co2crc
Building a low emissions future

The Role of CCS in the Energy Transition

Dr Geoffrey O’Brien

Chief Scientist

2022 Roundtable for
Energy Resources in SA

October 20th, National Wine Centre

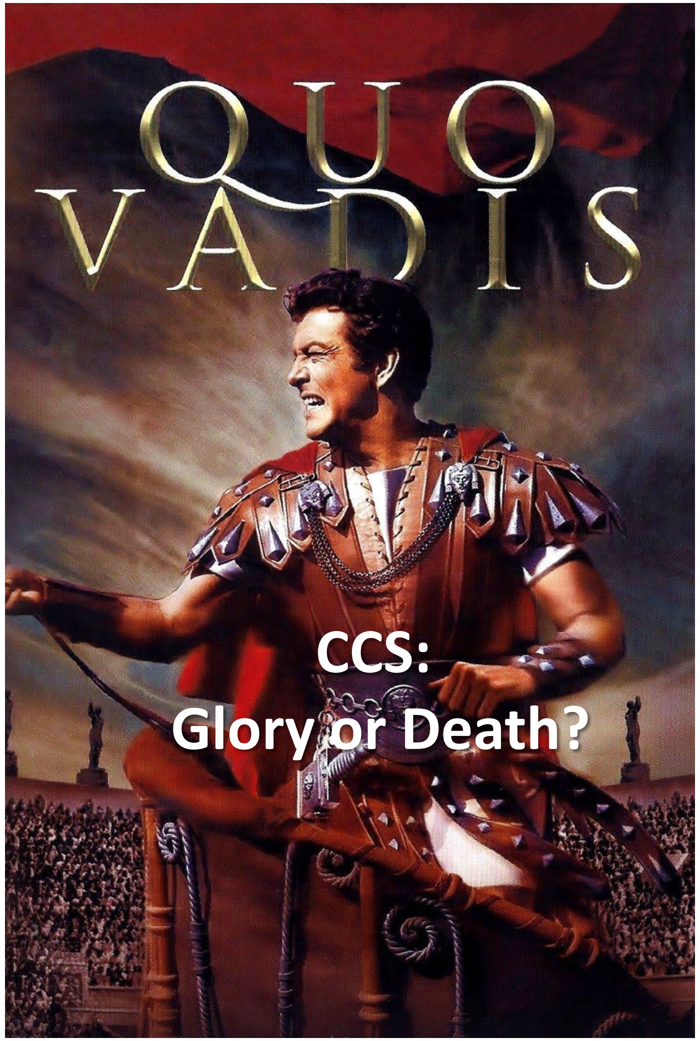
SA Round-Table Early Discussions…… *Inter Alia*!

- Provide the regulatory landscape
- Projects 10 years ago versus projects where we are now
  - Offshore
  - Onshore
- Onshore versus offshore
  - Inconsistencies onshore; problems with offshore – how do we deal with it?
- Bayu Undan and surrounding projects
- MMV – the view has changed a lot over time; from an R&D phase to major project roll-out

- Moomba CCS MMV monitoring and verification
- What is happening in CCS and MMV?; ER; risk-based regulation
- EOR-Green Oil with regulations preventing good economic and environmental outcomes
- DAC?
- OITC Update MMV
- But we would need two hours, this is a general audience, we only have 15 minutes …. and most importantly, I am up right before lunch!

Quo Vadis, CCS-CCUS?

