deepCstore

Unlocking Offshore CO2 Storage in the APAC region with Floating CCS Hub Developments

SEAPEX 7 March 2023

Table of Contents

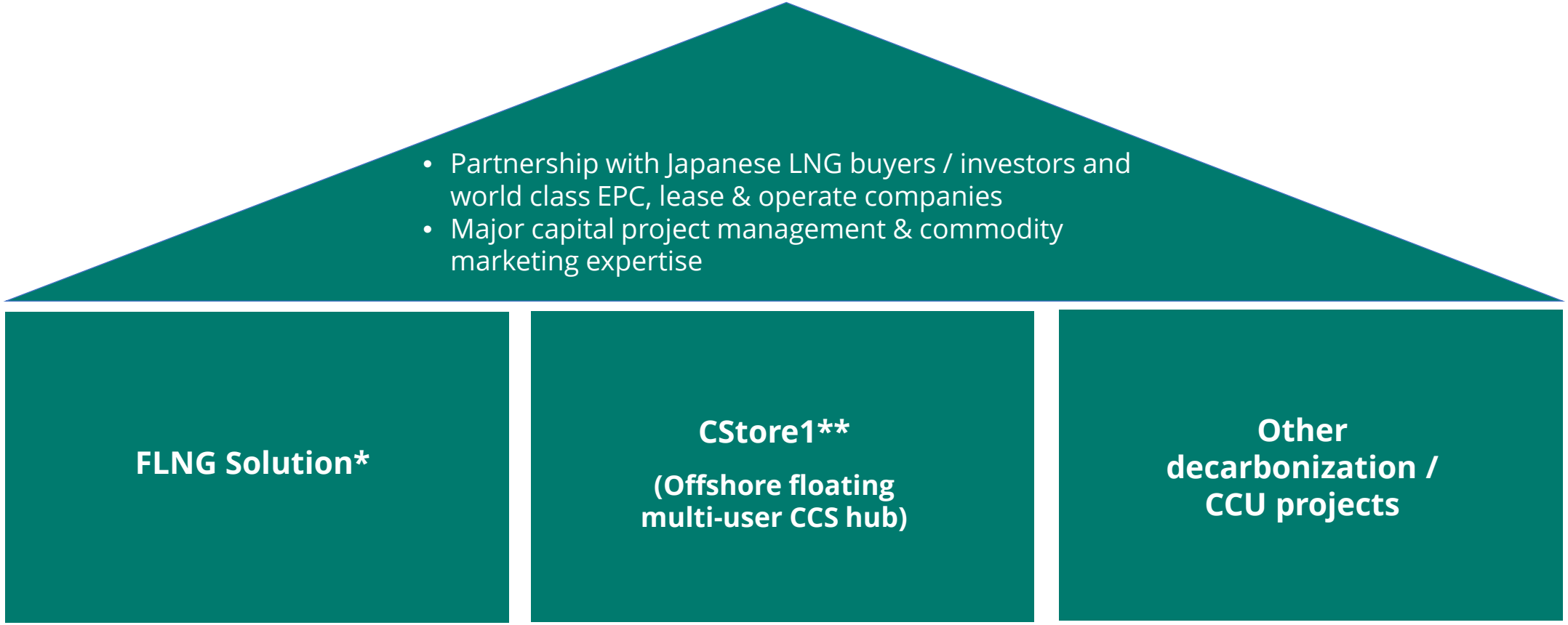
Acknowledgements

- deepC Store Limited (DCS)

- DCS's partners (in alphabetical order)
  - Add Energy Group
  - Commonwealth Scientific and Industrial Research Organisation (CSIRO)
  - JX Nippon Oil & Gas Exploration Corporation
  - Kyushu Electric Power
  - Mitsui OSK Lines
  - Osaka Gas and Osaka Gas Australia
  - PGS
  - Technip Energies
  - Toho Gas

Overview of TBE & dCS

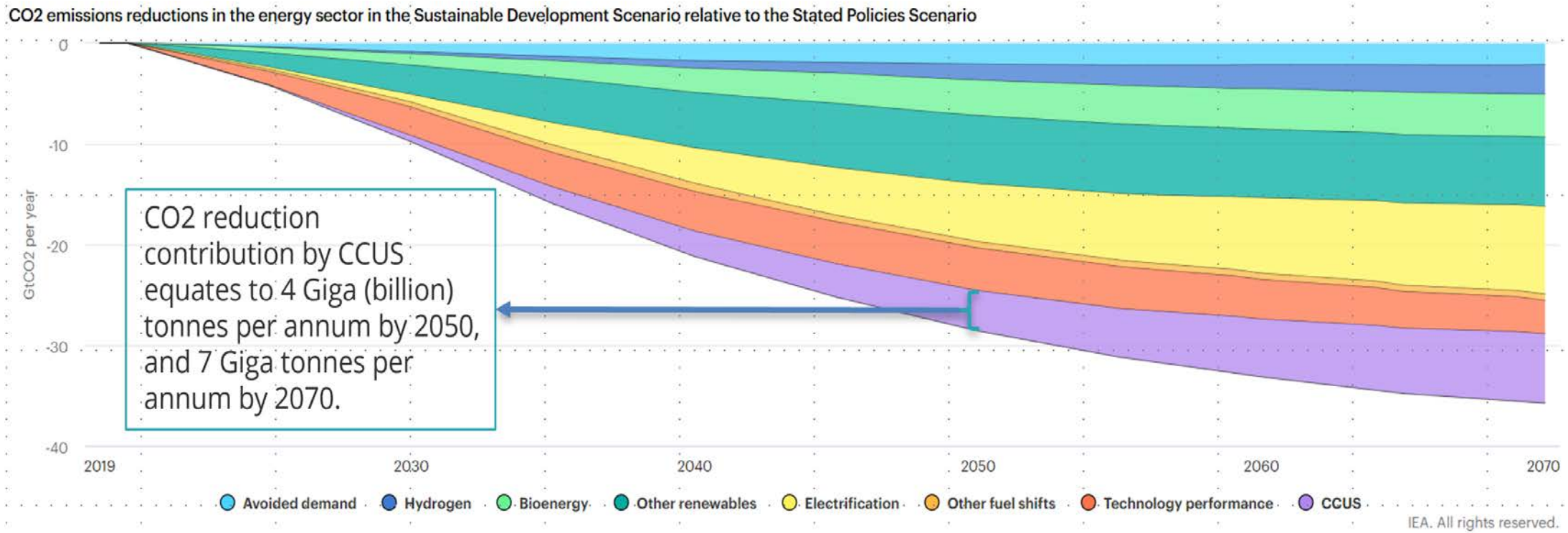
The founders of TBE & dCS realise step changes in value creation by developing & operating major capital projects for LNG and CCS, with interest to do the same for other decarbonization / CCU projects.



