MEETING REPORT

Awareness and capacity building in carbon capture and utilization*

In view of its growing importance in the energy industry a national-level awareness and capacity-building workshop on carbon capture storage and utilization (CCSU) was held last year. The objective was to put forth current perspectives on science and technology of carbon dioxide removal and utilization processes in the knowledge domain for addressing its role in climate change mitigation. The inaugural address was delivered by Madhukar O. Garg (Council for Scientific and Industrial Research, New Delhi). He said that power, transportation and industry sectors are major sources of carbon dioxide emissions. Describing research on CO_2 capture carried out at the Indian Institute of Petroleum, Dehradun using novel materials, he suggested that time is ripe for setting up a pilot-scale facility in the country to test all the CO_2 capture research results. He pointed out that refineries, while processing crude into transportation fuel also add to 8–10% of CO_2 emissions. Sooner or later science will provide solutions for utilization of CO_2 into fuel with the help of solar energy and we should work towards the same.

Introducing the theme, Malti Goel (Climate Change Research Institute, New Delhi) described the genesis of anthropogenic climate change and 120 years of science of global warming due to increased CO_2 emissions in the post-industrialization era. Increasing accumulation of CO_2 is causing perturbations in natural carbon cycle. She said globally industry consumes about 40% of the energy and contributes 37% of greenhouse gas (GHG) emissions. Carbon dioxide removal processes using biotic and non-biotic options were explained. She said a new model is being carved for CO_2 mitigation from energy industry by carbon capture and utilization (CCU). Internationally scientific research and demonstrations are growing in this area and about 74 large-scale CO_2 capture projects are currently in various stages of operation, construction or planning.

In the keynote lecture by Anupam Agnihotri (Jawaharlal Nehru Aluminum Research, Design and Development Centre, Nagpur) on 'CO_2 management – Indian aluminum industry perspective', key data on climate change ranking of different countries were presented. It was pointed out that India with 17.84% of the world population, has moderate performance on climate change index and its ranking has fallen from 24 in 2013 to 30 in 2014. Agnihotri mentioned that aluminum production, although energy-intensive, has 3% share of industrial GHG emissions. Increasingly, recycling is seen as a solution for reducing emissions as it consumes only 5% of the energy. Also, 100% recycling can save an estimated 84 million tonnes of GHG emissions per year in India.

In this five-day workshop, delegates nominated by various stakeholder agencies participated. Six technical sessions were held. In the first session on CO_2 utilization, V. S. Verma (Ex-member, Central Electricity Regulatory Commission) while describing power sector planning in India, said that CO_2 emissions from power sector have been a matter of concern and carbon footprint reduction has been attempted. However, due to high cost of electricity generation by adoption of carbon capture and storage and considerable safety risks involved, alternative approaches have been proposed such as retirement of 15,000 MW low-efficiency power plants, introduction of efficient super-critical boilers, and major induction of renewable energy. He also said more thrust is required in research and development (R&D) for carbon utilization rather than storage. Rabi Mukhopadhyay (National Thermal Power Corporation (NTPC)) introduced R&D on CCSU at NETRA (NTPC Energy Technology Research Alliance), an R&D unit of NTPC. Research at NTPC is on best practices, CO_2 capture using pressure-swing adsorption column and micro algal conversion. An open pond (50 × 20 sq. m) pilot plant has been set up in Faridabad to test the efficacy of CO_2 utilization and address the challenges.

K. Palanivelu (Anna University, Chennai) talked on climate change mitigation via utilization of carbon dioxide. He said that among various technologies, gas absorption technology is of great importance. He presented results of CO_2 capture using gas permeation through ceramic supported polymer–amine-based membrane and gave insights into further research in this area. K. Sudhakar (Mulana Azad National Institute of Technology, Bhopal) described model computations for a micro algae biomass reactor. He explained energy balance of biomass and oil yield. The computations suggested that 3.45 tonnes/ha/year biomass productivity can be expected. T. Satyanarayan (Delhi University – South Campus) in his lecture on 'Long-term microbial carbon sequestration options for enhanced CO_2 utilization', discussed biological systems at work using carbonic anhydrase. Biomimetic sequestration is a safe, stable and environmentally benign process. Satyanarayan described attempts for reaching the recombinant enzyme and comparison of its sequestration efficiency with other microbial processes.