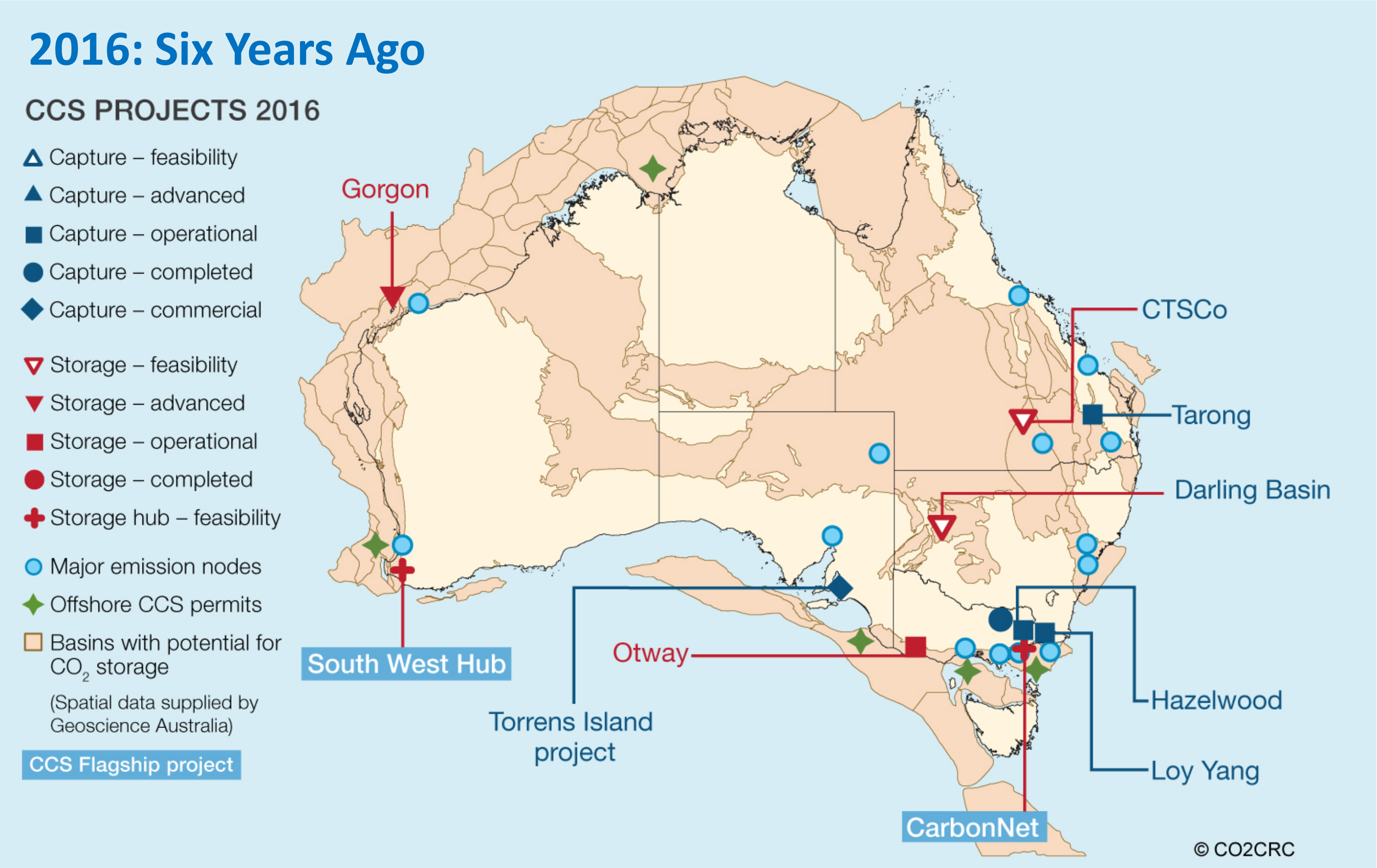
- Where have we been?
- Where are we now?
- What does the future look like?
- What could (possibly) go wrong?
- What do we need to fix and why does it matter?



co2crc
Building a low emissions future

Where Have We Been?

- A scattering of projects
- A strong R&D emphasis - how do we do this, is it safe, is it reliable, is it effective?
- Largely east coast-focussed
- A significant focus on capture from existing power generation facilities, principally coal
- These were not perceived as promising times, even then, and the nay-sayers were in ascendancy
  - CCS will never work
  - CCS is too expensive
  - There is no market-driver
  - Etc, etc



Building a low emissions future

Where Are We Now?

