ieaghg
Evaluating technology options to mitigate greenhouse gas emissions

Greenhouse News

• the official newsletter of IEAGHG and its members •

March 2016 • Issue 121

COP-21 and the Paris Agreement, by Tim Dixon & John Gale, IEAGHG

The panel at the side event (Photo courtesy of IISD)

Years of work within UNFCCC culminated in the Paris Agreement in December 2015, which is a major step forward in dealing with climate change. There are several points to note in this agreement; first that this is an agreement reached by 195 countries covering both the developed and developing world.

The second key point was the desire to reduce the temperature rise to below 2^{0}C. Setting such a goal represents a significant global ambition that we must work hard to realise. The Intended Nationally Determined Contributions (INDC's) volunteered by Governments before COP21 of course do not get us to this target, they are more likely to get us to 2.7^{0}C. But they represent a significant starting point and there is a commitment to update these every 5 years.

A third point of note that the players at COP21 were not just Governments. There were significant inputs from non-governmental actors such as major religions, companies and cities. Actions taken by non–Governmental actors to reduce their greenhouse gas emissions will have a big global impact.

The final point is the position of Carbon Capture and Storage (CCS) going forward. CCS is now an accepted technology in the UNFCCC, but CCS was only included in 6 of the INDC's submitted by Governments prior to COP21. However this is not surprising as the actions covered

In this issue

Photograph Courtesy of IISD

by the INDC's cover only up to the period 2025 or 2030 and will of course focus on early, low cost actions like energy efficiency and fuel switching. However at IEAGHG we believe that the new below 2^{0}C target makes CCS even more relevant in the future (as suggested by the IPCC 5th Assessment Report 2014). With many developing countries still planning to use fossil fuels into the next century, it is important that decisions now on these plants include the option to add CCS at a later date otherwise they could lock in these emissions into the next century and beyond. CCS is also crucial to decarbonise heavy industry. It is also likely that we will need negative emission options post 2030 and BioCCS is a proven option.

COP-21 Outcomes

Whilst the full interpretations of the outcomes are still underway, our quick summary of the outcomes of COP-21 are as follows.

COP-21 decisions included:

- To note the significant gap between current pledges and achieving 2^{0}C
- To calls for enhanced pre-2020 actions
- To request a new IPCC report on 1.5^{0}C ambition and appropriate emission trajectories, by 2018
- To adopt the Paris Agreement
- To adopt Decisions to give effect to Paris Agreement, including on: Mitigation; Adaptation; Loss and damage; Finance; Technology Development and Transfer; Capacity Building; Global stocktake
- On technology - to strengthen the Technology Mechanism (Technology Executive Committee and Climate Technology Centre and Network) in: (a) technology research, development and demonstration; and (b) development and enhancement of endogenous capacities and technologies.
- To develop a technology framework by Nov 2016 to facilitate: (a) undertaking technology needs assessments; (b) The provision of enhanced financial and technical support for the implementation of the results of the technology needs assessments; (c) The assessment of technologies that are ready for transfer; (d) The enhancement of enabling environments for and the addressing of barriers to the development and transfer of socially and environmentally sound technologies.

The Paris Agreement, in summary:

- Article 2 – Objectives. The purpose of the agreement is limit warming to "well below" 2.0^{0}C (by 2100) and pursue 1.5˚C. To be delivered by the pledges in Articles 3 and 4. To increase adaptation, increase finance. Also to continue the principle of "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances".
- Articles 3 and 4 – Mitigation. To be achieved at a national level by (Intended) Nationally Determined Contributions (I)(NDCs). 185 countries submitted = 94% global emissions, could achieve ~ 2.7^{0}C (cf 3.6^{0}C with existing policies). NDCs to be updated every 5 years. To represent a progression.
- Article 6 – mechanism for "internationally transferred mitigation outcomes" – this could be a new CDM-type mechanism, details to be developed.
- Article 9 Finance" – Financial Mechanism to continue, to be administered by continuing the Green Climate Fund (more than $100bn by 2025) and the Global Environmental Facility.
- Article 10 - Technology Development and Transfer. The technology framework to provide overarching guidance to the Technology Mechanism (i.e. CTCN) in promoting technology development and transfer and to "strengthen collaborative approaches to research and development". This is technology neutral at the moment, depends on the technology framework which will be developed.
- Article 11 – Capacity Building – including on technologies
- Article 12 – Education – including on technologies
- Article 13 – Transparency in reporting is called for.
- Article 14 – Stocktake - in 2023, then every 5 years.

