Minimising the environmental impact of CO2 storage monitoring with fibre-optics

Silixa's Distributed Acoustic Sensing (DAS) monitoring with fibre-optic cables at the CO2CRC Otway project, Australia is advancing the development of technically and environmentally safe solutions for CO2 storage.

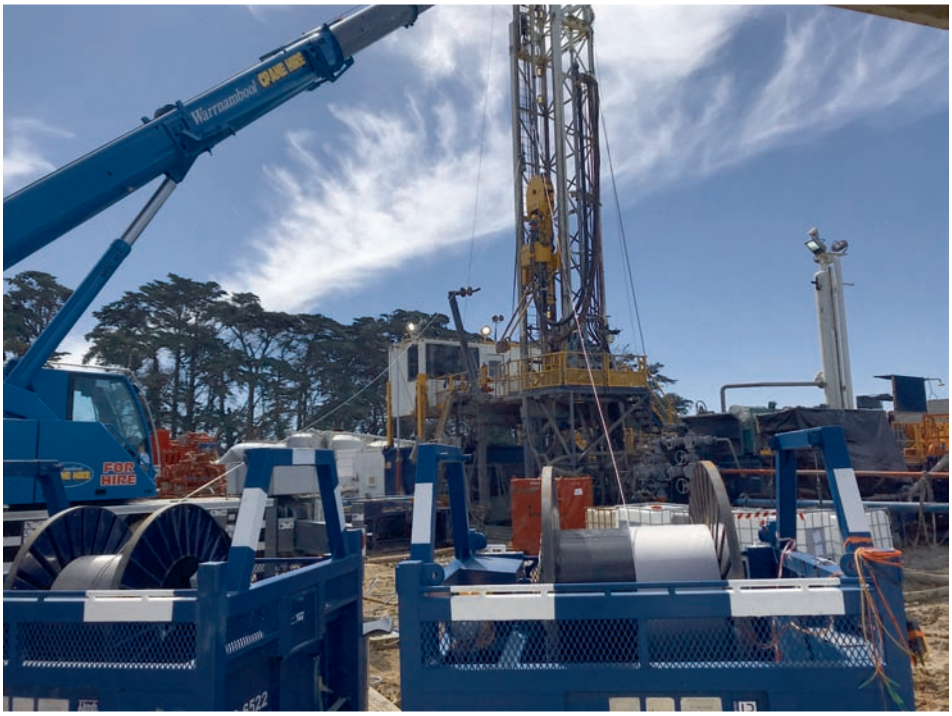
An extensive, world-class monitoring program is ongoing at the CO2CRC Otway CO2 storage test site in Victoria, Australia, where new capture and monitoring technologies are being benchmarked against conventional methods, such as traditional seismic surveys to monitor carbon capture and storage (CCS) sites.

Stage 3 of the project is now underway with the aim of developing continuous low-cost and low-environmental footprint solutions. This builds on the results from Stage 2 of the project which demonstrated safe injection of CO2 into a saline formation and successful monitoring of the CO2 plume evolution.

The inclusion of fibre-optic monitoring at Otway began in Stage 1 with a cable deployed on borehole tubing. Distributed Temperature Sensing (DTS) measurements were used to monitor the geothermal profile and identify potential leaks. During Stage 2, CO2CRC injected 15,000 tonnes of CO2 approximately 1,500 meters underground and a further fibre-optic cable was installed in one of the wells to benchmark DAS technology against seismic survey data recorded on geophones.

Fibre-optic DAS is a rapidly emerging technology to be applied to seismic monitoring. However, it is now accepted that, with careful survey design, the latest DAS technology rivals geophones in data quality and it provides many advantages such as the potential for long-term repeatable measurements and dense spatial sampling without the need for well intervention. This was tested during Stage 2 at Otway with a cable cemented behind casing in a borehole.

