

Workshop Examines CO₂ Capture, Geological Storage

The SPE Applied Technology Workshop (ATW) titled "Capture and Geological Storage of CO₂" was held in Perth, Australia, from 7–10 October. Attending the ATW were 107 participants, representing 50 different organizations from 15 countries. The workshop's chief objective was to provide an overview of current CO₂ capture and storage (CCS) technology and projects, as well as a look ahead into how technical, economic, and policy developments might facilitate large-scale, widespread application of CCS to mitigate greenhouse-gas (GHG) levels.

Cochairpersons Scott Imbus and John Kaldi opened the ATW's initial session with an overview of the goals and expectations for the week, which was followed by the first keynote address, "Carbon Dioxide Capture and Geologic Storage: Research, Development, and Application in Australia," given by Peter J. Cook, chief executive, Cooperative Research Centre for Greenhouse Gas Technologies, which is known as CO₂CRC. Cook focused on the role of CO₂CRC's Otway basin pilot project in setting a precedent for safe, effective geological storage of CO₂ in Australia.

The second keynote speaker, John Bradshaw, chief scientist, Geoscience Australia, spoke on "Technical and Regulatory Impacts of Implementing a Geological Storage Regime." Bradshaw reviewed results of the national storage-capacity assessment and the need for a regulatory regime knowledgeable on the trapping and migration properties of CO₂ at the large scale. The need for technical rigor to earn public assurance was stressed.

The perspectives of energy providers, including oil and gas companies, coal producers, and utilities, formed Session 2. While recognizing that capture technology is commercially available, speakers focused on the large costs that will be borne by the public and industry. Development and demonstration of more-cost-effective capture technology are needed, but funding for demonstration projects is lacking, they

agreed. Subsurface aspects of CCS are familiar to the oil and gas industry but not to the public, they pointed out. The risks of CO₂ storage can be managed during capture-and-storage operations. However, long-term liability afterward should be dealt with at the public-policy level rather than through the avenue of litigation against the project participants, the speakers noted.

Session 3 overviewed technologies and approaches to site assessment. A recurrent theme was balancing information available with that needed to provide suitable models and simulations, as well as the implications of uncertainty. The importance of natural analogs, flexible workflows, and improved, coupled simulations was stressed.

Storage assurance was the topic of Session 4. Monitoring programs should be fit-for-purpose, performance-based, and designed to detect and mitigate leakage in the deep subsurface, speakers said. Understanding fault stability through geomechanical studies will help determine whether faults will be vulnerable to CO₂ leakage. Well-integrity studies, including assessment protocols, new well-construction design, and materials and intervention options, will be essential to the long-term security of storage sites, speakers said, adding that risk assessment incorporates all technical assurance issues but at present is not "quantitative." By framing CO₂ injection, migration, and trapping scenarios, however, the assessment process serves to align stakeholder perception and risk tolerance, speakers noted.

Session 5 focused on enhanced recovery of hydrocarbons by means of CO₂ injection. Speakers discussed current or prospective enhanced-oil-recovery (EOR), -gas-recovery, and -coalbed-methane (CBM) -recovery projects and technologies. In existing and prospective EOR projects, important changes in planning, operations, and closure will be needed to accommodate CO₂ storage, speakers said. Enhanced CBM recovery (ECBMR) by means of inject-

ing CO₂ has yet to be demonstrated; but there are locales where the appropriate conditions exist, speakers noted.

In Session 6, speakers reviewed a series of international initiatives. These included BP's decarbonized fuel program, which has announced three projects to date and has forced debate among policy makers in the UK, US, and Australia. Statoil's existing and planned projects were also discussed, which include commercial-scale capture demonstrations and offshore disposal of CO₂ from process-gas, refinery, and power-plant operations. The European Union's (EU's) Zero Emissions Platform aims to achieve 20% GHG reductions by 2020, in part through launching 10 to 12 demonstration projects with reductions of up to 1000 million tonnes per annum achieved by means of CCS by 2030. An outline of UK and EU cooperative agreements in CCS with China and emerging developments in India was presented by the UK Department of Environment, Food and Rural Affairs.