* FLNG is developed by TBE

** CStore1 is developed by dCS

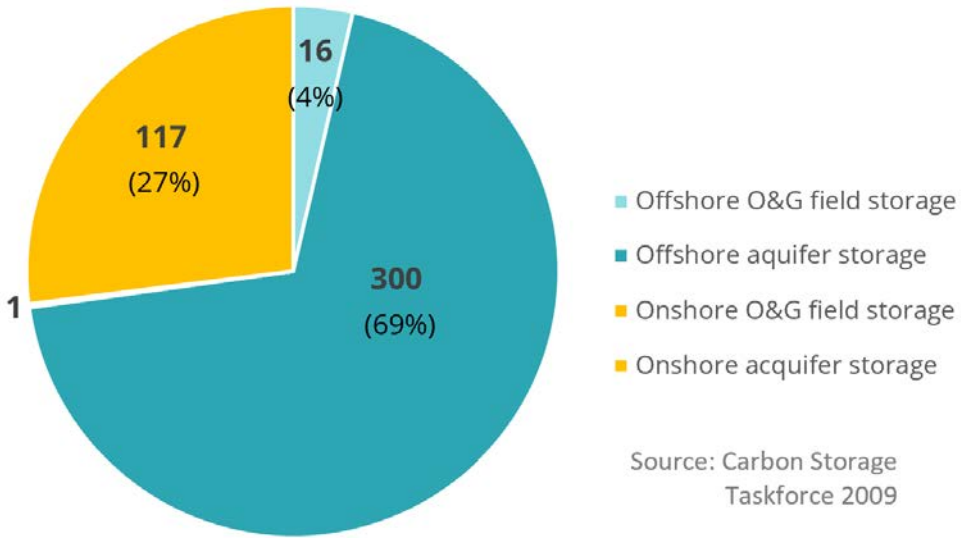
Why CCS?



- UN's IPCC & IEA forecasts ~4 billion tonnes p.a. needs to be CCUS-ed by 2050 to meet Paris Agreement target.
- Only 27 large scale CCS facilities totaling ~37 million tonnes p.a. of CCS operational globally. Massive number of new CCS projects needed by 2050.

Why Offshore Australia & Worldwide?

CO_2 Storage Capacities in Australia (Total 434 Billion Tonnes)



Source: Carbon Storage Taskforce 2009

Global CO_2 Storage Capacities (Total 13,000 Billion Tonnes)

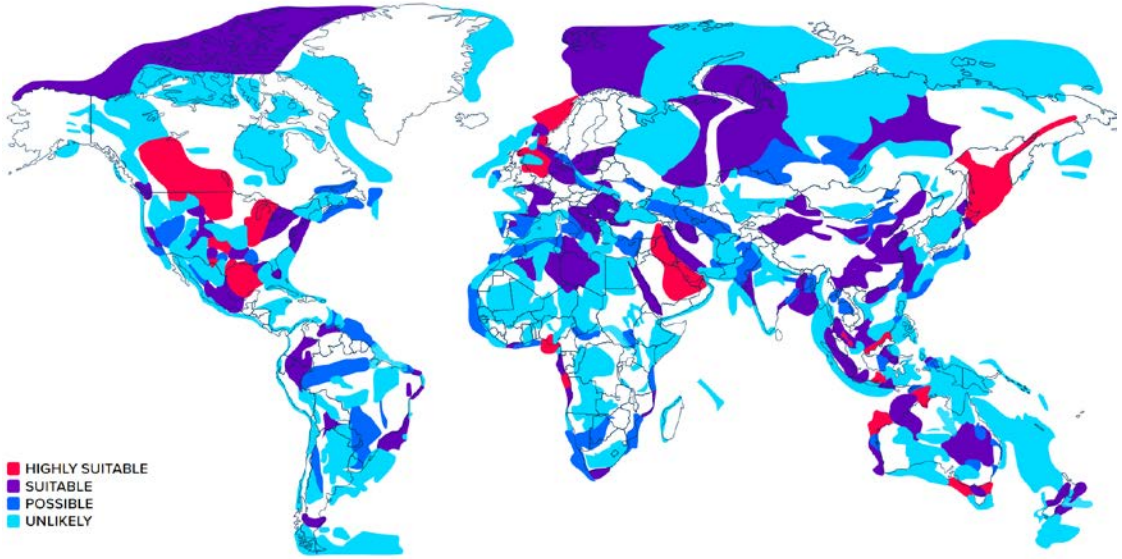


FIGURE 31 SUITABLE STORAGE REGIONS OF THE WORLD BASED ON THE GLOBAL CCS INSTITUTE'S STORAGE BASIN ASSESSMENT DATABASE

To fully unlock the CO_2 storage capacity in Australia and worldwide, the CCS industry must address the key challenge of the CO_2 storage sites and CO_2 emission sources not located in proximity.