DAS technology makes use of the fact that fibre-optic cables deployed in the ground are strained by the passage of seismic waves. The effect is measured by firing a laser into the fibre from a DAS interrogator and recording the light scattered back to the interrogator from closely spaced points on the fibre.



Fibre optic cable installation at Otway, Australia

An interrogator is able to record the full acoustic signal simultaneously along the whole length of the fibre. The advantage of this type of monitoring technology for seismic surveys is that many thousands of measurements can be made with cables up to 10s of km long. Such dense spatial sampling is logistically difficult and expensive for traditional technologies, where the typical spacing of borehole sensors is 25m.

Cables can be permanently installed in boreholes, on tubing or behind casing, or trenched in the ground and repeat surveys may be conducted on the same cable for several 10s of years. The sensitivity of DAS measurements makes the technology particularly well suited to Vertical Seismic Profile (VSP) surveys, used to produce high resolution images of the subsurface around a borehole.

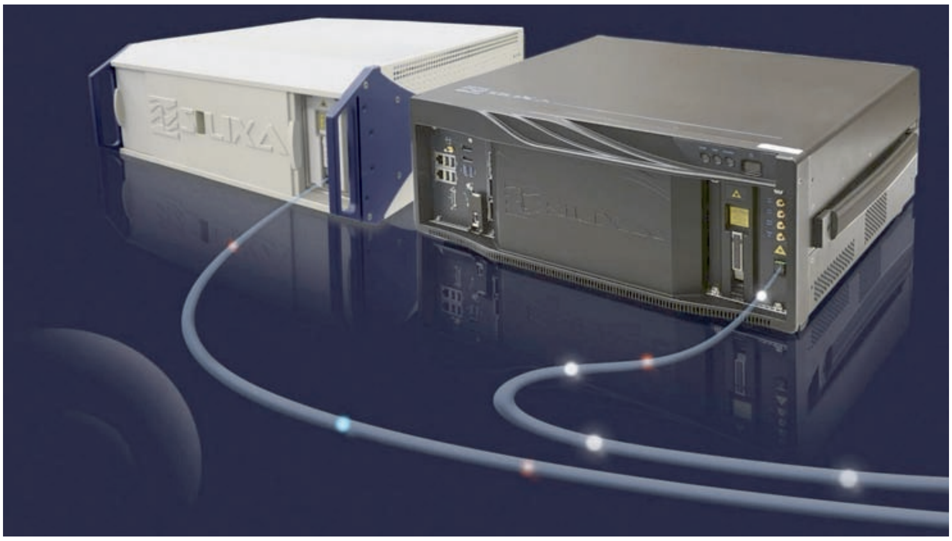
Ideally, borehole cables should be installed at construction so the fibre can be cemented in place behind casing to optimise cable coupling and signal-to-noise ratios. However, fibre cable installation is possible on tubing or suspended in-well.

Using 3D DAS VSP data recorded a tubing installation at Otway, researchers from Curtin University and Lawrence Berkeley National Laboratory found the data were of good quality and they were able to image geological interfaces beyond the CO2 injection depth.

The use of Silixa's new Carina® Sensing System technology highlighted a step change in the ability of DAS technology with an improvement in noise levels of 20dB over previous systems. The advancement in technology enables far-offset surveys, facilitating monitoring over a wider area. These types of surveys are possible even if cables are not cemented in place.

Recently, for Stage 3 of the Otway project, further fibre-optic cables have been installed in five wells at the site. The technology will be tested not only for active seismic surveys but will also be applied to microseismic monitoring and passive seismic imaging using recordings of background noise.

In addition, the cables include optical fibres to monitor temperature profiles during injection and for early detection of potential leaks. Also as part of Stage 3, surface cables with different specifications were installed at the site and similar surveys will be recorded on these cables.