- Article 16 – meetings to be known as Conference of the Parties serving as the meeting of the Parties to the Agreement (CMA). ADP becomes the Ad Hoc Working Group on the Paris Agreement (APA).

The Paris Agreement will enter into force when 55 Parties ratify with 55% of global emissions.

UNFCCC Side-event on CCS at COP-21

The main UNFCCC Side-event on CCS was organised by IEAGHG, University of Texas, CCSA and CO2GeoNet. The event was titled "Carbon Capture and Storage (CCS): Achievements and Opportunities for Developing Country Involvement". The event was very well attended, with around 200 attendees, many from developing countries, and various media.

After scene-setting by IEAGHG, Philip Ringrose of Statoil presented on 19 years of operations in the North Sea region. Ton Wildenborg of CO2GeoNet presented on EU pilot projects which have collectively demonstrated the safety of storage. We were privileged to have The Honourable Brad Wall, Premier of Saskatchewan, Canada, provide a politicians perspective and to introduce Mike Marsh, President of Saskpower to talk about the first year of operation at Boundary Dam. This included their global knowledge centre which is going to be launched and will be supported by BHP Billiton. Katherine Romanak of the University of Texas BEG presented on new collaboration opportunities in offshore storage. The event concluded with a talk on the Climate Technology Centre and Network, a funding source for technology transfer and capacity building in developing countries, by its Director Jukka Uosukainen.

The excellent quantity and quality of questions that followed demonstrated the high level of interest and positive engagement in the event and the topics, such that discussions had to continue after the event outside the room, with panel members also being interviewed by various media. Reporting of the event was provided voluntarily by IISD (who are the primary media reporting inside COPs) and by NHK World Television. The IISD coverage can be seen at **www.iisd.ca/climate/cop21/enbots/1dec.html#event-6** .

Photograph Courtesy of UKCCSRC

In addition, the exhibit booth on CCS, run jointly by University of Texas, CO2GeoNet, CCSA and IEAGHG, proved very busy, with a continuous flow of COP delegates seeking a range of information on CCS. IEAGHG used it in particular to promote the International Journal of Greenhouse Gas Control Special Issue and the new report on Boundary Dam.