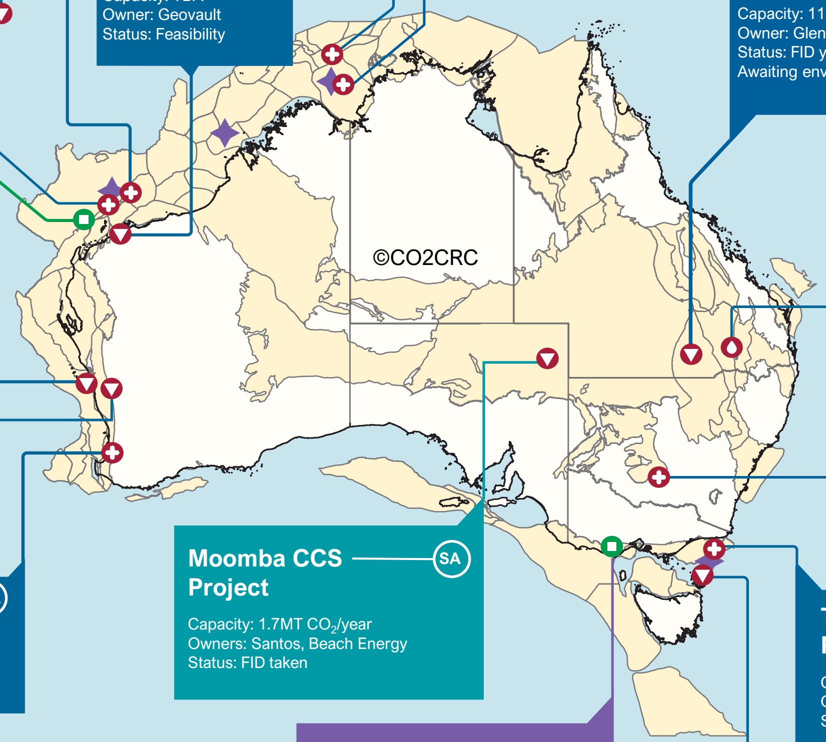
CCS Projects 2022

- Many projects from 2016 did not make it
- The nature of the projects has changed

1	Operational Project
1	Final Investment Decision taken
14	Projects in feasibility

Legend

- Operational
- CO2-EOR
- CCS
- Storage hub
- Offshore CCS permits
- Geological Basins



DeepCstore 1 (WA)
Capacity: TBA
Owner: DeepCstore
Status: Feasibility

Karratha CCS Project (WA)
Capacity: TBA
Owners: Woodside, BHP, BP, Chevron, Shell, MIMI
Status: Feasibility

Bayu Undan CCS Project (NT)
Capacity: 10MT CO_2/year
Owners: Santos, Timor Leste, Inpex, Eni, SK E&S and Tokyo Timor Resources
Status: FEED

Petrel CCS (NT)
Capacity: TBA
Owners: NT Gov, CSIRO, Santos, INPEX, Woodside, Eni, Origin Energy and Xodus
Status: Research phase

Gorgon (WA)
Capacity: 4MT CO_2/year
Owner: Chevron, ExxonMobil, Shell, Osaka Gas, Tokyo Gas, JERA
Status: Operational

Reindeer (WA)
Capacity:TBA
Owner: Santos
Status: Feasibility

Geovault (WA)
Carnarvon Basin
Capacity: TBA
Owner: Geovault
Status: Feasibility

CTSCo Project (QLD)
Capacity: 110,000 T CO_2/year
Owner: Glencore
Status: FID yet to be taken. Awaiting environmental approvals

Moonie CCUS Project (QLD)
Capacity: 10MT CO_2/year
Owner: Bridgeport Energy
Status: Early development

Midwest Clean Energy (WA)
Capacity: 500,000T CO_2/yr
Owners: Pilot Energy & Triangle Energy
Status: Feasibility

NSW CO2 SAP (NSW)
Capacity: TBA
Owner: Coal Innovation NSW
Status: Assess

Low Carbon Ammonia Development (LCAD) (WA)
Capacity: TBA
Owners: Mitsui/Wesfarmers & JOGMEC
Status: Feasibility

Moomba CCS Project (SA)
Capacity: 1.7MT CO_2/year
Owners: Santos, Beach Energy
Status: FID taken

South West Hub (WA)
Capacity: 800,000 T CO_2/year
Owner: Western Australian Government
Status: Research phase

The CarbonNet Project (VIC)
Capacity: 5MT CO_2/yr
Owner: DJPR
Status: Pre-FEED

CO2CRC Otway International Test Centre (VIC)
Capacity: Research facility
Owner: CO2CRC
Status: Research project

The SEA CCS Hub (VIC)
Capacity: 2MT CO_2/yr
Owner: ExxonMobil
Status: Feasibility

What Does (Or Could) The Future Look Like?

