Editorial

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Biographical notes: Wojciech M. Budzianowski is a Leader at Renewable Energy and Sustainable Development (RESD) Group and an Associate Professor at the Wrocław University of Technology. He holds a PhD in Chemical Engineering and DSc in Mechanical Engineering. His research interests include: renewable energy, bioenergy, decarbonisation, process engineering, bioeconomy and sustainable development. He is involved in editorial activities for several academic journals and consultancies for various organisations, industries, national and international R&D agencies, etc.

Jon Gibbins has worked on coal and biomass gasification and combustion for over 30 years, at the Foster Wheeler, Imperial College and the University of Edinburgh and on carbon capture and storage (CCS) since 2002. He is currently a Professor of Power Plant Engineering and Carbon Capture at the University of Edinburgh and the Director of the UK CCS Research Centre (http://www.ukccsrc.ac.uk), which is supported by Research Councils UK to lead and coordinate a programme of underpinning research on all aspects of CCS in support of basic science and UK Government efforts on energy and climate change.

Suzanne Hangx is a postdoctoral Researcher at the High Pressure and Temperature Laboratory of Utrecht University, the Netherlands. She received her PhD at UU in the field of CO_2 storage, coupling CO_2-induced chemical reactions and interactions to changes in mechanical properties. After her PhD, she worked within the Subsurface Storage and Containment Technologies team at Shell Global Solutions International (Rijswijk, the Netherlands). In this position, she studied the chemo-mechanical properties of natural CO_2 fields, as well as provided support to upcoming CCS projects, such as the Peterhead CCS project. Currently, she is back at the Utrecht University, continuing to work on CCS and other socially relevant problems related to sustainable geo-energy production.

Mathieu Lucquiaud is a Lecturer in the School of Engineering and a Royal Academy of Engineering Research Fellow at the University of Edinburgh (UK). He received his PhD in Mechanical Engineering from Imperial College London in 2010 and has been working on CCS since 2005. His research focuses on thermal power plant engineering with carbon capture and lies at the interface between mechanical engineering, chemical engineering and techno-economics. He is particularly interested in developing capture-ready and retrofit options for existing and new capture technologies, exhaust gas recycling in gas turbines and the operational flexibility of CCS.

Andrea Ramirez is an Associate Professor at Utrecht University (the Netherlands). She received her PhD on the field of monitoring energy efficiency. Since May 2005, she works as a Senior Researcher on CCS. She coordinated the subprogram CO_2 transport and chain integration (SP2) of the Dutch national program on CCS CATO2. She is a Principal Investigator of the international research project environmental due diligence of novel CO_2 capture and utilisation technologies (EDDICCUT). She has over 25 articles on CCS and was the Lead Author of the CCS chapter in the Global Energy Assessment.

The current rate of anthropogenic carbon emissions (~35 Gt CO_2/y) is not sustainable with respect to acceptable levels of climate change, even if it may have to be tolerated on the short term for economic reasons. Ultimately, there is a limit to the carbon content in the atmosphere that can be sustained in the longer term without destructive consequences to the environment and human well-being. Many experts agree that the cumulative emissions of greenhouse gas in the atmosphere for a 1.5ºC to 2ºC of global warming has already been achieved or will be achieved in the near future. Accordingly, as pointed out by the Intergovernmental Panel on Climate Change, global CO_2 emissions would have to peak in the near future, then decrease in the medium term, before they are significantly limited, potentially to zero, in the longer-term future. Carbon capture, utilisation and storage (CCUS) are essential low-carbon technologies to meet the recommendations of the IPCC without excessive cost. Overall, CCUS, at least in its most conventional form, is considered to add a low-carbon premium to energy costs, in particular significant costs related to the production of high-purity compressed CO_2 streams and to establishing transport and storage infrastructure. Therefore, research directed at finding innovative solutions to reduce this premium needs to be prioritised. Especially economically viable approaches that properly address all technical and environmental issues of the entire value chain are seen as critical for successful implementation of CCUS at a meaningful scale.

This special issue of the *International Journal of Global Warming* entitled ‘Developments in carbon capture, utilisation and storage’ has been developed as a primary forum for sharing expertise on CCUS among both academic and industry researchers and practitioners to propose and foster discussion on state-of-the-art research and developments in the areas of CCUS. The guest editors invited manuscripts with a focus on CCUS innovative technologies, R&D project outcomes, policy design and many other issues with significant impact on CCUS development. This special issue combines eight articles from leading groups in Northern America (USA), Asia (China) and Europe (Poland), outlining a range of key research currently being carried out into the context of CCUS.

Regarding the capture aspects of CCUS, this issue contains three papers discussing the integration of CCUS into power plants. The first study investigates process integration of CO_2 capture in a power plant. A 600 MWe supercritical coal-fired power plant is tested and plant efficiencies are calculated for various techniques aimed at improving plant performance. The study indicates that appropriate flowsheet modifications for the integrated process can significantly improve the overall energy efficiency. The second study analyses the impact of CO_2 capture and compression units on the performance of a modern GT combined cycle unit. It provides insights into how power plant efficiency is affected by various CO_2 separation and compression processes, as well as by the combined cycle plant configuration. The third paper is dedicated to oxy-fuel combustion and its thermodynamics and economics. It finds that the loss of net efficiency of electricity production in the presented oxy-firing coal power plant unit can be limited to about 6% relative to the reference power plant.

Two other papers are dedicated to improved CO_2 capture. One of them investigates the performance of CO_2 capture with different flowsheets by using process simulation and energy intensity analysis. The methodology is useful in evaluating configurations that require different amounts of electricity and thermal energy, i.e., bearing significant cost for the process and potentially lowering CCUS efficiency. The second study reports a novel technology employing a one-step sol-gel method followed by supercritical drying to synthesise novel CO_2 capture sorbents [amine hybrid silica aerogel (AHSA)]. The CO_2 adsorption and desorption performance of AHSA revealed that it is has very short adsorption half time and low desorption temperature. Thus, the resulting adsorbent possesses excellent regenerability for low-concentration CO_2 capture with potentials to lower capture costs.

From a carbon dioxide storage perspective, the special issue presents two studies, both reporting on recent developments in CO_2-enhanced oil recovery (EOR), aimed to improve economics of CCUS. The first article investigates water-alternating-gas (WAG) CO_2 flooding in a heterogeneous oil reservoir of low permeability. The presented optimisation algorithm could support improved feasibility for this approach. The second paper provides insights into the impact of CO_2 content on the physical properties of the liquid phase mixture, such as density and viscosity in oil production wells. The employed methodology includes the theory of two phase flash.

Last, in order to implement CCUS on a large-scale, it is important that policies are put in place. The eighth paper in the issue is a conceptual study addressing policy design to facilitate deployment of CCUS. It investigates methods for the optimal implementation of CCUS in a circular economy and takes into account technology developments and economic issues. It suggests that for successful implementation of CCUS greater integration of CCUS with future business lines will be needed and characterises scenarios improving such integration within the context of the circular economy.

The guest editors thank all authors for sharing their research results, insights and conclusions on prospects and challenges associated with expanding CCUS in the future low-carbon global economy. The studies shed light on the current CCUS challenges and provide a springboard for governments, industries and research organisations for further developing CCUS technology to the level where it can provide a significant contribution to lowering CO_2 emissions. The guest editors are also grateful to all the reviewers for their constructive criticism of the draft manuscripts. Before closing, the guest editors would also like to acknowledge the support and guidance provided by Editor-in-Chief Professor Dr. Ibrahim Dincer and journal manager Ms. Liz Harris to bring this issue to fruition.