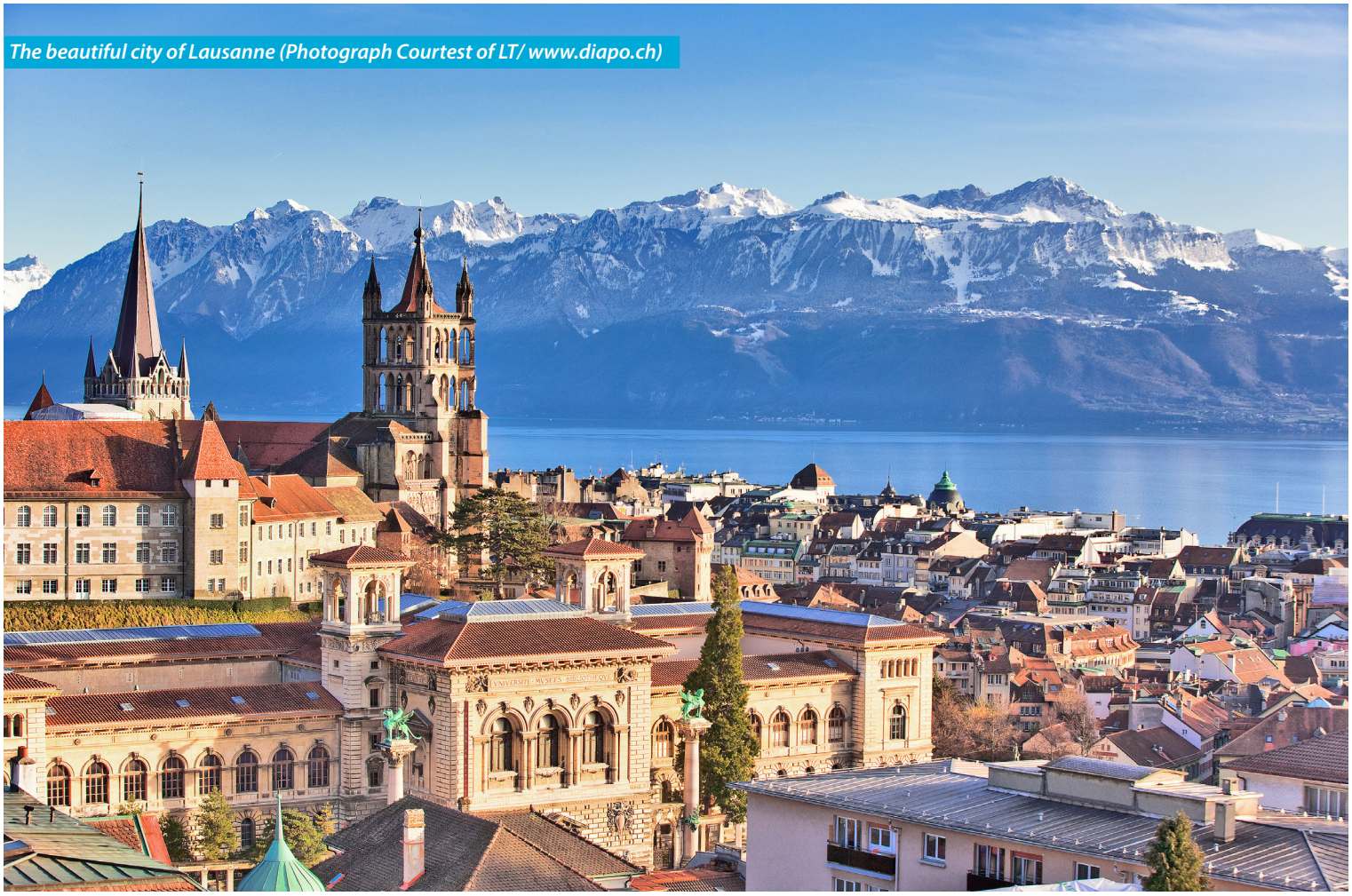
In Conclusion

IEAGHG and our partners at COP were happy to play our modest role in providing technical information to support the high level agreement, but we all played a bigger role in our work over the years, such that the IPCC and UNFCCC now recognise the need and viability of CCS. We attempted to make all this knowledge available at this COP, through the UNFCCC Side-event, the booth, the Special Issue of the International Journal of Greenhouse Gas Control, and our reports.

This was indeed a historic UNFCCC meeting. The headline message is to limit warming to "well below" 2.0^{0}C (by 2100) and pursue 1.5^{0}C, thus needing more mitigation activities, including more CCS. Whilst the emissions reduction pledges in the Paris Agreement are voluntary by each country, they send a political message to each country and to businesses, and the national performance to these pledges will be re-evaluated every five years in the UNFCCC. Let us hope that the policy-makers turn their words into significant and rapid actions. ●

GHGT-13: The Place to be this November,

by Siân Twinning, IEAGHG



The beautiful city of Lausanne (Photograph Courtest of LT/ www.diapo.ch)

It is easy to hype up a conference only for the event itself to be a let-down, however, GHGT-13 is a conference developed by a committee who are fully committed to the advancement and deployment of the CCS technologies and therefore have a deep understanding of the technical, legal, regulatory, economic and political scenes involved. Despite reports having demonstrated the need to include CCS to achieve goals of creating a low carbon future, still there are barriers to rolling out such a crucial piece of the energy puzzle.

Having secured the International Energy Agency's Director for Sustainable Energy Policy and Technology, Kamel Ben Naceur to deliver one of the opening plenaries and with two more big names in the pipeline, delegates can look forward to the start of the conference that will set the scene for the week. At the time of writing the 1,017 abstracts that were received from all areas of the CCS world, are being reviewed by the Expert Review Panel ready for the Technical Programme Committee to develop these into the seven parallel technical sessions.

During the last few months, we have given you all of the arguments for submitting and attending the conference, aside from the obvious opportunities to update yourself on the latest developments and thinking on CCS. The relationships that are renewed and built during the week cannot be underestimated. So much more is learnt over a coffee or a dinner table chat than can be presented. With so many people attending all with the same goal, the atmosphere is energising and uplifting and can serve as a reminder as to why we are all doing what we do and where our particular cog fits into the CCS machine.