Global Competition for Capital & Talent is Intensifying

- Aside from EU & USA, dCS considers Australia to be the most suitable jurisdiction to pursue CCS projects.
- dCS seeks further regulatory guidance to enhance Australia's CCS business environment.

dCS Assessment of CCS Business Environment Readiness

	EU	**US**	Australia	**Asia**	**Japan**
CO_2 storage potential	○	○	○	○	△ / ○
CCS legislation	○	△	○	△	△
Carbon pricing	○	△ → ○ (via subsidy)	△	△	△
CCS project delivery capability	○	○	○	○ / △	△
Community understanding	△ / ○	△	△	△	△

CCS Status in the Asia/Pacific Region

- **China**
  - 38 projects (mostly demonstration) operational, with CO2 capture capacity 3 MTPA (as of 2021) & includes Jilin EOR/CCS 0.6 MTPA.
  - Shengli EGR/CCUS (1 MTPA) started operation Aug 2022
  - Ordos coal power+CCS (1.5 MTPA) FID-ed
- **Malaysia**
  - Kasawari CCS (~3.3 MTPA) FID-ed Nov 2022. Ops start ~2025
  - Lang Lebah emerging as 2nd Gas+CCS project
- **Indonesia**
  - Tangguh & Vorwata EGR/CCUS (up to 4 MTPA) approved by SKK Migas Aug 2021. FID ~2023 & Ops start ~2026/2027
- **Thailand**
  - Arthit Gas+CCS (~1 MTPA) announced by PTTEP Jun 2022, targeting Ops start ~2026

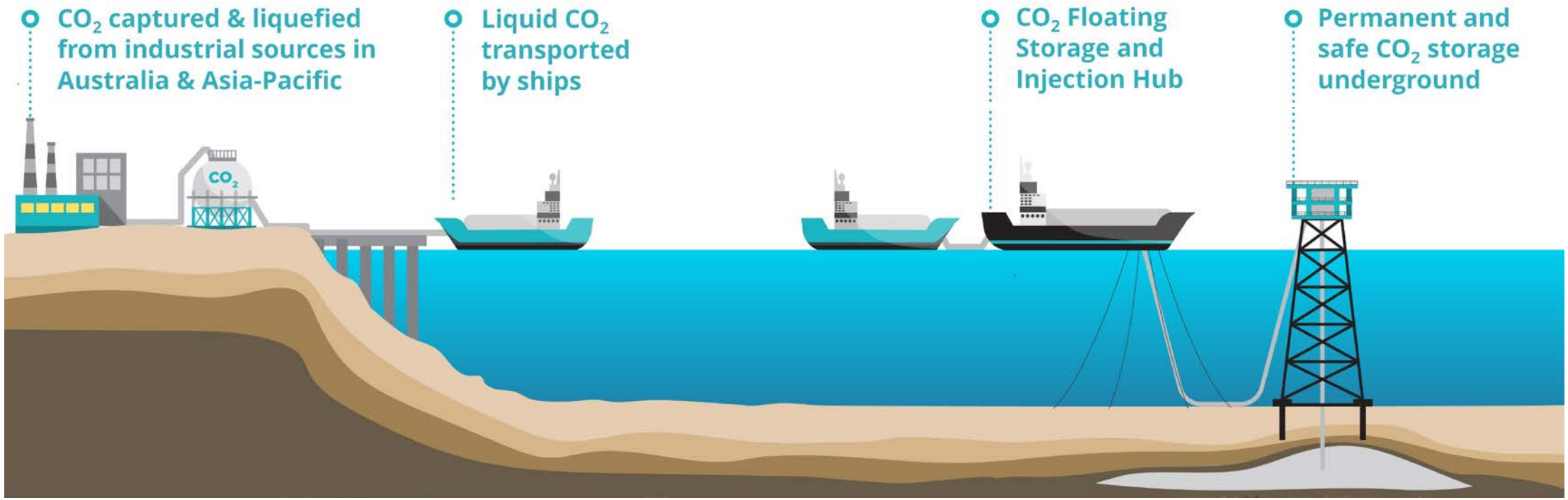
- **Australia/Timor Leste (TL)**
  - Gorgon CCS (up to 4 MTPA) in operation.
  - Moomba CCS (1.7 MTPA) FID-ed Nov 2021 & Ops start 2024
  - Bayu-Undan (TL) CCS (up to 10 MTPA) FEED Mar 2022, targeting FID 2023

Source: Global CCS Institute (2022)

CCS Status in the Asia/Pacific Region

- Some of the larger emitting countries such as Japan and Korea do not have the optimum geological conditions for significant storage.
- These countries will seek to collect and deliver significant volumes of CO2 to host nations with more appropriate geology for successful CO2sequestration.
- dCS has developed a process that can receive, transport and sequester 3rd party CO2 focused on sequestration in Australia.
- There is a need to establish bilateral agreements to allow for the movement of CO2 across international borders.

