Advancing carbon capture: sensor technology to monitor safely and at scale

Identifying proven sensor pathways for safe, long-term CO_2 storage

Context

As carbon capture and storage (CCS) projects scale globally, the delivery of robust storage infrastructure and monitoring technology are among the factors driving medium-term growth. In the US, the Environmental Protection Agency (EPA) is evaluating whether existing oil and gas infrastructure can be repurposed to store CO_2 safely for extended periods. In parallel, the agency is developing regulations to ensure captured carbon is stored and monitored securely. Against this backdrop, a leading CCS operator commissioned Sentec to conduct a comprehensive review of sensor technology.

The goal was to identify emerging solutions, as well as proven approaches from adjacent sectors, that could be adapted to monitor stored CO_2. The client also tasked Sentec to assess integration challenges and identify commercially viable, compliant pathways to embed recommended technology into its systems.

Challenge

The project centred on a critical question: how can the CO_2 distribution and diffusion in the storage site be monitored in real time? This is a key element needed to ensure safe long-term storage of captured CO_2. When CO_2 dissolves in water it forms carbonic acid. This lowers pH levels and potentially dissolves harmful chemicals from rock formations, creating significant hydrological challenges. Sampling water regularly for decreased pH levels is expensive, complex and time-consuming. Deploying a real-time monitoring system would reduce costs and enable a faster response to changing condition in the reservoir.

The recommended sensors had to work in high salinity, over long deployment periods and in changing conditions. Moreover, Sentec's proposed solutions had to fit with the client's operational workflow, data systems and safety procedures.

> "It's never just about the device: it has to work in the client's real-world process, or the solution becomes too complicated and costly."
>
> Riccardo Di Pietro, Technical Director, Sentec

Solution

Sentec delivered the project in two phases. Phase one focused on developing a first-principles understanding of the science behind the challenge. Equipped with this knowledge, the project team looked beyond the CCS

industry to related activities like environmental monitoring and oceanographic surveys, where CO_2 monitoring in salt water is common. As part of the sensor technology review, the team assessed cost, power requirements, performance and lifetime. During this process, the project team drew on chemical engineering and sensor technology expertise in Sentec's network. "Having access to a network of experts who reviewed the findings was incredibly helpful," Sentec's Technical Director, Riccardo Di Pietro, noted.

Arising from the review, Sentec identified a shortlist of technologies that would enable real-time CO_2 monitoring, as well as available technologies to measure pH with minimal drift over prolonged timescales—both measurements being required to accurately measure CO_2 concentration.

Phase two involved testing the client's preferred option in a laboratory setting, to understand how the sensor could be embedded in the client's existing capabilities. Sentec also developed an integration plan that mapped out development steps and a cost-effective, risk-free implementation methodology.

Cross-Sector Insight

de-risked path to field trials

Outcome

Sentec delivered clear, actionable recommendations grounded in first-principles analysis and validated by cross-sectoral knowledge. The team's ability to draw on specialist insight ensured the findings were both scientifically rigorous and technically viable.

With this foundation in place, the client was able to move rapidly into prototyping, avoiding costly development paths. Sentec's review also positioned the client to comply with emerging regulations.

Conclusion

By identifying proven technology from adjacent sectors, Sentec helped the client reduce costs and build a monitoring strategy informed by science, commercial realities and operational constraints.

In the rapidly evolving CCS sector, the client can move forward with clarity and confidence – supported by a validated roadmap for CO_2 monitoring.

> "Our aim is to guide clients towards the option that works best for them, not just the most advanced. In this case, the right answer was the one that fit their needs, their timeline and the realities of subsurface monitoring."
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> Riccardo Di Pietro, Technical Director, Sentec