- CCS-CCUS is in a great place in Australia and the future looks bright, with a large number of new and substantial projects in the early to mature phases of evaluation
  - Driven by the wide acknowledgement within industry about the need to decarbonize and more recently by the 43% reduction by 2030 and by the net-zero 2050 targets
  - Most of the projects in the North West Shelf and Timor Sea are driven by LNG (a high-value product)
  - Projects in the South West of WA are mostly driven by the needs of the onshore heavy industrial emitters
  - Projects in southeastern Australia are a hybrid (SEA CCS at Bream and CarbonNet)
  - Substantial projects onshore in eastern Australia (Moomba CCS; Moonie CCUS etc, also hybrids)

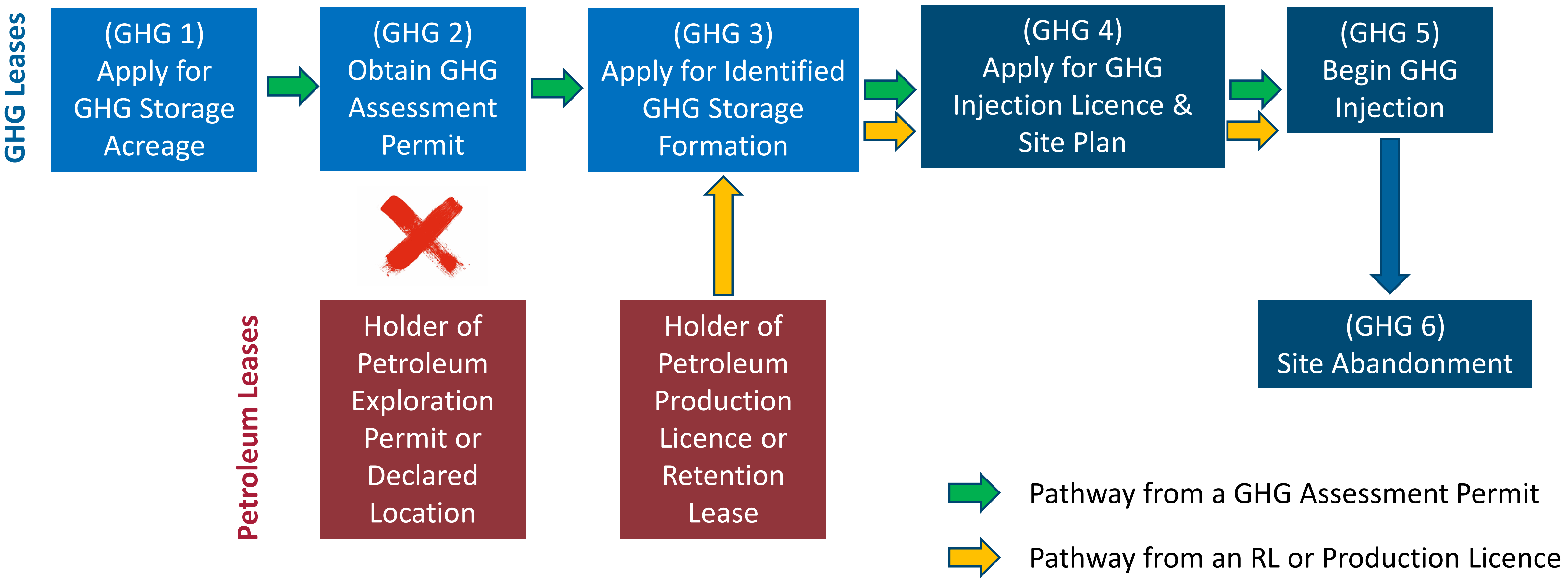
- The next 5-15 years will probably represent the major “project roll-out” phase for CCS-CCUS, with a growing number of large projects coming on-stream

- But nothing is guaranteed, and major speed humps exist

What Could (Possibly) Go Wrong?