Floating CCS Hub - “CStore1”



CCS: 5 Stage Geoscience Evaluation Process

- Site details (geographic location, infrastructure etc.)
- Interaction with natural/existing resources
- Storage capacity
- Injectivity potential
- Containment

Most parts of the workflow are off the shelf technologies, tried and tested but certain challenges are faced

Factor	Criteria	Inputs
Site details (Is the location economically, technically, socially viable?)	Distance from source	Point location buffer
	onshore/offshore (Water depth)	Bathymetry
	Reservoir depth	Depth structure map, formation tops, check datum
	Accessibility	Jurisdiction, topography, population, wave conditions, archaeologically or environmentally significant
	Infrastructure	Cadastral layers, pipelines, easements, lease,
Existing resources (Will any natural resources at the site be compromised?)	Known hydrocarbon resources	Shows, fields, stranded, EOR
	undiscovered	Active petroleum system, plays, exploration data
	Other	Ground water, coal, environmental, biological, geothermal, waste disposal etc
Storage capacity (Will the site meet the volume of the source? (MT/Per An x N years))	Reservoir area	Depth structure map, paleo-depo/sand presence map, lease boundary, fault boundary
	Reservoir thickness (net)	Formation tops, isopach map
	Net/gross (sand%)	Core, logs, AI seismic inversion, analogues
	porosity	
	Temperature (depth)	Logs, pressure tests, water samples
	Pressure (depth)	
	Salinity	
Injectivity (Do the reservoir conditions allow for deliverability of source? (T/Per day/per well))	Porosity	Core, logs, AI seismic inversion, analogues
	Permeability	Core, logs, production data, LoTs, transforms
	Thickness (sands)	Core, logs, formation tops
	Continuity	Fault maps, reservoir maps, production & pressure injection tests
Containment (Will the trap and seal retain the proposed volume (column height) of CO2 in the long term?)	Trapping type* (structural, residual, geochemical)	Structural maps, salinity, Sgr, geochemical analysis, production data
	Trap style*	hydrodynamic, fault interp, juxtaposition analysis, SGR
	Cap rock continuity	Sequence strat boundaries, paleo depo maps, isopachs, fault interp, gas seeps, seismic attributes
	Cap rock thickness	Formation tops, Vclay logs, cores
	Cap rock properties	Lithology from core/logs, minerology, capillary entry pressure
	Tectonic setting	Seismicity, fault reactivation, fault orientation WRT stress regime

CCS: Geoscience Challenges

- Plume monitoring: technology, duration and cost (during and post injection)
- Pressure studies: fracture gradient studies pre and post injection
- Seal integrity: pressure, faulting and diagenesis
- Reservoir geochemistry: interaction/diagenesis of CO2 with reservoir
- Integrity of legacy wells: who is responsible for them and integrity monitoring post injection?
- Saline injection: seismic required over large areas, containment (structural/stratigraphic), CO2 absorption into water

CCS: Technologies Required

- Most parts of the workflow are “off the shelf” technologies, tried and tested
- Trap integrity will be a prime focus and will require:
  - Structural definition (seismic)
  - Detailed seal studies (cores): thickness, fracture gradient, pressures
  - Diagenesis: interaction of CO2 with the reservoir chemistry
  - Detailed fault studies: seismic history/forecasts, reaction to increased pressure
- Plume monitoring technologies are available, but cost reductions will be required especially in the geophysical space

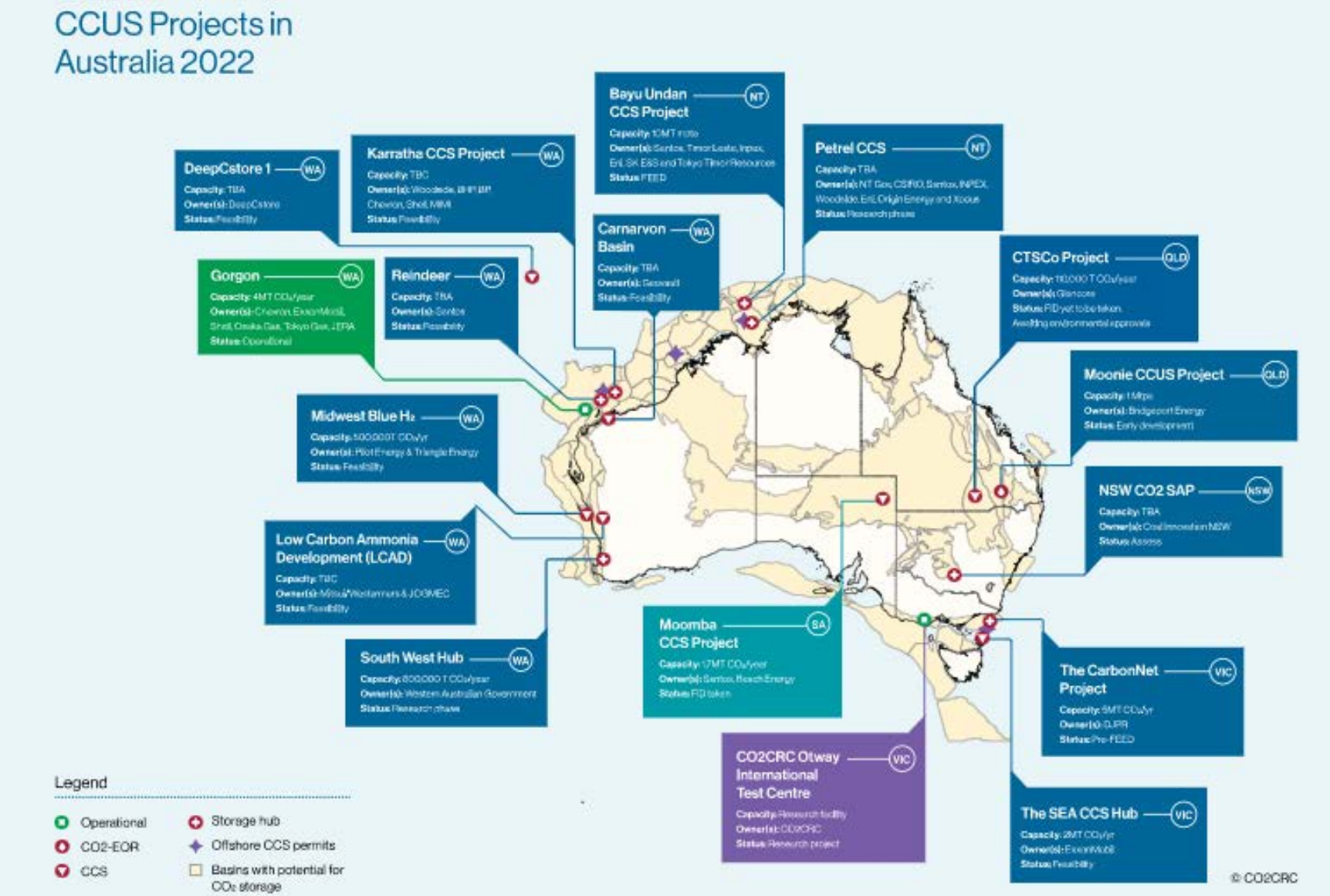
Status and Challenges for CCS in Australia