Projects in Australia and New Zealand received an overview by several speakers in Session 7. These included

- The Otway basin pilot, which is slated to store 100 000 tonnes over 1.5 years with a comprehensive monitoring program
- A project led by ZeroGen to store 4 million tonnes over 10 years in the Denison Trough
- The Monash concept, by which up to 50 million tonnes per year of CO₂ from coal power generation at Latrobe Valley will be stored in the Gippsland basin. (The potential effect of this on oil production there was noted.)
- A project at Huntly, New Zealand, to examine the feasibility of CO₂ injection for ECBMR (CO₂ ECBMR)
- CO₂ ECBMR at Fairview, Queensland, with focus on the key financial, commercial, and regulatory challenges involved

Session 8 dealt with the technical aspects of the Gorgon development, the world's largest planned CO₂-injec-

tion project to date (130 million tones over 40 years). On the basis of technical evaluation, project management is attempting to reduce uncertainty by means of established workflows and, ultimately, drilling a data well with a comprehensive logging, coring, testing, and analytical program.

In Session 9, participants engaged in a competitive "project-development game." Six teams divided into government and contractor subteams in an effort to illustrate the technical and business risks involved in designing a CO₂-storage project. All teams negotiated a settlement with widely varying terms, some favoring the contractor and others the government. A panel of judges chose a winning team, on the basis of financial-outcome, negotiation, and presentation criteria.

Emerging topics were introduced in Session 10. Storage limits imposed by low permeability and the possibility of overcoming them by drilling and stimulating horizontal wells were discussed. The technical and economic feasibility of CCS networks, so-called carbon hubs, in Australia was examined. These included Bass Strait and the Galilee, Bowen, and Perth basins. The estimated economic impact of CCS at this scale was analyzed. It was estimated that the cost of infrastructure required to dispose of 34% of Australia's emissions through these networks would entail 9.5% of gross domestic product. Breakout groups then addressed the issues of (1) public assurance and acceptance, along with associated risk, and (2) technology/solution gaps and barriers, along with CCS's impact on and interrelationship with oil and gas operations.

The final session was a lunch presentation by Kamel Bennaçeur, who has been seconded from Schlumberger to the International Energy Agency (IEA), on the IEA's progressing scenarios for emissions and their mitigation by 2015, 2030, and 2050. It was concluded that to achieve the needed emissions reductions will require a combination of factors, including technological, legal, and regulatory changes; energy-efficiency gains; and CCS applications. For perspective, a path meeting IEA sustainability criteria within the full timeframe would require the equivalent of 6,000 Sleipner-field (1 million tonnes per year) CCS projects.

In an assessment of the ATW program overall, participants indicated that the workshop was worthwhile and its content generally met their expectations.

The workshop program committee included Cochairpersons Imbus, Chevron, and Kaldi, CO₂CRC, Guy Allinson, University of New South Wales; Matthew Andruchow, Schlumberger; Geoff Barker, RISC; Kamel Bennaçeur, Schlumberger/IEA; John Bradshaw, Geoscience Australia; Michael Congreve, Santos; Calvin Cooper, ConocoPhillips; Steve Crookshank, American Petroleum Institute; Catherine Gibson-Poole,

CO₂CRC; Gelein de Koeijer, Statoil; Tony Espie, BP; Matthew Flett, Chevron; Robert Funnell, GNS Science; Geoffrey Ingram, Schlumberger; Haroon Khesghi, ExxonMobil; Sjaak Lemmens, Vanguard Enviro; Kim Matthews, Halliburton; Lincoln Paterson, CSIRO Petroleum; Sandeep Sharma, seconded from Schlumberger to CO₂CRC; Jurgen Streit, Woodside Energy; and Emry Hisham Yusoff, Petronas. **JPT**

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