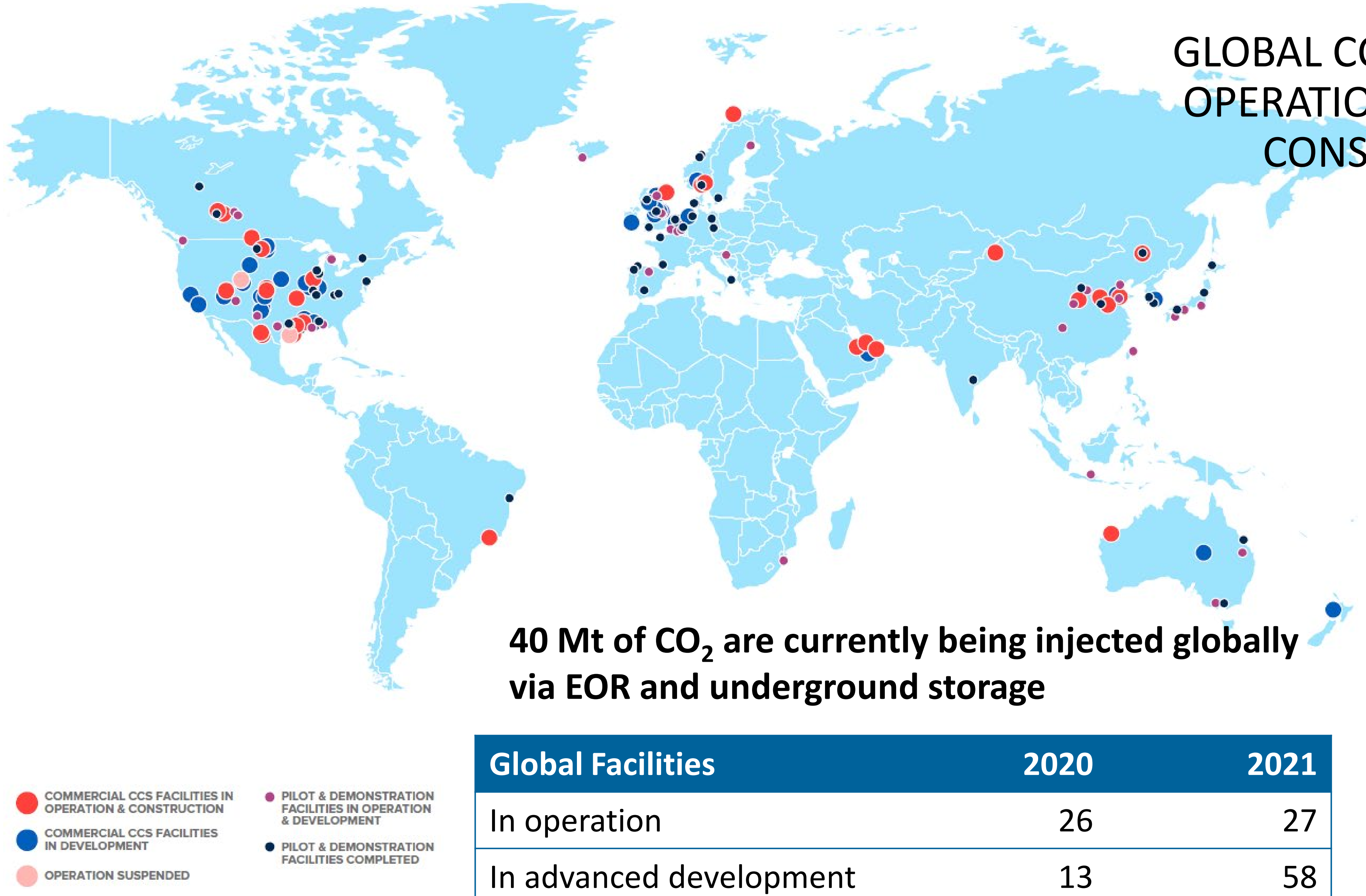
- The short answer is lots, including the following:
  - The regulatory framework is a genuine mixed bag
    - Varies state by state and some states have no framework as yet; SA is the best (obviously)!
    - The Federal framework is comprehensive but is over 15 years old (when Windows XP reigned) and is not particularly fit-for-purpose; it contains lots of issues and inconsistencies which can produce genuinely perverse outcomes (examples to follow)
  - There are glaring omissions with respect to ACCU credits (e.g., for CO2-EOR; Direct Air Capture or DAC), which are counter-intuitive and actually encourage higher emissions and poorer economic outcomes in some geologic settings
  - The regulators know all about petroleum but not necessarily CCS-CCUS
    - Some *"like DAC but not CCS"* (which suggests that tag and release is the goal) and so education is critical
  - The science supporting CCS (e.g., monitoring and verification) is moving very rapidly and is not reflected in the regulations (e.g., "old school" emphasis on 4D seismic for plume monitoring etc)