Source: Commonwealth of Australia (DISER) 2021

- Australia has the worlds largest CCS project Gorgon
- Commonwealth legislation is in place to govern offshore CCS
- State legislation not fully in place for onshore CCS
- Successful CCS bid round held in 2022, 5 awards made under a work programme bidding system
- 2nd bid round expected in 2023

- We must address the distances between storage sites and emission sources
- CCS needs to be made available for all industry sectors (power gen, manufacturing, mining and O&G)
- Legislation required for international transfer of CO2

Australian/Timor Leste CCUS Projects 2022 (CO2CRC)



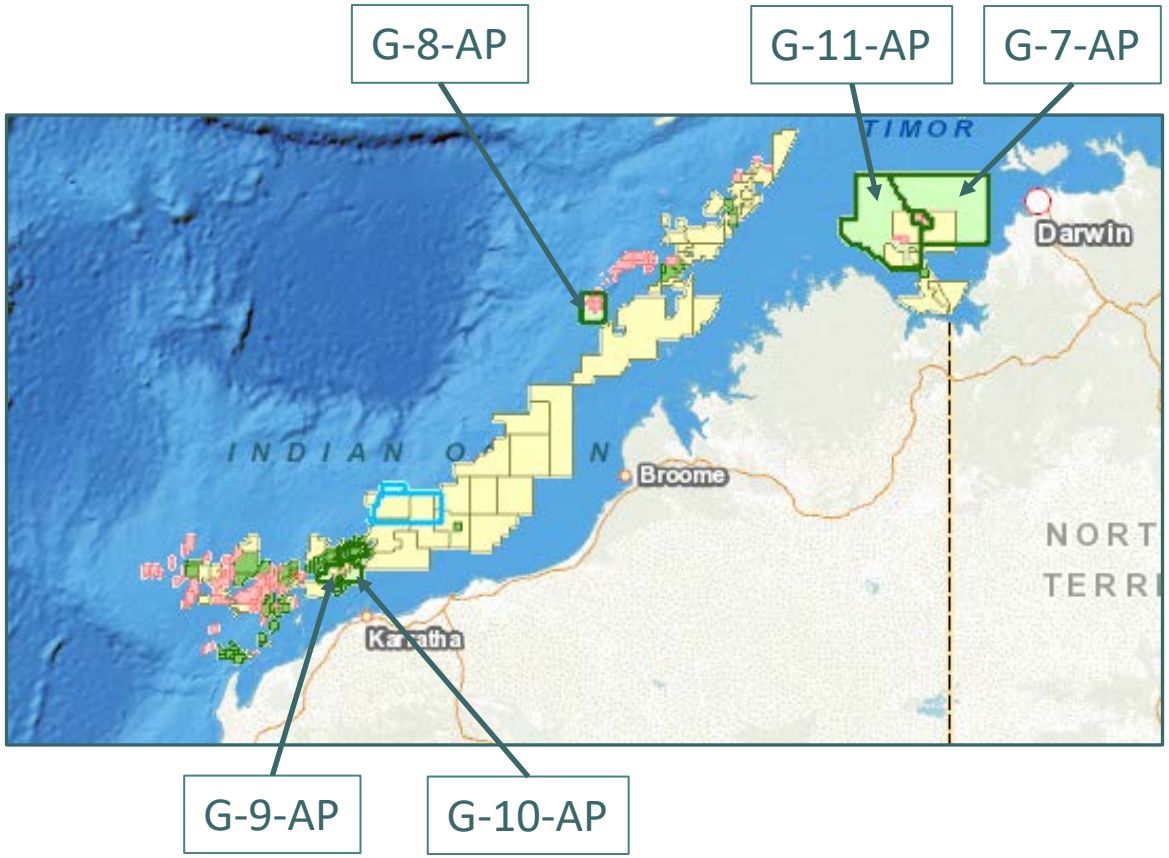
CCS Australia Bid Submission Work Strategy

