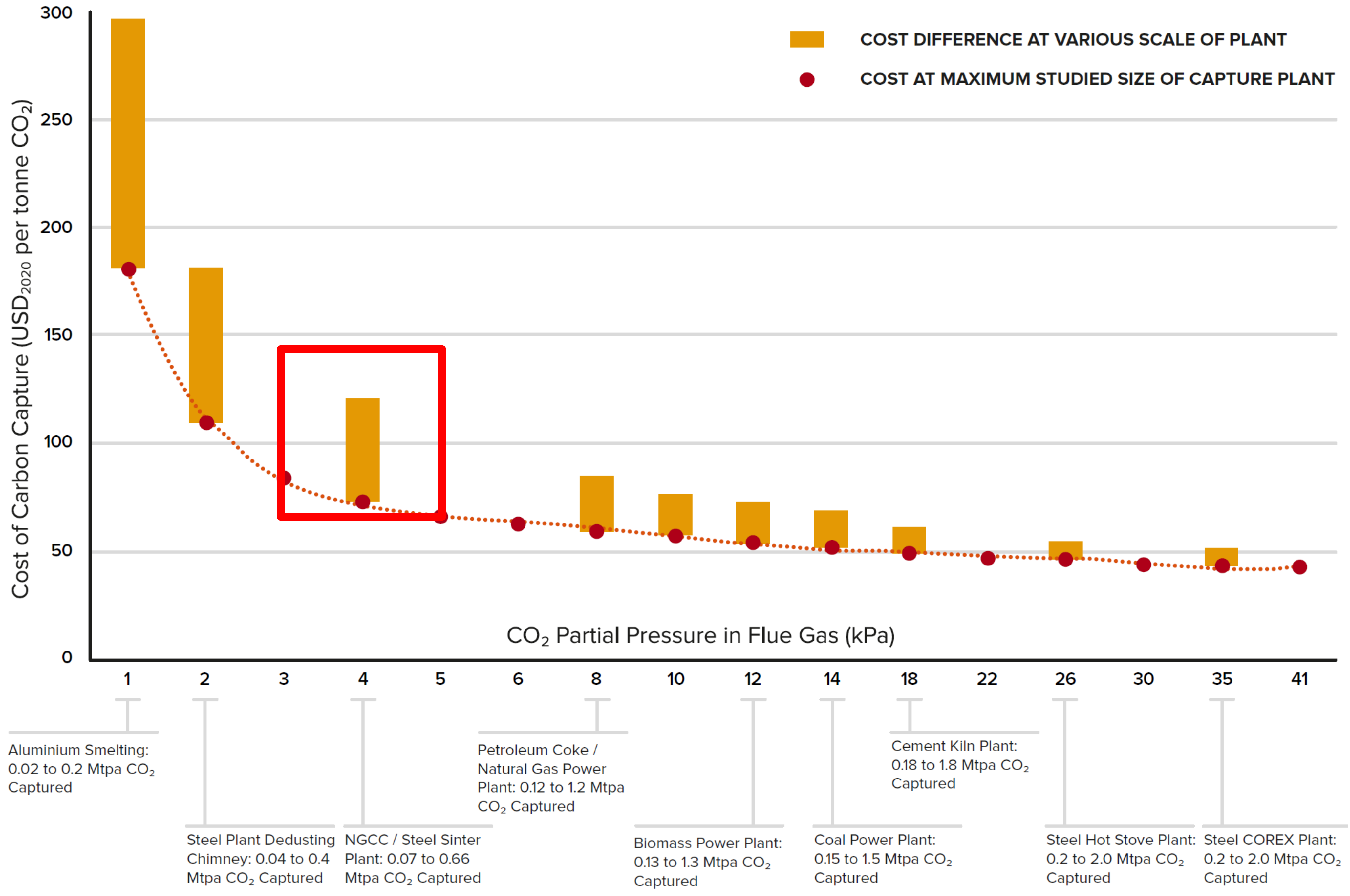
COST OF CO_2 CAPTURE – BENCHMARK TECHNOLOGY (MEA)



Kearns, Liu and Consoli (2021) *Technology Readiness and Costs of CCS,* Global CCS Institute.

Kearns et al. (2021) assessed benchmark levelised CO_2 capture costs as a function of source gas CO_2 partial pressure (kPa) and source gas CO_2 annual flowrate (Mtpa).

Methane combusted stoichiometrically with air yields an outlet CO_2 partial pressure of ~9 kPa at atmospheric pressure.

Gas turbines typically operate with high excess air, pulling typical partial pressures down to the 3-5% range.

Capture costs in range of USD 60-140 depending on volume. Less attractive than in other industrial applications. This is why MEA has not made inroads into GT applications.

High costs due to physical scale of equipment, high energy consumption, solvent degradation.