Federal GHG Regulatory Steps and Pathways



Building a low emissions future

GLOBAL CCS FACILITIES IN OPERATION AND UNDER CONSTRUCTION



40 Mt of CO_2 are currently being injected globally via EOR and underground storage

Global Facilities	2020	2021
In operation	26	27
In advanced development	13	58
In early development	21	44

Source: GCCSI, Global Status of CCS, 2020, 2021

co2crc
Building a low emissions future

The Global Challenge

As countries take action to achieve the Paris commitments, new incentives will be needed globally

~39Mt per year	Existing global CCUS capacity estimated at **~39 million tons per year** in 2018
~3.8Gt per year	Paris accord calls for CCUS target of **~3.8 billion tons per year by 2040**
~100 times growth	Achieving the Paris target implies **100x growth**

Additional incentives need to be created if countries truly commit

~25%

Average Annual Growth Rate in capacity required to meet Paris in 2040

co2crc
Building a low emissions future

Source: OGCI and United Nations Environment Programme; CCUS Institute

What Do We Need To Fix And Why Does It Matter?

- Without CCS-CCUS, it will be impossible for the world to reach net-zero by 2050 and indeed, impossible for Australia to reach a 43% reduction by 2030; we must choose *Glory Over Death!*
- GHG storage is moving from the R&D (which has a low regulatory impact) to the major roll-out phase for multiple projects, wherein both the Australian GHG regulatory system and its regulators are going to be stress-tested within a charged political and social environment
- Our science is advancing rapidly (especially in MMV) but the regulations are static and so there is a potential disconnect between regulatory expectations and the industry's technical capacity and capability, now and into the future, which will require a high level of communication between all of the interested parties (in effect, mutual, continuous education and feedback)

OITC Forward plans – 2028+

Otway Stage 4: 2020 – 2026

- Demonstrate commercially-focused reservoir management technologies to improve injection, storage, and monitoring efficiencies, and thereby materially lower project costs

