Building a low emissions future

Instrumentation in CO2 monitoring wells

Innovations for advanced surveillance and reservoir monitoring

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Agenda

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Who is CO2CRC?

- CO2CRC is Australia's **leading CCUS research organisation**, invested A$150 million in research during past decade.
- A **Not-For-Profit** Organisation, we are supported by Government and Industry to develop technologies for future GHG Management.
- We aim to align high-quality R&D from various national and international institutions with industry partners **to find innovative, efficient and economic ways** to manage their CO_2 emissions.
- Our Otway International Test Centre is one of the largest **CO_2 injection demonstration sites** in the world and is truly unique in both scope and capability

Optimising Storage

Reducing Capture Costs

Testing Innovative Technologies

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Otway Test Centre

During the drilling of CRC-3 - Stage 3 Injector Well

Project Context and History

Otway Stage 1: 2004 – 2009

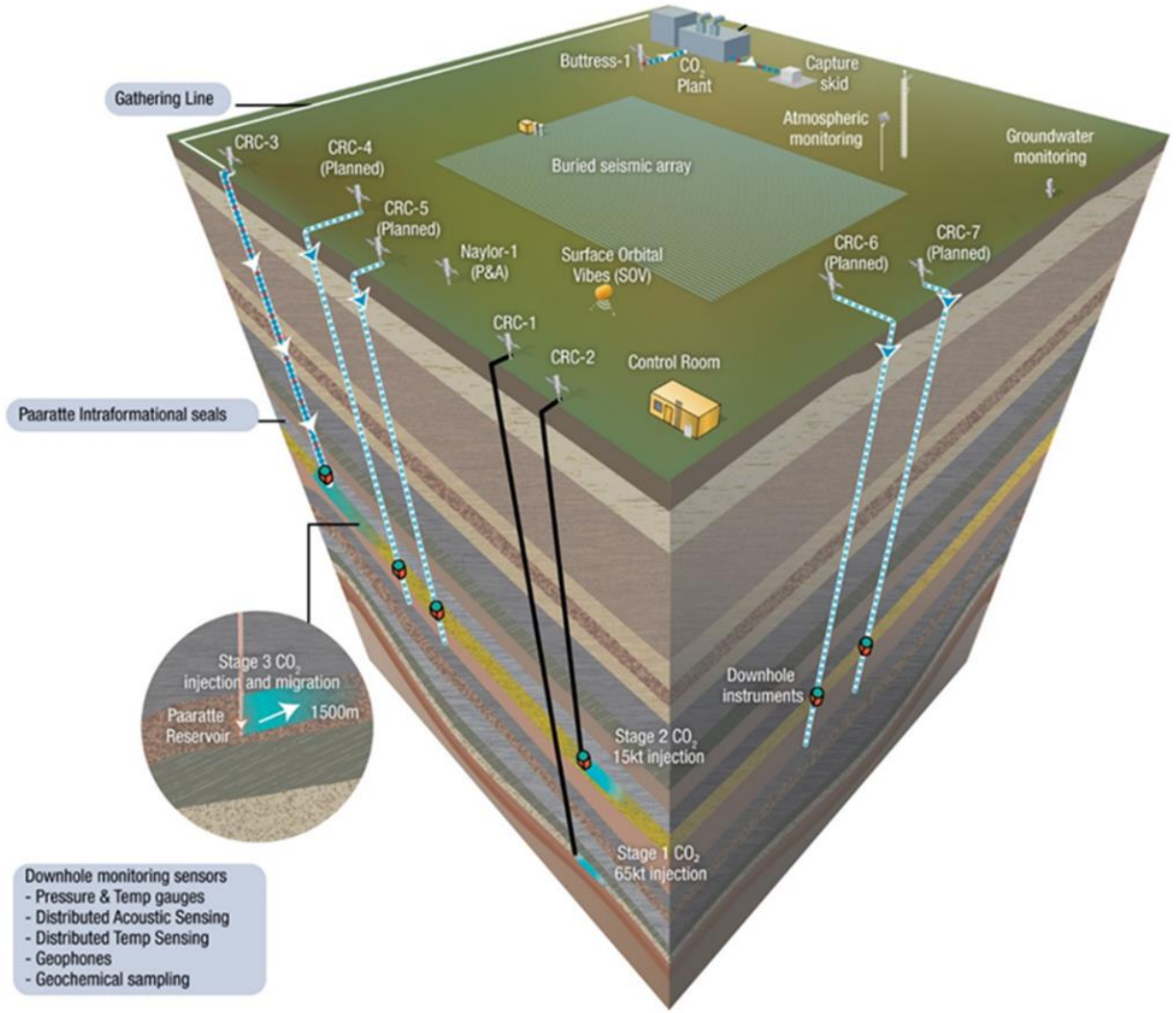
- ✓ Demonstrated safe transport, injection and storage of CO_2 into a depleted gas reservoir

Otway Stage 2: 2009 – 2019

- ✓ Demonstrate safe injection of CO_2 into a saline formation
- ✓ Demonstrate stable and permanent storage of CO2 in subsurface saline formations

