Case Study:

The Gorgon CO₂ Injection Project

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Gorgon CO₂ Injection Project
Key Messages

- The Gorgon Project Joint Venture Partners have agreed to construct the world’s largest subsurface CO\textsubscript{2} disposal facility on Barrow Island, off Australia’s northwest coast.

- Subsurface disposal of CO\textsubscript{2} requires many of the same technologies and skills as other major petroleum developments:
  - Data acquisition and subsurface evaluation using multidisciplinary subsurface teams
  - Coordinated approach to field development planning and uncertainty management
  - Integrated reservoir surveillance planning to monitor subsurface CO\textsubscript{2} behaviour following injection

- The CO\textsubscript{2} Injection Project was therefore treated with the same attitude and approach as for the gas field development plans.

- The technical feasibility of CO\textsubscript{2} disposal beneath Barrow Island has undergone several phases of Joint Venture and State Government sponsored peer review.
Gorgon Project Development Concept

- Gas produced from subsea wells in Gorgon & Jansz fields (>2 Bcf/day gross)
- LNG (15 MTPA) + Domestic Gas (300 TJ/d) processed & exported from Barrow Island
- Gorgon gas ~14% CO₂
- Jansz gas <1% CO₂
- CO₂ separated and injected into Dupuy formation below Barrow Island (1.6-2.4 Tcf total CO₂)
- Project now under construction
- First gas production 2014
- Additional discovered fields under evaluation for future tieback
Reservoir CO₂ Injection Project

- The first major project in Australia to significantly reduce project emissions by the underground injection of carbon dioxide
- Project emissions expected to be reduced by approximately 40% (~3.4-4 MTPA CO₂-equivalent)
- About A$2 billion will be invested in the design and construction of the CO₂ project
- Costs per tonne remain less expensive than alternate abatement options
- Number of world firsts
  - First geosequestration legislation
  - First CO₂ injection project to undergo detailed environmental impact assessment (including public review and comment)
  - Largest subsurface CO₂ disposal project in the world

![Bar chart showing CO₂ emissions for different projects and improvements.](chart.png)
Site screening and selection

Four criteria considered:

- **Containment risk** – e.g. security of top seal, distance to faults, number / condition of existing well penetrations
- **Storage capacity** – e.g. gross rock volume, regional structure capacity, reservoir architecture, connected aquifer extent
- **Injectivity** – e.g. permeability, thickness and extent of target reservoir sands
- **Risk to other assets** – e.g. risk of fluid / pressure interference with other operating, discovered or undiscovered hydrocarbon fields

19 sites / concepts initially assessed in screening study:

- Saline aquifers
- Existing hydrocarbon fields
- Enhanced Oil Recovery opportunities

Five sites further assessed with screening-level simulation studies

Barrow Island Dupuy Formation only site that adequately satisfied all criteria
CO₂ Reference Case Development Plan

- Project sited on north-east of island
- Nine CO₂ injection wells (with space for nine more) from three drill centres
- Four water production wells + water injection wells
- Peak stream day CO₂ rate: 220 MMscf/d
- CO₂ volume: 1.6 – 2.4 Tcf (~ 80-130 million tonnes)

Reservoir Surveillance:
- Surveillance wells - two initially plus two in later field life
- Repeat 4D seismic (if successful) + Vertical Seismic Profiles
- Soil Gas surveys

- Abandonment of existing Dupuy wells in plume area; program for ensuring existing well penetrations in the plume area do not provide leakage pathways
- Commitment to make data from the ongoing monitoring available to the public
Barrow Island Stratigraphy

- Site selection was vital – Dupuy has adequate permeability for injectivity but low enough for good residual gas trapping
- Adequate existing subsurface data
- Several seals between injection zone and surface

**Dupuy Formation**

- Proposed injection interval

**CO₂ Injection Interval – Barrow Island**

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Reservoir Simulation – Testing Development Plan

- CO₂ plume migration influenced by pressure management wells, reservoir quality & distribution, buoyancy, rate of dissolution
- Effects incorporated into reservoir simulation models
- Wide range of subsurface uncertainties investigated using:
  - Full field models (testing overall development plan)
  - Sector models (investigating specific effects, e.g. near-wellbore)
- Development plan tested against two main criteria:
  - **INJECTIVITY** – i.e. scheme must handle rate of produced CO₂ from Gorgon
  - **CONTAINMENT** – i.e. scheme must retain total volume of CO₂ in the subsurface
Pressure Management Concept

- Pressure management required to reduce impact of rising pressure on CO₂ injection performance:
  - Maintain injection rates
  - Avoid reaching bottom hole pressure limit

- 100% offtake balance not necessary – expect large connected aquifer to "absorb" much of the pressure increase

- Produced water injected into overlying Barrow Group (depleted)
Growth of CO$_2$ plume over time

- Plume movement influenced by water offtake, reservoir depositional trends and structure
- Growth in plume area is rapid during injection, but limited following site closure
- CO$_2$ concentrated in centre, very diffuse at edges
Growth of CO₂ plume over time

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Net CO₂ Thickness: \( \Sigma S_g \cdot \Phi \cdot h \)

YEAR 0020

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Line of section

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Water production well (proj.)
CO₂ injection wells (proj.)

Net CO₂ Thickness: $\Sigma S_g \Phi \cdot h$

YEAR
0500

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Managing Risk – Reservoir Surveillance Objectives

- Reservoir surveillance options have been selected to assist responsible reservoir management.
- Reservoir surveillance focused on early identification of uncertainty “signposts” (as per Uncertainty Management Plan).
- When signposts are identified, then mitigation plans can be implemented to ensure the injected carbon dioxide continues to be properly managed.
- Integration of reservoir surveillance and reservoir simulation data will assist the demonstration of site integrity.
Integrated Monitoring Plan

- **CO₂ Injection & Pressure Management Wells**
  - Wellhead pressure and flow rate
  - Continuous down-hole pressure
  - PLT & casing/cement integrity logs

- **Surveillance Wells – Vertical distribution and volumetric calculation**
  - Continuous downhole pressure (Barrow Gp)
  - Saturation & casing/cement integrity logs
  - Vertical Seismic Profiling (VSP)

- **4D Surface Seismic – Lateral extent and broad vertical distribution**
  - 3D baseline survey
  - Repeat 2D and 3D surveys determined by viability of seismic for monitoring plume position

- **Soil Gas - Verification**
  - Soil gas flux sampling over the 3D seismic source grid and at potential near-surface seepage points

- **Surface – Safety & environment**
  - Pressure sensors and CO₂ detection equipment within compression and pipeline facilities

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Reservoir Monitoring, Risk Mitigation & Site Closure

- Monitoring aimed at identifying signposts so that effective mitigation actions can be implemented
- Site closure is the point where operational responsibility ends and is marked by satisfaction of site closure criteria
  - Criteria to be determined by legislation
  - Future land use objectives can be met
  - Residual risk of leakage and resulting liability is acceptably low
  - Any ongoing costs are low or otherwise appropriately managed
  - Liability transferred to State and Commonwealth Governments

Conceptual Risk Profile

- Injection Period
- Post-Injection Period
- Post-Closure Period

Risk

Time

Site Closure

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Concluding Messages

- The Gorgon CO₂ Injection Project is first of its kind in many technical and regulatory aspects.

- The same attitude and approach to subsurface studies and development was adopted for the CO₂ project as for the hydrocarbon fields.

- Much effort was invested into project assurance for internal and external stakeholders.

- Pressure management wells are fundamental to the development plan.

- Reservoir surveillance is important to maintain performance and to capture lessons learned.
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