Editorial

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The increasing atmospheric concentration of carbon dioxide (CO_2) in the environment has raised concerns about the potential for global warming. Although improving the efficiencies of various energy conversion processes and using lower-carbon fuels or alternate energy sources are certainly two methods for decreasing the emissions of CO_2, a third technique is carbon sequestration, where the capture/separation of the gas from large point sources is followed by secure storage in depleted oil and gas fields, in deep saline formations (aquifers), in unmineable coal seams, or in the deep ocean. In the overall carbon sequestration scenario, the capture/separation step is critical, since it may be the most costly and may require a substantial amount of energy [1]. Improvements in existing capture technologies will lower the energy penalty of this step, but there is an urgency to advance carbon sequestration technology through novel, revolutionary capture/separation techniques.

Power generation using fossil fuels is thought to contribute about one-third of the world's CO_2 emissions from fossil-fuel sources [2,3]. These power generation point sources represent an ideal place to remove the CO_2 since it is concentrated, to some extent, in the system gas streams. In conventional pulverised coal-firing combustors, the exit flue gas contains up to about 15 vol % CO_2. More advanced power generation systems, such as integrated gasification combined cycle with oxygen gasification, produce flue gas after combusting the fuel in the turbine, but it may be advantageous to separate the CO_2 from the high pressure streams before the gas turbine. In either case, novel capture technologies can make a significant impact on the power generation and carbon sequestration schemes.

Various types of post-combustion and pre-combustion capture and separation technologies can be used to remove carbon dioxide from power generation point sources. Certain capture techniques can be retrofitted within existing conventional air-based fossil fuel-fired power plants or integrated into new advanced power generation facilities. The capture technologies include solvent wet scrubbing with chemical or physical absorbents; solid dry scrubbing with physical adsorbents or chemical absorbents; cryogenic methods; gas membrane separation; and advanced concepts [3–7]. The selection of a technology for a given capture application will depend on many factors as outlined by Herzog *et al*. [8]. These can include partial pressure of the CO_2 in the gas stream; extent of CO_2 recovery required; sensitivity of the technology to impurities, such as acid gases and particulates that may be present in the gas stream; purity of the desired CO_2 product; capital and operating costs of the process including cost of additives necessary to overcome fouling and corrosion when applicable; and environmental impacts of the process.

This special issue of *IJETM* introduces some of the newer techniques that fall within the various categories of capture technologies. The use of an ionic liquid to physically absorb CO_2 represents a novel method to remove CO_2 from a gas stream as compared to more conventional techniques. A new chemical absorption, wet scrubbing process that involves an ammonia-based scrubbing solution is reported to remove not only CO_2 but other acid gases from flue gas. A flurry of activity in the solid dry scrubbing area for the removal of CO_2 from pre- or post-combustion gas streams is occurring. It is envisioned that sorbents would be used in a dry, regenerable mode of operation. Experimental information on chemical absorbents with alkali- or alkaline earth-metals as the active component or with amines deposited on substrates is reported along with the certain unique features to the capture process. A low-temperature molecular basket sorbent offers the prospect of a significant breakthrough in physical adsorption of CO_2 from gas streams. Results for CO_2 removal from flue gas with magnesium hydroxide slurry reclaimed from lime-based flue gas desulphurisation are described. Finally, characterisation and experimental results with a membrane for selective CO_2 separation from gas streams are discussed.

Most all of the capture and separation techniques described in this issue are in their initial developmental stages. Once a reasonable database and an in-depth systems analysis have been established, promising technologies will be demonstrated on a larger scale. Nevertheless, the experimental and theoretical information provided in the following manuscripts can provide a basis for preliminary evaluations of the respective technologies and will, hopefully, introduce new options to conventional techniques that can capture and separate CO_2 from large point sources.

References

1 'Carbon sequestration research and development', *DOE Report No. DOE/SC/FE-1*, US Department of Energy, Washington, DC, December 1999.

2 Herzog, H., Golomb, D. and Zemba, S. (1991) 'Feasibility, modeling and economics of sequestering power plant CO_2 emissions in the deep ocean', *Envir. Progress*, Vol. 10, No. 1, pp.64–74.

3 UK Department of Trade and Industry (2000) 'Carbon dioxide capture and storage', *IEA Report DTI/Pub URN 00/1081*, UKDTI Cleaner Coal Technology Programme, London, UK, September 2000.

4 Wolsky, A.M., Daniels, E.J. and Jody, B.J. (1994) 'CO_2 capture from the flue gas of conventional fossil-fuel-fired power plants', *Envir. Progress*, Vol. 13, No. 3, pp.214–219.

5 Riemer, P., Audus, H. and Smith, A. (1994) 'Carbon dioxide capture from power stations', *IEA Report ISBN 1-898373-15-9*, International Energy Agency, Greenhouse Gas R&D Programme, Cheltenham, UK.

6 Smith, I.M. (1999) 'CO_2 reduction – prospects for coal', *IEA Report ISBN 92-9029-336-5*, International Energy Agency, Coal Research, London, UK, December 1999.

7 White, C.M., Strazisar, B.R., Granite, E.J., Hoffman, J.S. and Pennline, H.W. (2003) 'Separation and capture of CO_2 from large stationary sources and sequestration in geological formations – coalbeds and deep saline aquifers', *J. Air & Waste Mange. Assoc*, Vol. 53, pp.645–715.

8 Herzog, H., Drake, E., Tester, J. and Rosenthal, R. (1993) 'A research needs assessment for the capture, utilization and disposal of carbon dioxide from fossil fuel-fired power plants', *Final Report US DOE Contract No. DE-FG02-92ER30194*, Massachusetts Institute of Technology, Cambridge, MA, July 1993.