- The work strategy should link the technical evaluation of the release area, with the work program proposed for the permit term.
- Applicants should propose a work strategy that has capability to significantly advance the understanding of the fundamental suitability determinants of potential GHG storage formations and potential GHG injection sites
- The work strategy should explain how the release area will be explored over the permit term, including how the different work program elements will investigate the fundamental suitability determinants to mature potential storage formations of the area.
- If the applicant has access to, or expects to have access to, a source (or sources) of GHG for storage, this information should also be included, along with a description of the GHG source(s), timing of when the GHG stream is expected to become available for injection, and the nature of any agreements between the applicant and capture facility(ies).
- The proposed work strategy underpinning the work program should significantly advance the understanding of the fundamental suitability determinants of potential GHG storage formations within the release area to demonstrate the existence (or otherwise) of an eligible GHG storage formation

CCS Australia Bid Submission Technical Evaluation

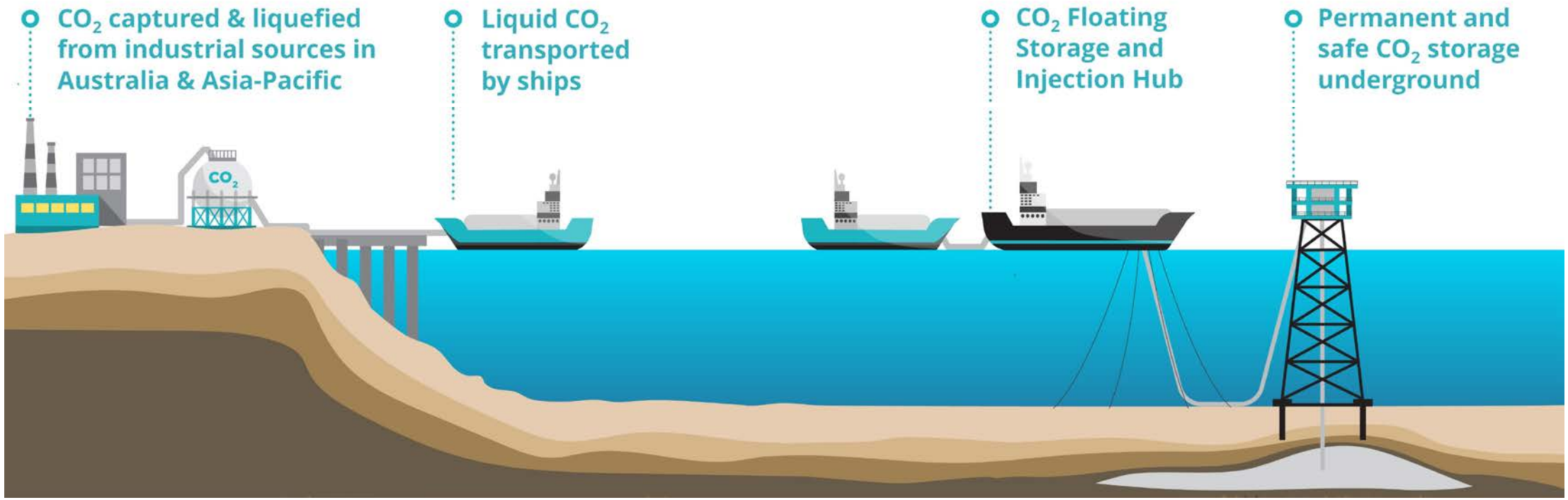
- Understanding of the geology and permanent storage potential of the release area.
- The technical evaluation should include, but is not limited to, a description of:
  - the data and/or studies the technical evaluation is based on
  - any geotechnical studies, seismic interpretation, mapping or any other work that has been undertaken as part of the technical evaluation
  - consideration of the geotechnical characteristics of a geological formation for the permanent storage of a GHG substance
  - consideration of data to support the spatial extent and monitoring of a potential future storage project that might be undertaken in the permit area
  - any potential storage formations mapped within the release area, including supporting material such as images, interpreted seismic sections and horizon maps, including a description of the fundamental suitability determinants that relate to the potential storage formation.
  - how the applicant proposes to use any existing data over the release area, including how this data is to be used in the proposed work program

Australian CCUS Awards 2022



2022 CCUS Awards				
			A$MM	A$MM
Permit	**Basin**	**Company**	**Yrs 1-3**	**Yrs 4-6**
G-7-AP	Bonaparte	Woodside/Total/Inpex	159	6
G-8-AP	Browse	Woodside	4.5	9.5
G-9-AP	Carnavon	Santos/Chevron	16.35	57.33
G-10-AP	Carnavon	Woodside/BP/Shell/MIMI/Chevron	9.86	10
G-11-AP	Bonaparte	Santos/Chevron/Prism	81.33	45.33

