2021-IP15 - Carbon Management and Oil and Gas Research Project Review Meeting, August 6th – 11th 2021

This annual review meeting, held every year in August, is an up-to-date summary of all the US DOE funded projects in CO_2 storage, transportation and utilisation. The imposition of travel restrictions due to the COVID-19 pandemic meant a series of virtual meetings was delivered between August 6th and 11th.

The meeting, between these dates, included a highly informative range of subjects which are of active interest to members. These included: large-scale injection programmes under the CarbonSAFE initiative; improved monitoring; minimisation of induced seismicity; new geophysical tools and methods including well integrity analysis; and new materials to remediate leaks. A summary of the international CCS scene was presented by Tim Dixon from IEAGHG.

The CarbonSAFE Phase III latest updates have been reorganised from the former 6 Regional Carbon Sequestration Partnerships. There are now four regions: the Midwest Regional Initiative (MRCI) (headed by Battelle) which includes the north-eastern contiguous US; the Southeast Regional Sequestration Partnership (SECARB-USA) (managed by the Southern States Energy Board); the Carbon Utilization and Storage Partnership ((CUSP) directed by New Mexico Tech) which covers the western half of contiguous US); and the Plains CO_2 Reduction Partnership (PCOR) run by EERC. This region includes the Dakotas, Nebraska, Wyoming, Minnesota, the eastern half of Montana and parts of Wisconsin, Iowa and Missouri. PCOR also includes four Canadian provinces (Alberta, British Columbia, Manitoba, and Saskatchewan) and Alaska.

CarbonSAFE Highlights

PCOR are currently working on a Front-End Engineering and Design (FEED) for the Project Tundra Carbon Capture System in central North Dakota which is 2.5 times the size of Petra Nova. The FEED would enable a decision to be made on a commercial project with the aim of using experience from the project to reach a target of $30/tonne by 2030. There are CO_2-EOR and saline storage opportunities in Williston Basin in this region and a deep saline formation DSF directly beneath the Project Tundra location. A characterisation well has been drilled to the Precambrian basement 10,300 ft (3,140 m). The Basal Black Island / Deadwood Formation, immediately above Precambrian basement, is a prime storage target. To date two North Dakota storage permit applications were submitted in May. The state has Class VI primacy which is invaluable for progress.

The MRCI is a significant new regional initiative. It includes a systematic storage systems development and a regional structure and stress assessment of the Precambrian. Regional infrastructure assessment and requirements to accelerate CCS development are also included with a focus on the Illinois Basin which has large storage potential. The MRCI consortium are working on two major new CCS projects including the Prairie State Generating Station FEED study in southern Illinois. This is a design for a retrofit capture plant to one of two 816 MWe coal-fired gen sets capable of capturing 6Mt/yr. Subsurface characterisation of a potential storage site in St Peter Sandstone, and another at the One Earth Ethanol plant that could secure 0.45 – 1.7 Mt/yr, form part of this stage. A secondary target for Prairie State, and in contrast to the basal sandstone, is the stratigraphically higher Potosi Dolostone (a carbonate formation with very high permeability).

The Precambrian basement characterisation, at regional scale, is focused on the identification of basement faults and well data that has penetrated the basement. Outcrop investigation is included although exposure is comparatively limited in the north-eastern US. Data acquisition from faults, cores and well logs will be used to evaluate stress data and gain a better understanding of basement

stability. The goal is to determine regional induced seismicity potential and demonstrate methods for evaluating site-specific induced seismicity for selected example sites.

NRAP are also developing a methodology to address induced seismicity and its related issues. They include recommended practices for site developers that cover previous cases, legislation and risk assessments based on limits of potential impacts. This initiative is currently open for public comment and review by academia, industry and government. The sharing of lessons learned, case study experience and best practices are encouraged.

MRCI are also assessing requirements for regional infrastructure to accelerate CCUS. The activity covers social, economic and workforce development as well as CO_2 source concentrations and aggregation. Developing source-sink transportation links is based on this work. MRCI also plan to analyse pore space issues, tax incentives and policy. Outreach activities and website development include Site Readiness Factsheets for policy makers and industry. Policy review includes individual climate policy especially for model states which are more advanced in terms of legislation relevant to CCUS, notably Wyoming, North Dakota and Montana.

