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Opinion

CO_2 Capture and Storage has Potential to Become Silver Bullet in Controlling the Greenhouse Gas Emission

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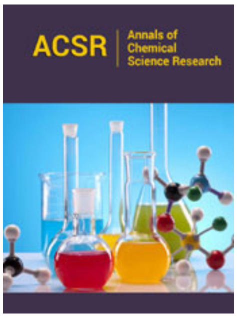

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Opinion

Greenhouse gas (GHG) emission is continuously increasing, and CO_2 is one of the major components in it. Increased concentration of CO_2 in the atmosphere absorbs infrared rays and increases the temperature. It is projected that if nothing is done to control this menace, temperature may rise to more than 3 °C by end of the century from current level. Climate change is happening due to increase of GHG gases and causing devastating impact worldwide. Major source of these gases are economic development and use of fossil fuels viz oil & gas, coal and biomass. All the sectors namely power generation, transport, industry, residential use and lifestyle is contributing to increase of CO_2 emission. Fossil fuels are easy to use and affordable and industrial fuel consumption heavily depends upon this. This has been recognized by all the Governments and efforts are being made to control and minimize unavoidable emission of CO_2.

Companies are also targeting for generation of green fuels and renewable energy which are environment friendly. Focus is shifting to renewable energy like solar, wind, hydrogen etc. Renewable energy is already in use but its contribution to total energy mix is not significant. Nuclear energy is another source of energy which contributes 2-3% in overall energy mix but mainly used in few developed countries and is expensive and has its negative points of disaster. Extensive collaborative research is being pursued for Nuclear Fusion but a long way to go for its success and commercial application. Energy consumption is going to increase due to increasing population, industrial development in less developed and poor countries and massive urbanisation and fossil fuel will continue to play an important role in the coming time in total energy mix. Natural gas generates less CO_2 compared to coal and oil. Therefore, it is poised to play the role of a transition fuel. Economic activities will increase so more CO_2 will be generated. Biomass and agricultural waste have been used for various purposes and also generate CO_2 emission. Its management for useful products makes it essential to manage the produced CO_2 in the utilisation process. Some of the hydrogen generation processes also generate CO_2 and that requires management and reduction in CO_2 production. CO_2 has been used in the industry for manufacturing various useful products. Many reactions are well established, and research is being pursued worldwide. The challenge in massive utilisation of CO_2 in product preparation is the yield of the useful products. Research is progressing to enhance CO_2 utilisation. A multipronged strategy would be required to manage the CO_2 and adopt the plans for CO_2 reduction. However, the biggest contributor to managing the CO_2 is the subsurface geological storage.

Application of CO_2 in enhanced oil recovery has been practised since more than 60-70 years. However, storage or sequestration of CO_2 purely for storage is a recent phenomenon. There are few good projects. Bulk CO_2 can be stored in depleted oil and gas fields and saline aquifers. Other storage sites are coal seams and basalt formations. However, storage in depleted oil and gas fields and saline aquifers are increasing whereas coal seam and basalt formation are yet to be started. The challenge with coal seam is that they occur at shallower depth and CO_2 may not be in the supercritical stage and storage mechanism is adsorption which may not be very efficient. However, adsorption of CO_2 is more than methane so it can be adsorbed and is termed as enhanced coal bed methane recovery (ECBM). Pilot has been done but no commercial storage so far. Similarly, basalt can be one storage site. Estimates suggest huge theoretical capacity, but it will require a huge volume of water during successful injection of CO_2 and water mix. No commercial projects so far. Shale oil application also pilot tested mainly for EOR. The CO_2 hydrate storage technique has also moved ahead of laboratories.

Therefore, CO_2 storage in depleted oil and gas fields and saline aquifer becomes the storage site for the choice for bulk CO_2 storage. However, CO_2 cannot be stored in any subsurface oil and gas fields or saline aquifers. A storage site has to be identified for safe storage. For any storage projects three things are important: capacity, containment and injectivity. Capacity means storage sites must have enough space to accommodate the pressurised CO_2 in bulk. Containment is the seal in overburden and side burden of formation which can hold the CO_2 for a long period and does not allow it to escape. Depleted oil and gas fields have had good seal and storage capacity as they have held the hydrocarbon for millions of years. They are better understood and characterised. Saline aquifers are large, pervasive and present at most of the places near to CO_2 generating units which may not be the case with oil and gas fields. Additionally, saline aquifers do not have any economic value but carry more uncertainty in terms of structure, and caprock integrity. Saline aquifers must be understood and characterised before deciding them for their suitability for CO_2 storage. Stored CO_2 exist in the subsurface geological formation in four forms viz. structural, dissolution, residual trapping and mineralization.