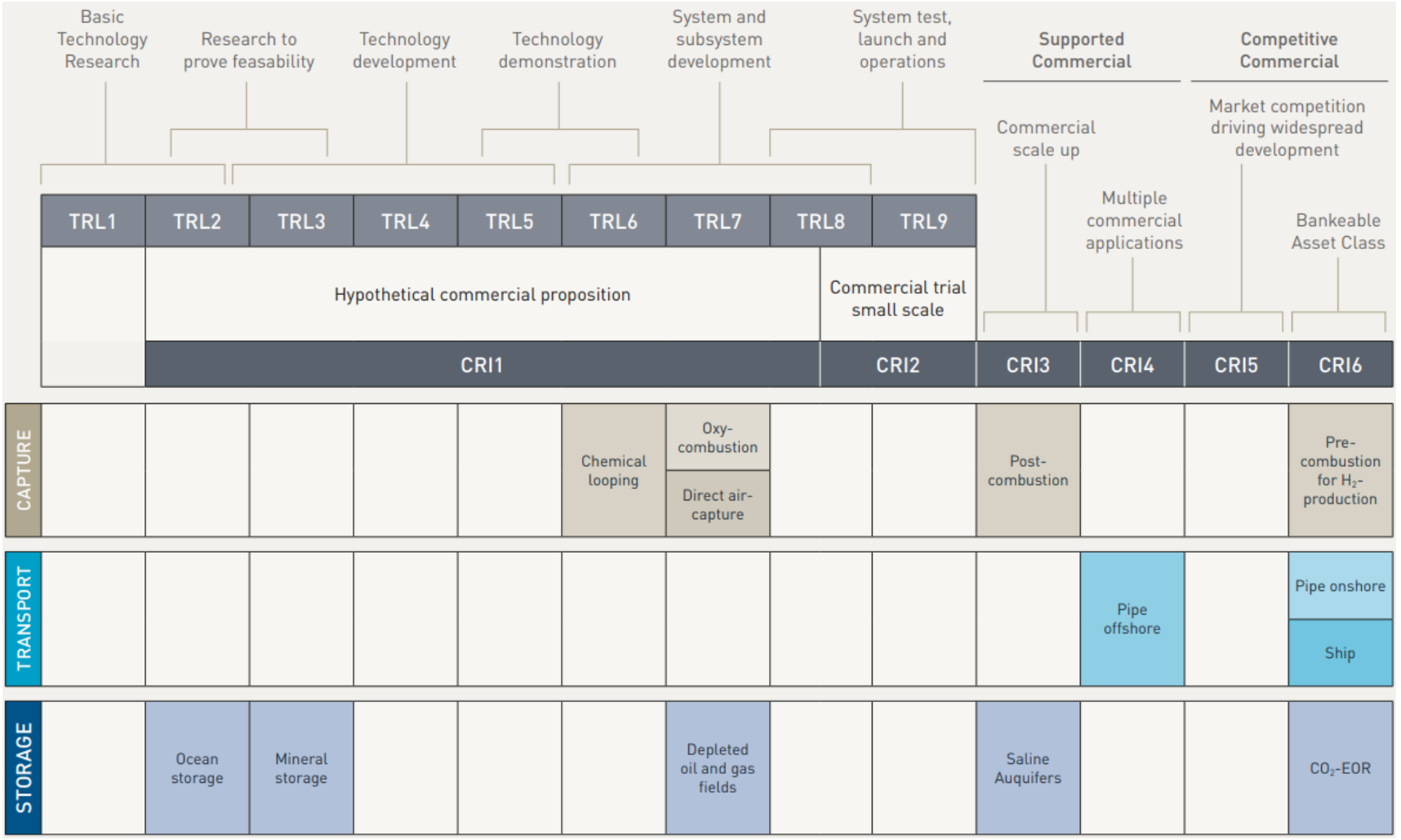
Floating CCS Hub - “CStore1”



Uniqueness of the Floating CCS Hub

- Multi-User based
- Minimal pipeline distance
- Reduced residual value risk
- Replicable, transferable and scalable

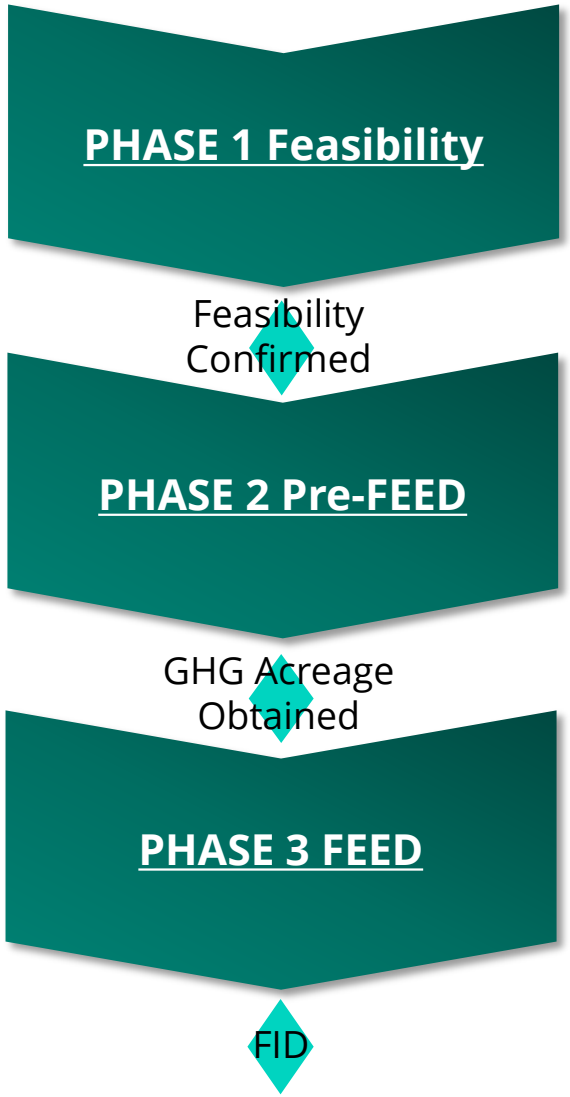
CCUS Technology is ready for Commercial Deployment



- Technical solutions throughout the CCUS value chain are advanced, based on decades of industry application.
- Areas for further improvement are:
  - CO_2 capture from exhaust (post-combustion or industrial processes)
  - Large scale liquefied CO_2 shipping
  - FSRU / FSI Hub

From "Potential for reduced costs for carbon capture, transport and storage value chains (CCS)", DNV GL, 2019. Report No.: 2019-1092, Rev. 2