Stacked green-field and brown-field residual oil-zone (ROZ) fairways by the Illinois Basin Geo-Laboratory is an initiative to co-optimize EOR and associated CO_2 storage. Four formations within the Illinois Basin have been selected for potential CO_2-EOR and associated storage in ROZs. Field tests have demonstrated oil mobilisation with CO_2 from an ROZ. Field data to further develop models to assess CO_2-EOR and storage potential in target formations is required. ROZ storage potential has also been investigated in the Williston Basin by a team from PCOR. Key characterisation data have been acquired as a prelude to determining ROZ storage potential. This project, along with many others, has been delayed because of the impact of COVID-19.

Elsewhere PCOR, which now includes Alaska, has been evaluating regional infrastructure challenges including source-sink matching. The Wyoming Pipeline Corridor Initiative has been formed to promote the development of a CO_2 pipeline network across the state. In January 2021 the Bureau of Land Management approved a proposal to designate over 1,000 miles (~1,609 km) to the pipeline network.

SECARB are also assessing information requirements necessary to develop regional CCUS projects in terms of urgency specifically how much data is already available to make a decision. The idea is to identify relative investment costs compared with the stage a project has reached. Southern Company is actively planning strategic test wellbores in areas with limited data. Further work on assessment of a series of sub-basins and regional infrastructure, including pipeline networks, is now underway. An initial inventory of non-technical challenges, and the establishment of a working group with a number of prominent NGOs, has begun.

In the CUSP region the CarbonSAFE focus is on 50M+ tonne sites. An Industrial Advisory Group that includes state regulatory agencies, CO_2 emitters, CO_2 capture and transport companies, oil and gas operators, policy think tanks has been formed. A select portfolio that includes 12 projects has now been instigated. The projects include: de-risking CO_2 mineralisation in basalts; a pilot project as a prelude to a regional storage hub in California; and CO_2 storage potential in the Harquahala Basin of western-central Arizona; plus CO_2 storage in the geothermal basins of Nevada.

Summary of other significant ongoing R&D

Reservoir pressure control plume management and produced water strategies form the basis of two projects. A project, run by EPRI, is testing the concept of using pressure relief in a storage reservoir, and associated re-injection into a different formation, as a means of controlling reservoir pressure whilst maintaining CO_2 injection. The test site in northern Florida is a formation with highly saline brines (140,000 TDS) which are too expensive to desalinate. Technical complications have impacted the injection phase of the project and a hurricane has imposed additional delays. A similar project in western North Dakota called Active Reservoir Management (ARM) has a key objective to test technologies that can treat high salinity brines.

Test salinity ranges from 17,000 mg/L TDS to 170,000 mg/L TDS. Surface treatment at small-scale has achieved a brine concentration of 40 – 60% and produced a near drinking water quality standard.

NETL (Research Innovation Center) RIC's Carbon Storage Research

NETL's RIC is developing a number of innovative tools. These include an on-line screening tool which can provide an initial storage capacity estimate in different geological environments including shale, ROZs and saline formations. Key data from core characterisation from CarbonSAFE sites like FutureGen2 are already available and can therefore contribute to new projects in the same regions. All data can be accessed on-line via NETL's EDX database. Sophisticated CT (computed tomography) 3D imaging of pore space is also stored. Images can be informative where there is evidence of reactive minerals.

NETL have developed a series of tools to aid integrated decision support for site risk management assessment. There is also wellbore data analysis for three US states that can provide new insights into well leakage risk. A large quantity of data (integrity data form 105,031 wellbores) has been compiled but it requires data mining and machine learning techniques to analyse and identify trends or key information. This approach has been used to estimate leakage frequency trends in Colorado, New Mexico and Pennsylvania.

Wabash CarbonSAFE

Situated at the former WRGS: IGCC (Wabash River Gen Station integrated gas combine cycle) power plant in western Indiana is a modification plan to produce net-zero carbon intensity hydrogen production from a petcoke syngas plant. The hydrogen would be used for ammonia and potentially other markets for power generation transportation fuels and chemical markets. It has a target to produce 1.65 m tonnes, 99% pure CO_2 and begin commercial operations by 2024. This site is of notable interest because although the Mt Simon Sandstone is a target reservoir formation, there is another excellent candidate stratigraphically higher and not in contact with the Precambrian basement. The secondary target, the Potosi Dolomite, has extraordinary permeability (~2,400 mD) over a thin interval 10 ft (~3.0 m) at this site. Elsewhere this formation is used as a waste disposal facility. Since 1970 18 billion US gallons (~68 billion litres) of waste has been injected from a single well equivalent to injecting more than 50 million tonnes of CO_2. Injection continues at a rate equivalent to 60,000 tonnes CO_2 per month. Regional characterisation at site shows the formation is 784 ft (239 m) thick with a good regional seal of calcareous shales and limestones (Maquoketa) with a high fracture pressure threshold. Modelling estimations indicate that an injection rate of 1.67 Mta, injected over 30 years, would store 50 Mt of CO_2. A plume of this scale would extend over a radius of 3.8 miles (6.16 km) or ~45.4 square miles (~119 km^2). Some vertical migration into the overlying Oneota Dolomite could occur but this is still more than 1,270 ft (~387 m) below the base of Maquoketa seal. Modelling also indicates that the reservoir pressure would not exceed the fracture pressure of the seal. The target formations appear to be unfaulted in this area although faults are known in the Precambrian basement. Technical and risk assessments are still ongoing. Source transport assessment continues including a conceptual pipeline connection from industrial sources in neighbouring central Illinois.