In the beginning contributions from structural components are the maximum 70-80% and mineralization is almost nil. Solubility of CO_2 in water, residual trapping and mineralization increase over the period. Increase of these components further stabilises the CO_2 stability in the formation. Thus, important steps for CCS projects are screening of storage sites, reservoir and caprock/seal characterization and making a comprehensive storage development plan. Storage development becomes a master document for CCS. Its deliverables are a selection of suitable CO_2 capturing techniques, transportation and injection techniques. It provides capacity estimates P10, P50 and P90 and limit of reservoir pressure for injection so that the overburden seal/caprock is intact. Monitoring, measurement and verification popularly called as MMV proved the guidance for monitoring and data collection to understand and report to the regulators for CO2 plume movement and its behaviour in the porous medium. SDP also provides the number of wells to be drilled, types of wells (vertical or horizontal) size of facilities to be created for capturing, transportation, injection and monitoring and frequency of data acquisition. It also captures the major uncertainties of the projects in capturing, transportation and storage and their planning their mitigations. SDP is prepared by a pool of subsurface and surface experts mostly from the oil and gas industry. These disciplines are Geophysics, Geology, Petrophysics, Reservoir Engineering, Well Engineering, Production Technologist, Reservoir Geomechanics, Reservoir Geochemistry from subsurface, facilities engineers from surface engineering and Economists. SDP reports are generally certified by experts for the endorsement of their robustness. This helps to get government and regulatory approval, insurance and financial institutions acceptance and public acceptability that the project is technically sound, and no risk is expected to occur in future. There is no short cut in the SDP. All data needs to be acquired and laboratory studies must be carried out for geo-mechanical, geochemical, geological, petrophysical, reservoir engineering data to be incorporated in SDP. 3D seismic data must be acquired to understand the structure at large scale and to be included in geological modelling. Time lapse seismic data is also acquired at a certain frequency to monitor the CO_2 plume in the subsurface along with pressure, temperature, injection and CO_2 concentration at the surface of leakage detection. Corrosion could be a challenge in pipelines during transport and injection in the tubing's. Suitable materials compatible with CO_2 become a must. Generally, 21Cr material is used which is expensive and adds additional cost to the project. In addition to materials of wells and pipelines, CO_2 compatible cements are required to be used. Geopolymer is one such cement used during drilling and completion of the wells.

CO_2 storage in saline aquifers may require water producers for pressure management in formation for enough voidage and plume management. Water producers' wells are also required to be completed for prevention of sand production. Disposal of produced water also needs to be planned. Flow assurance is also common in the CO_2 injection process as salt precipitation may take place in the wellbore to incompatible fluid and temperature differences. This has to be studied in the lab and a proper plan must be in place to remove the flow assurance issues.

Another striking difference between oil and gas fields and CO_2 injection is the uncertainty. Uncertainty decreases in the former case as more data is acquired with drilling and production in oil and gas production whereas more uncertainty is introduced with time in CO_2 storage. Five stages are critical in a new CCS project which can facilitate a successful project.

A. Feasibility: This is the first stage when Geotechnical and operations experts screen the storage sites both onshore and offshore for geologic and economic potential of CO_2 storage.

B. Storage Development Plan (SDP): SDP is prepared based on the feasibility report by incorporation the subsurface and surface data. A detailed plan for CO_2 capturing transportation, injection and storage including monitoring plan is typical deliverable of SDP.

C. Permission for operation: Permission for CCUS is obtained based on SDP. Sometimes when no data related to injectivity, or geological description is not available a test well is drilled and used to collect data for additional models. This data helps to strengthen the SDP quality.

D. Implementation: The carbon capture, transportation and injection infrastructures are designed and built. Facilities are created and wells are drilled for injection and monitoring.

E. Operation and Monitoring: Actual injection of CO_2 happens during this phase. Typical injection period varies from 25 to 30 years. CO_2 injection is thoroughly monitored for subsurface and subsurface activities. Field is handed over post closure with the advice of monitoring and CO_2 stored volume and status.