Otway Shallow CO_2 Migration (Injection) 2022 - 2025

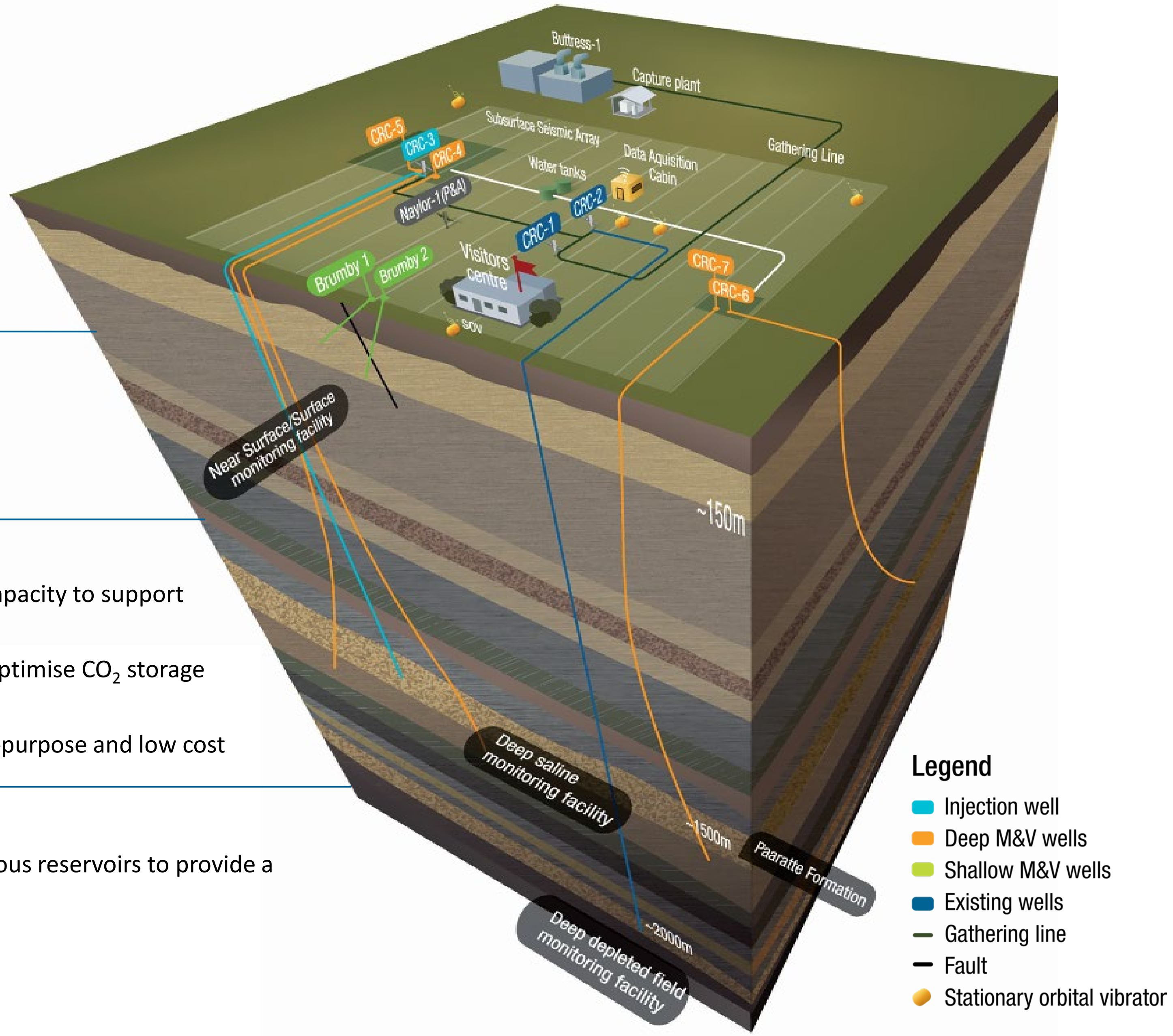
- Distributed Strain Sensing and Reverse VSP trials
- Assessment of capability to predict the role of faults in controlling CO_2 fluid flow in the near surface

Otway Deep Projects (Optimisation): 2020 – 2027

- Improved modelling workflow, with sufficient predictive capacity to support performance-based closure.
- Demonstrate a suite of technologies and workflows that optimise CO_2 storage usage while minimising capital and operating costs.
- Develop storage ‘performance’ monitoring which is fit-for-purpose and low cost

Underground Hydrogen Storage Demonstration: 2021 – 2028

- Field-scale demonstration of underground hydrogen storage in porous reservoirs to provide a platform for technology development



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

Australian Government
Department of Industry, Science, Energy and Resources

Australian Government
Department of Education, Skills and Employment

Australian Government
Geoscience Australia

NSW GOVERNMENT | Planning & Environment

VICTORIA State Government

anlecr&d

BHP

bp

CarbonNet Project
Enabling a Net Zero Future

Chevron

ConocoPhillips

CSIRO

eni

ExxonMobil

GLOBAL CCS INSTITUTE

J-POWER EPDC

LETA
Low Emission Technology Australia

RITE
Research Institute of Innovative Technology for the Earth

Santos

TotalEnergies

woodside

THE UNIVERSITY OF MELBOURNE

THE UNIVERSITY of ADELAIDE

Australian National University

Curtin University

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

UNSW AUSTRALIA

Federation UNIVERSITY · AUSTRALIA

THE UNIVERSITY of EDINBURGH

BERKELEY LAB

UKCCS RESEARCH CENTRE

UNIVERSITY OF CAMBRIDGE

Stanford University

GFZ
Helmholtz Centre POTSDAM

King Abdullah University of Science and Technology

UNIVERSITY OF WOLLONGONG AUSTRALIA

DEAKIN UNIVERSITY

co2crc
Building a low emissions future

© CO2CRC Limited 2022