Otway Shallow CO2 Migration

- ✓ Improve capability to predict the role of faults in controlling CO2 fluid flow in the near surface;



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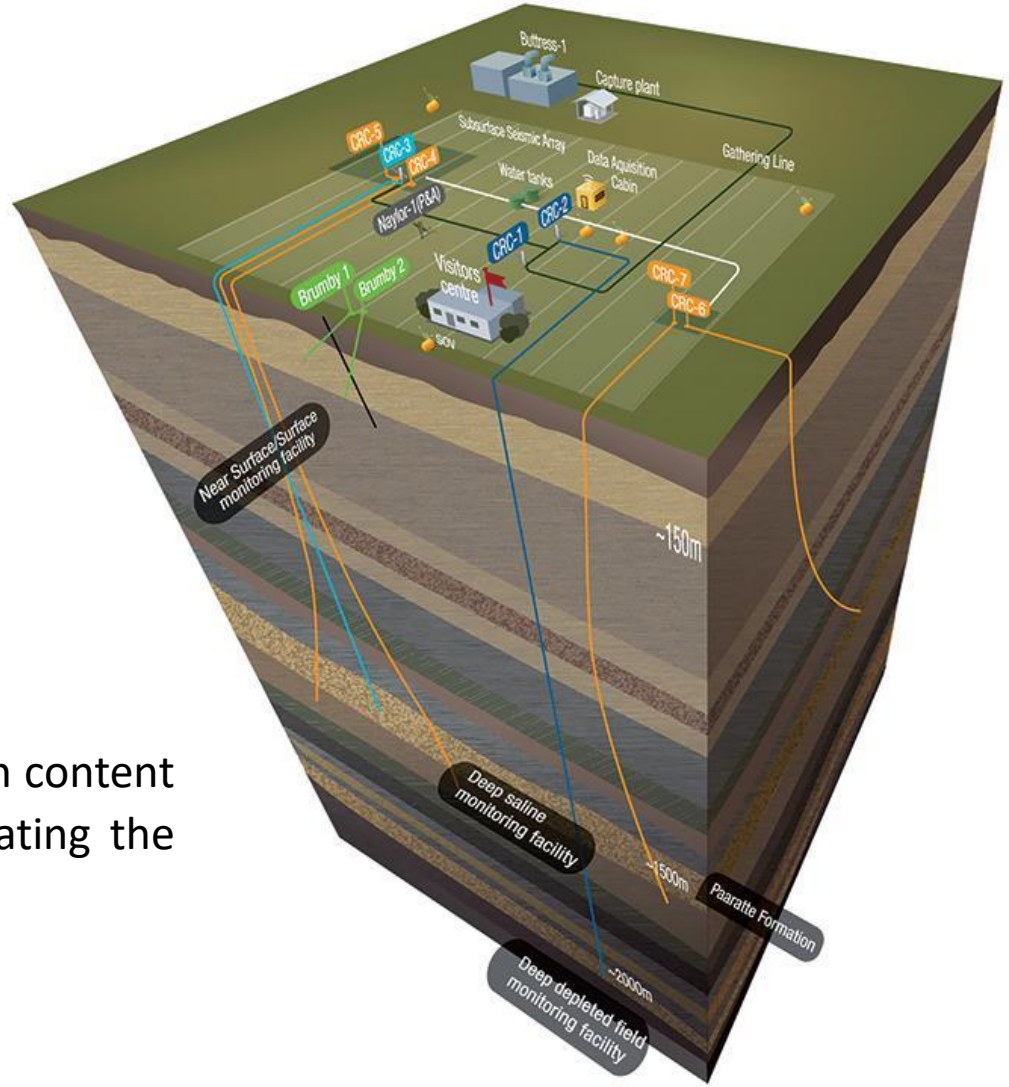
Stage 3 Project Summary

Project Overview

CO2CRC's Stage 3 Project aims to field test innovative technologies to enable CCS Storage Projects by offering monitoring technologies that provide:

1) Fit for purpose data
2) On-demand monitoring
3) Cost effective monitoring programs
4) Minimised impact to the environment and communities



Project Scope

To simulate a commercial CCS Storage Project by injecting 15,000t of high content CO_2 gas into a saline aquifer (at 1650m) for the purpose of demonstrating the effectiveness of the Stage 3 monitoring techniques

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Stage 3 Execution – Wells Infrastructure

Project Technical Objective: *to be able to observe the growing gas plume in the reservoir using the innovative technologies of Downhole Seismic and Pressure Tomography*

- Wells drilled directionally from 2 x wellpads
- Positioned specifically to monitor the injection
- One Vertical Injection Well – CRC-3
  - Tubing and packer completion
  - 15,000t injection CO2 supercritical condition
- 4 directional monitoring wells – CRC 4,5,6,7
  - 2 close monitors; 2 “far field” monitors
  - CO2 compliant metals and cement
  - Water injection capable

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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*