In the session on industry perspectives. Ajay Mathur (Bureau of Energy Efficiency, Delhi) talked about the energy efficiency improvement strategies adopted by Indian industry. He said under the phase I of performance, achieve and trade (PAT) scheme, 478 plants in nine designated industry sectors are reducing energy consumption, thereby mitigating CO_2 emissions. Future plans to add new sectors in the phase II, such as refineries, railways and electricity distribution companies were discussed. He also said that for reduction of CO_2, technologies like oxy fuel combustion which produces pure CO_2 which is easy to capture, are a future possibility. Supriya Sarkar (Tata Steel Ltd, Jamshedpur) outlined carbon management strategies adopted by Tata Steel from mining to finished products. Introduction of non-recovery coke oven and utilization of blast furnace CO_2 gas through algae

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route have been successfully attempted. Utilization of CO_2 in water purification is foreseen. Nirmal Jeet Singh (National Fertilizers Ltd (NFL, Vijaipur) presented highlights of contribution of NFL to fulfil the promise of carbon mitigation by installing a carbon dioxide recovery (CDR) plant at their Vijaipur unit. CO_2 from the CDR unit of capacity 450 TPD is utilized for increasing urea production for the company. Amitava Bandhopadhyay (University of Calcutta, Kolkata) talked about limitations of the commonly accepted amine-based absorption process of CO_2 capture such as partial solvent loss and corrosion. He described an alternative approach using ammonia for CO_2 capture. He also presented an outline of multi-sectoral programme with the scope of collaborative R&D with industry for a NH_3–CO_2 process.

In the sessions on CO_2 bio-sequestration and CO_2 storage, Tapas Bhattacharya (ICRISAT Development Centre, Patancheru) described soil as source as well as sink for atmospheric CO_2. Introducing the concept of quasi-equilibrium value of organic carbon, he explained the role of total organic carbon stock in soil on global warming and presented studies carried out on soil minerals in peninsular and extra peninsular regions. Good agriculture management practices are required for improving CO_2 absorption capacity of soil. Pratap S. Yadav (Manipur University, Imphal) said that about three times more carbon is contained in soils than vegetation. He presented data on soil organic carbon stock for different tropical and subtropical forests of North East India. He summarized soil carbon management strategies for NE India, suggesting the need to encourage agroforestry practices utilizing indigenous species of trees such as bamboo plantation in highly degraded land. Baishnab C. Tripathi (Jawaharlal Nehru University, New Delhi) described Free Air Carbon dioxide Enrichment (FACE) facility built on the JNU campus for CO_2 assimilation studies. Enhanced photosynthesis effect on plants leading to larger number of leaves, larger roots and high biomass was explained.

Vinod A. Mendhe (Central Institute of Mining and Fuel Research, Dhanbad), while talking about the Indian scenario of coal bed methane (CBM) recovery, said that India has the fourth largest proven coal reserves and being the third largest coal producer in the world holds significant prospects for recovery of CBM on a large scale. It is anticipated that in 2022 CBM may constitute 10–15% of our natural gas requirement. CO_2 sequestration can lead to enhanced CBM recovery. He said that although CO_2 storage potential in our coal fields is estimated high, more work is required. P. S. R. Prasad (National Geophysical Research Institute (NGRI), Hyderabad) discussed the role of gas hydrates in CO_2 sequestration. Gas hydrates are clathrate compounds in which a gas molecule is surrounded by an organized solid architecture consisting of water molecules. He said studies have been initiated in NGRI and results of the simulation studies are encouraging. Challenges for CO_2 storage were presented by B. Kumar (formerly NGRI). When CO_2 is injected underground, it gets dissolved and can eventually react with reservoir material, if appropriate mineralogy is encountered. He said CO_2 can be injected in geothermal fields and utilized in geothermal energy extraction in place of water, especially in water-scarce areas. Abhijit Mitra (University of Calcutta) talked about marine storage and mentioned that seaweeds are macro algae and serve as a unique reservoir for carbon sequestration. He presented data on seasonal variations of biomass and carbon content of seaweeds in mangrove regions. Gautam Sen (formerly Oil and Natural Gas Corporation) explained the process of enhanced oil recovery from CO_2 injection in depleted oil wells. Time-lapse seismic studies for monitoring and verification and tracking of changes in CO_2 are important for its storage in oil wells. According to an estimate, 140 billion tonnes of carbon can be stored in 50 large oil fields producing additional 470 billion barrels of oil.

The concluding session was chaired by R. K. Sachdev (formerly Ministry of Coal, Government of India). He said that for a coal-based economy like ours, we need to look for solutions in an integrated manner for GHG mitigation, including CO_2 sequestration. The open roundtable discussion topic was CCSU and its acceptance as a low-carbon growth strategy. Different perspectives were presented by the panelists, who agreed that CCU can be a promising strategy in the future, but more work is required to prove its commercial viability. Recommendations were made for a CO_2 capture test facility which can help in making the process cost-effective, and a multi-sectoral research programme for development of ammonia-based CO_2 capture with the participation from Ministries of Chemicals and Fertilizers, Agriculture, Steel and Power as well as academic institutions. The CCU being an infrastructure-intensive multi-disciplinary research, a nodal institution is needed to organize knowledge sharing among the various stakeholders in order to accelerate the pace of work in the country.

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