Can boost volumes by aggregating flue gas from multiple GTs. Could tweak excess air a little. Both would reduce costs.

But primary opportunity to bring costs down is new technologies.

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NEXT-GENERATION CAPTURE TECHNOLOGIES (1/2)

ENZYMATIC / CATALYTIC SOLVENTS

Solvents for CO_2 capture rely on efficient kinetics to swiftly transfer and react CO_2 within the solution.

1) gas-to-liquid mass transfer, then;
2) Chemical reaction of CO_2 with solvent compounds to form a stable solution.

The rate of CO_2 capture directly depends on these combined kinetics. Reaction rate is often the rate-limiting step.

Catalysts or enzymes can boost reaction rates, especially in flue gas applications, allowing for smaller capture systems.

CO_2 capture is faster, allowing for smaller physical equipment sizes and reducing Capex.

CO_2 Solutions Saipem, based in Canada, use proprietary enzymes in a potassium carbonate solvent.

MODULARISATION

Most capture plants are unique.

The costs associated with bespoke engineering design and on-site equipment assembly/construction are considerable.

Modularisation is the approach of standardising equipment and flowsheets, as well as making the equipment transportable to site.

Capex savings through mass production, design once/build many approach.

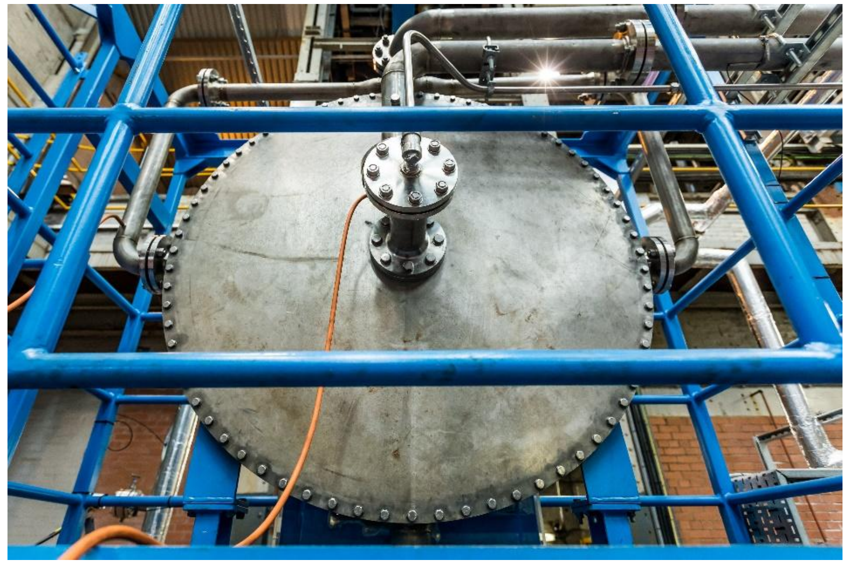
Together these enable economies of scale of fabrication and spreading engineering costs across multiple plants.

SLB Capturi has developed a range of modular, solvent-based capture plants branded as Just Catch™. Much of the equipment is containerised.

Standard capacities: 40, 100 & 400 kTpa CO_2 capture capacities.

NEXT-GENERATION CAPTURE TECHNOLOGIES (2/2)

PROCESS INTENSIFICATION



Making CO_2 capture plant capital investments work more intensively is an effective strategy to reduce capture costs.

One high-profile approach has been developed by Carbon Clean in the UK.

They have developed a rotating packed bed absorption system branded CycloneCC™.

CO_2 absorber uses centripetal force to effectively enhance the gravity. This enables far more gas and liquid to pass through an absorber of a given size.

This enables a much smaller absorber unit, reducing costs and footprint.

Reduced capital costs and a smaller capture plant footprint both contribute to bringing down capture costs.

NEW SOLVENT CHEMISTRIES

Companies including Mitsubishi Heavy Industries, C-Capture, and Carbon Clean, have developed novel solvent chemistries for their capture systems.

These next-generation solvents have a range of improvements, particularly:

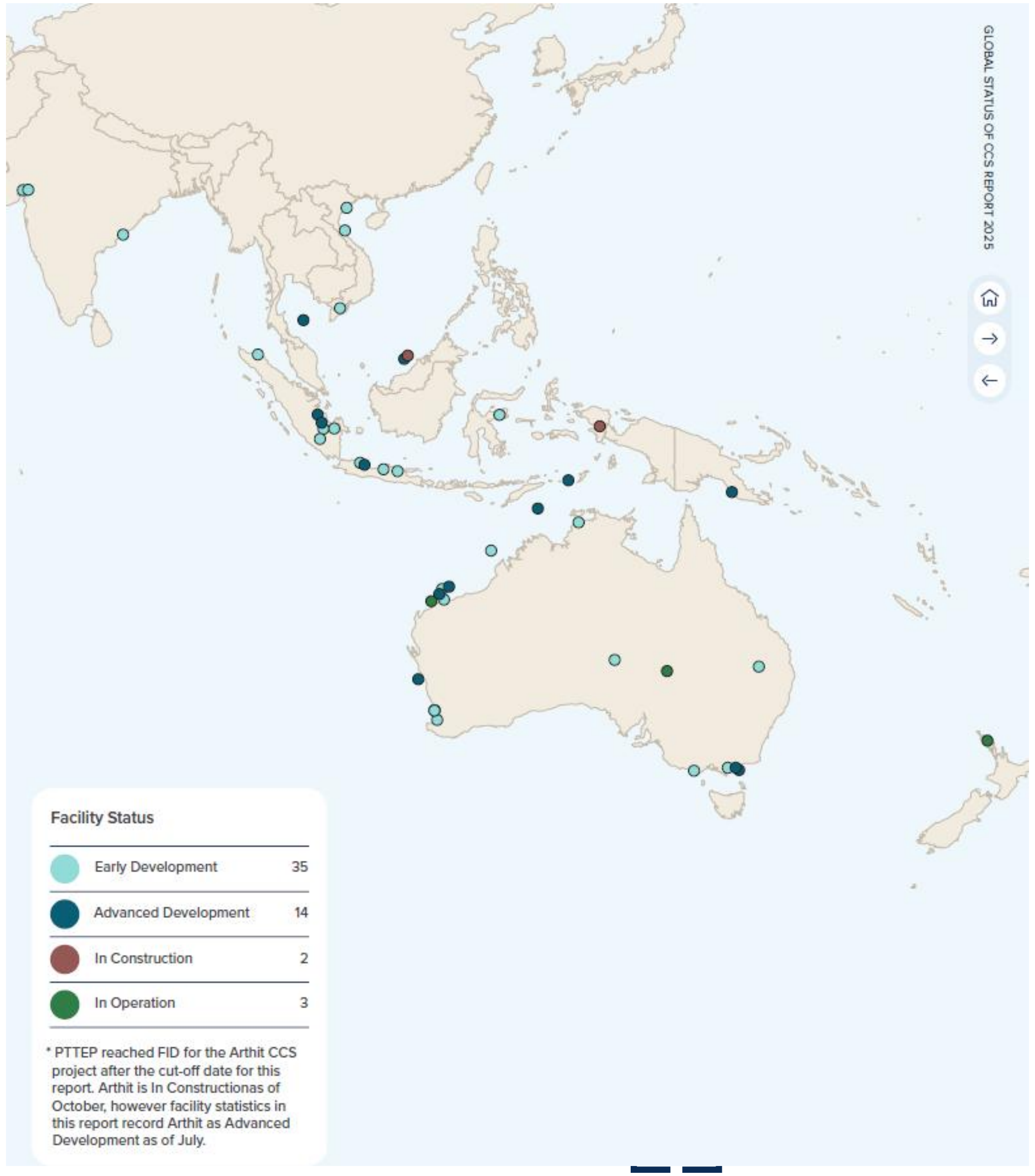
- Improved solvent stability, reducing or eliminating solvent degradation to reduce opex;
- Reduced heat requirements for regeneration of solvent (heat is the largest opex item in solvent-based capture)
- Improved capture kinetics, enabling smaller CO_2 absorbers and desorbers to be built for a given application, which lowers capex.

Improved solvents support lower capital and operating costs compared with conventional amine-based capture systems.

Australia and SE Asia

Critical role of CCS creating both opportunities and challenges

- **Progress:** Key regulatory gains in Australia, Indonesia & Malaysia.
- **Collaboration:** Cross-border CO_2 trade advancing as governments strike deals & companies form JVs/MoUs.
- **Challenges:** Low-cost CCS applications moving ahead, but higher-cost projects lack policy support.
- **Momentum:** New projects and studies announced as CCS opportunities gain traction.



Regional Spotlight

Australia, SE Asia and India

Regulation, projects, collaboration

- Regulatory progress: Governments (Commonwealth and State/Territory) have been establishing CCS regulations and frameworks, but incentives are not yet sufficient to fully unlock large-scale investment and deployment. Only lowest-cost opportunities (e.g. reservoir CO_2) will emerge under current settings

- Collaboration & transport: Cross-border MoUs, CO_2 shipping hubs, and innovative CO_2 vessels improving regional CCS deployment. CCS Networks will increasingly be justified by imports of CO_2.

- Operational & developing projects: Australia has early-mover advantage but Malaysia and Indonesia moving rapidly. Opportunities to take CO_2 from Japan & South Korea will move north if Australia is too slow to capitalise. Requires clear government and industry intent to encourage international partners to invest.

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