Fibre Optics Installations

Issues to address

1. Centralisation
2. Protection
3. Isolation
4. Perforations

Specific Actions – **Centralisation and Protection**

- Centralisation of casing at each joint through non-vertical section
- Centralisers every 3rd joint in vertical with cross-coupling protectors
- Vendor provided protectors as specified (1/200m)
- Additional TEF clamps mid-joint throughout
- BHA/turnaround clamp and protector at TEF end
- At planned perforated interval blast/detection joint installed

Fibre Optics Installations

Issues to address

1. Centralisation
2. Protection
3. Isolation
4. Perforations

Specific Actions – **Isolation**

- 9-5/8” casing extended to >900m to isolate deep water aquifer
- Cemented with standard cement to surface
- 5-1/2” casing run to TD
- Cemented with a tail of CO2 resistant cement to above target zone with standard cement to surface
- Always follow good cementing practice

Fibre Optics Installations

Issues to address

1. Centralisation
2. Protection
3. Isolation
4. Perforations

Specific Actions – **Perforations**

- Redundant TEF installed and terminated above perforated interval
- Guns were downloaded from 6spf to 4spf to provide a 180^{o} clearance
- Vendor provided a gun-string capable of detection and downhole rotation
- Blast/detection joint provided directionality
- Each run limited to 2 standard guns (~12m)
- TEF were “active” during perforation to confirm no damage

Fibre Optics Installations – Running TEF

Key Focus areas and actions to ensure success

- Individual reelers for each TEF to ensure tension was maintained
- Clamping did take rig time – but it was essential
- Frequent continuity checks (splicing kits on hand)
- Keep the crew focused on the job and constantly aware of the situation… clear communication between clamping crew and casing crew with oversight of the driller

Pressure Gauge Installation

Injection Well

- Conventional gauges mounted in gauge mandrel
- 2 gauges run on tubing above and below perfs
- Single TEC with feed through on upper gauge

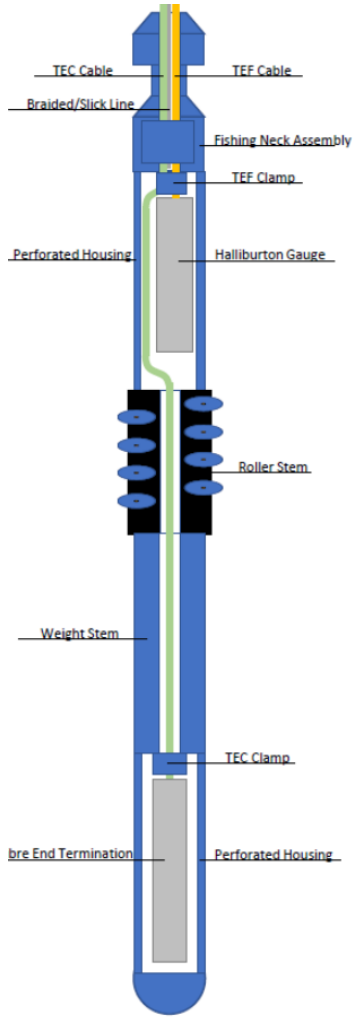
Monitor Wells

- Single gauge suspended from wellhead
- Suspension cable used to support gauge and BHA and protect the TEC
- Specifically designed clamps to secure cables during RIH
- Entire system run using a single deployment vehicle and reeler
- Allowed deployment of TEF suspended from the wellhead

Pressure Gauge Installation – Running in Hole

Key focus areas and actions taken to ensure success

- Tension on the suspension cable and TEC required continuous attention
- Depth measurement is critical
- Regular pressure measurements support equipment checks and depth confirmation



Monitoring Outcomes - 1

Downhole Seismic – Primary Objectives

- In combination with surface seismic sources, DAS images clearly identify the gas plume
- Monitoring images were acquired, processed and produced automatically every 2 days
- DAS data from all wells was acquired continuously for ~12 months with a high level of reliability

Downhole Fibres – Additional Benefits (Temperature Monitoring)

- Temperature during cementing – provides a comparative dataset to the CBL measurements
- Temperature during injection – providing critical information on the well's performance
- Temperature during well operations – ongoing realtime wellbore integrity

Monitoring Outcomes - 2

Pressure Tomography

- The technique worked as planned with separate pressure surveys identifying the plume
- The system was tested and able to detect a plume of only 4.5 kt gas injected
- Deployment method worked well, pressure accurately and reliably recorded for >12 months

Pressure Monitoring – Additional Benefits

- Pressure inversion in a passive environment to examine for above zone leakage events
- Earth Tides monitoring for gas plume identification
- Correlation of pressure response with dynamic reservoir models

Conclusions

The Otway International Test Centre has expanded capabilities for testing a variety of CCS monitoring systems. The Stage 3 field trials of innovative technologies has shown:

- That the installation of TEF outside of tubing can be performed efficiently and successfully
- Perforation of casing with TEF installed can be delivered reliably and without damage to the fibres
- The benefit of hybrid TEF with temperature sensing fibres provide many further opportunities
- Pressure tomography is a viable technique for monitoring gas plumes in storage aquifers
- A suspended gauge system is a low cost and flexible solution to be considered in any monitoring system

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