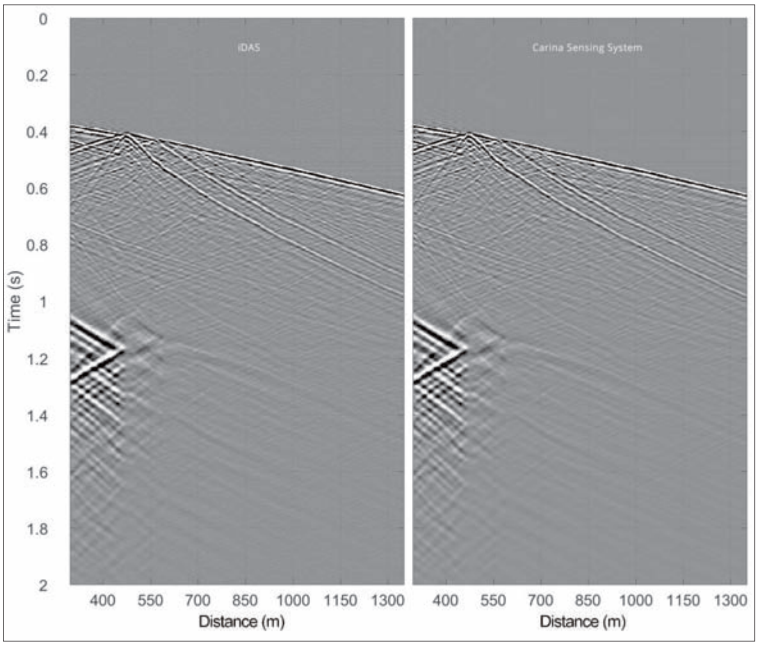


Silixa's iDAS™ and Carina® Sensing System operate according to a radar-style process. The interrogator sends a series of pulses into the fibre and records the return of the naturally occurring scattered signal against time. In doing this, the distributed sensor measures at all points along the fibre

The environmental impact of monitoring is an important consideration for CO2CRC. Vibroseis trucks or dynamite are the most commonly used sources for land seismic surveys. Both these techniques have a significant environmental impact requiring the transport of heavy equipment and personnel. Once onsite the sources are also disruptive to local residents and/or farming activities because they are noisy and require access to extensive areas of land, up to a few square kilometres.

The deployment of large numbers (1000s) of geophones also requires considerable effort in terms of personnel. To reduce the environmental impact of seismic surveys CO2CRC, Curtin University and Lawrence Berkeley National Laboratory have been trialing the use of surface orbital vibrators (SOVs) in combination with fibre-optic sensors. SOVs are small seismic sources that are permanently deployed on the surface and can be operated remotely without disrupting local stakeholders.

They have a small physical footprint and although they are much less energetic than a Vibroseis source, the remote operation of the SOVs over a period of time can impart total energy, and hence signal quality, equivalent to the data obtained from a Vibroseis survey.



VSP data recorded on iDAS (on the left) and Carina Sensing System (on the right)

The success and environmental, safety and cost benefits of the combined SOV operation with the Carina Sensing System recordings have resulted in the carrying forward of both these technologies to Stage 3.

It is envisioned that fibre-optic monitoring will be available for multipurpose monitoring; for use in continuous passive and time-lapse active seismic surveys, in-well temperature measurements and deformation measurements.

Detailed techno-economic studies will be performed as part of the Otway project, but it is estimated that overall a cost saving of up to 75 percent of monitoring costs over traditional monitoring technologies can be realised.

Stage 3 of the CO2CRC Otway project represents an exciting opportunity to decrease costs and minimise the environmental impact of CO2 storage projects, making the solution more attractive and hence facilitating uptake of CCS technologies globally. This is essential if targets for CO2 emission cuts are to be met.

The CO2CRC Otway Stage 3 project is jointly funded by the Commonwealth Government's Education Investment Fund (EIF), COAL21 through ANLEC R&D, BHP and the Victorian State Government.

Correa et al. (2019) 3D vertical seismic profile acquired with distributed acoustic sensing on tubing installation: A case study from the CO2CRC Otway Project, Interpretation, doi: 10.1190/INT-2018-0086.1

More information

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