The ambition to scale-up regional storage capacity now extends to the Gulf of Mexico (GoM) which has been divided into two separate regions: the Southeast Regional Carbon Storage Partnership (SECARB) led by Southern States Energy Board, which covers the eastern half; and GoMCARB – Offshore CO_2 Storage Partnership under the domain of Gulf Coast Carbon Center, University of Texas at Austin which is mainly focussed on the state coastal waters of Texas and Louisiana.

SECARB's investigation by the University of Oklahoma and ARI has conducted initial geological characterisation of the eastern half of GoM for CO_2 storage with a focus on an area south of the Mississippi delta. Identification of submarine channel complexes have attracted interest.

Further offshore fault partition in depleted oil and gas fields are considered by the research team as candidates for potential CO_2-EOR. The area is geologically complex with allochthonous (detached) salt diapirs. Evidence suggests some prospective storage reservoirs would require pressure management. Preliminary indications suggest that with these complexities storage development costs could be high.

GoMCARB has acquired digital records of 2,959 wells in an area of interest along the coast of Texas. Investigation includes analysis of digital records and the use of machine learning to analyse digital records within a pilot area. BEG have simulated CO_2 injection into the offshore Galveston Island Formation. Assessment of existing infrastructure for re-use of CO_2 transport and storage by Trimeric Corporation, which has a background in oil and gas infrastructure and CO_2-EOR, is being conducted. Accomplishments include a cost estimate for a new offshore CO_2 pipeline and engagement activities with Port of Corpus Christi, industry and NGOs, to discuss CCS prospects in the region.

Preliminary conclusions show that GoM offers gigatonne scale storage potential. Extensive oil and gas exploration and production means that there is an immense geological and geophysical database plus rapidly growing interest especially in the State waters of Texas and Louisiana.

New sensing technologies

This year's meeting highlighted the early stage development of wireless sensors that can transmit signals from subsurface positions. This concept is technically challenging. The subsurface environment imposes demanding conditions so sensors must be robust and be able to sustain functionality. The requirement to be able to withstand P/T conditions during cementation is an obvious example. Moreover wireless telemetry at the depths envisaged must be able to deliver signals from sustainable energy supplies possibly for 30+ years. Bench scale tests to simulate subsurface conditions prior to field testing have been successfully tested under supercritical lab conditions. Two test wells have also been identified in eastern Ohio for field testing in September – October 2021.

Wellbore integrity could be monitored by a concept based on incorporation of wireless microsensors, at millimetre scale, embedded into cement and capable of detecting changes in CO_2, pH, temperature and CH_4. The sensors communicate with 'smart' collars around casing and wired pipe which transmits signals to surface. A sensor coating is to be developed which provides hermetic encapsulation, abrasion resistance and specific gravity. Field experimentation is now planned at a test wellbore facility. If successful the concept could have applications in drilling, pumping and EOR as well as CO_2 storage.

Other wellbore monitoring innovations included: silica coated optical fibre sensors capable of multi-point distributed pH sensing in high pH solutions; a high resolution 3D imaging technology to enhance wellbore images and integrity assessment based on collimated acoustic beams and enhanced receiver processing to improve wellbore images; and thermopile energy sources for downhole wireless sensors. This technology is based on thermoelectric flux to produce electrical energy. The temperature differential between two different materials can produce a voltage that could power sensitive monitoring devices without a surface energy source. Modelled performance has been validated against lab data but progression to field testing is necessary.

In summary, the diversity of projects covered by this year's review meeting, clearly reflects the US ambition to scale-up and broaden CO_2 storage across the country and extend offshore. Despite COVID-19 induced delays good progress is being made with field related projects which show potential of brine and pressure management. A drive towards a more detailed understanding of induced seismicity is a key step for risk assessment especially for continental based storage sites. Initial R&D into wireless microsensors also shows promise although still at an early TRL stage.

James Craig

7th September 2021