CStore1 Development Timeline



- Completed Phase 1 work.
- Agreement executed with Nippon Steel Corporation (Japan's largest steel producer) to negotiate terms to offtake up to 5 MTPA of CO_2 from NSC's steelworks to CStore1
- Joint bid submitted with JX Nippon O&G for GHG acreage in offshore Australia
- Shares subscription agreement executed with PGS
- LoI executed with MOL and TEN for Pre-FEED, FEED, EPCI, O&M services for CStore1's FSI Hub
- Agreement executed with Kansai Electric Power (Japan's 2nd largest power utility) to consider developing a supply chain for capturing and transporting up to 10 MTPA of CO2 from KEPCO's power station to CStore1

We are here

- **Complete Phase 2 Pre-FEED work**
- **Obtain GHG acreage**
- **Fundraise for Phase 3**

dCS aims for FID by end 2026

Cost Reduction Initiatives

- **Design Optimisation**
  - CO_2 transport conditions – affects liquefaction condition & facility material selection

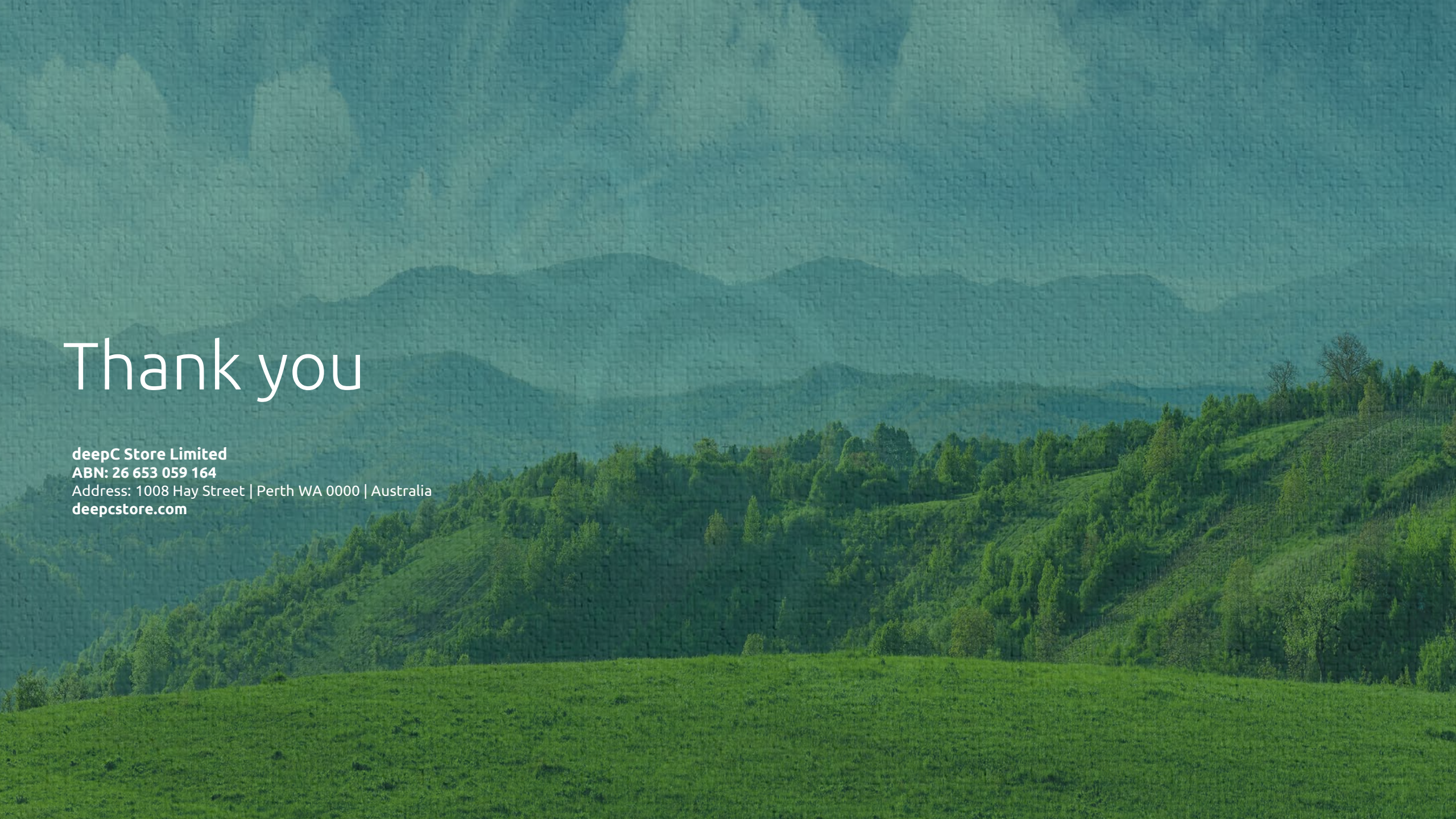
Pressure Regime	Overview
Low	typically 5 to 10 barg, and -55 to -40°C
Medium	typically 15-20 barg, and -30 to -20°C
High	typically 70-100 barg

  - CO_2 injection capacity – affects total unit cost, CO_2 supply sourcing & CO_2 injection site selection

- **Manufacturing Efficiencies** – Design one build many (CO_2 ships & Floating CCS Hub)
- **Reuse of facility** - CO_2 ships & Floating CCS Hub

Conclusion

- CCS is central to the clean energy transition in the APAC region
- Australia has strong potential to unlock significant CO_2 storage capacity and associated CCS business opportunities with a plethora of injection sites.
- Subsurface processes are tried and tested. CCS introduces new considerations, including its interface with potential overlapping hydrocarbon play.
- Floating CCS Hub development concept can address the key challenge of proximity between CO_2 storage sites and CO_2 emitter sources.
- Bilateral agreements are required to allow the free transfer of CO2 from the “emitters” to the “sequesters”



Thank you

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