Aside from the conference itself is the city of Lausanne, this is well worth taking a few extra days to explore. Unusually, the conference runs from Monday to Friday, leaving the weekend as an ideal opportunity to discover the local area. In close proximity you have the contrasts of Lake Geneva and the Swiss/French Alps .

Lausanne!
Like you've never seen it before.

There's no end to the delights of the spectacular Swiss Riviera. In a country awash with beautiful scenery, this region still stands out for its picture-postcard vistas, flower-fringed promenades, rolling hills and romantic waterways.
Visit the Olympic city of Lausanne, said by some to be the loveliest landscape in the world. From the UNESCO-protected vineyards of Lavaux to the dizzying heights of Mont Blanc, you can choose to enjoy iconic architecture, tranquil train journeys or energetic pursuits.
Our hosts have planned some excursions to include a visit to the Diablerets Glacier and (if you would like something that feels less work related) the Chillion Castle, but these are just two of the packages on offer that can be booked during the conference registration.

And with a seamless link to the conference registration, this will open on the 7th April with an Early Bird offer of CHF 900. With author notification being sent and the draft programme available on the 1st June, you will have plenty of time to get the travel request forms in and approved before the offer closes on the 13th July! The Steering Committee have worked hard to encourage sponsorship of the conference enabling the fee to be kept far below that of commercial conferences and to assist student attendance, there will be a lower fee of CHF 450.

Abstracts were received from 39 countries, with the US, Norway and UK leading the way with 100-200 abstracts each, some of the other countries may be more surprising and with attendees anticipated from a similar global spread where else can you learn of developments in Kenya, Israel, and Turkey to name just a few?

Registration will be online at **https://meeting.artegis.com/lw/LoginPage?T=1&custom=1451&navid=12966&event=11684** (but don't worry, we will send a reminder as soon as it opens!) at the centre of excellence for technology, EPFL on the shores of Lake Geneva. Lausanne is very easy to get to, with trains running every 15 minutes from Geneva airport and of course, they run on Swiss timing and being the smallest city in the world to have a rapid transport system, the 28 station metro will ensure that wherever you stay in the city, you will have quick and easy access to the GHGT-13 Venue. Local transport cards are provided for the duration of your stay by the hotels so no need to allocate additional budget for getting round during your stay.

Don't forget to join the event on Facebook where you can get all the latest conference news, information and announcements: **www.facebook.com/events/803103549835901/**

Conference website: **www.ghgt.info**●

A CCS Seismic First at Aquistore, by Norm Sacuta, PTRC

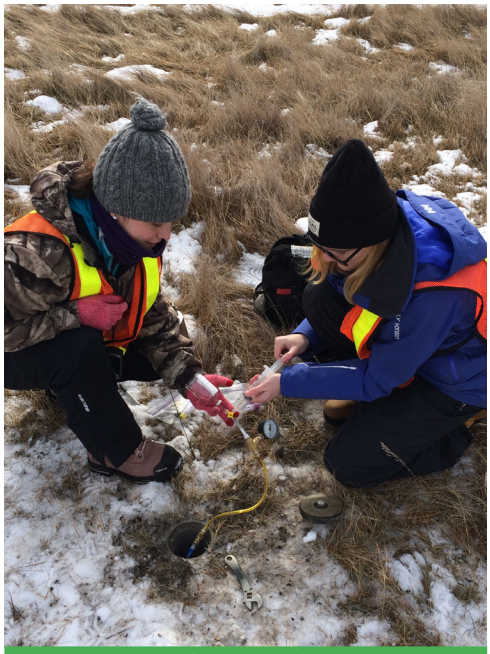
Vibroseis vehicle at the Aquistore site

The Aquistore site in southeastern Saskatchewan proved to be a hive of activity in February with the deployment and acquisition of three dimensional (3D) seismic over the injection area as well as a vertical seismic profile (VSP) around the injection well. Carbon capture and storage projects rely on effective monitoring of injected CO_2.

Aquistore is the deep saline storage project, managed by the Petroleum Technology Research Centre, affiliated with SaskPower's Boundary Dam Carbon Capture facility near Estevan, Saskatchewan. Its mandate is to test the efficacy of various measurement, monitoring and verification techniques and technologies, with seismic imaging a critical component.

"Before injection started, our researchers developed a predictive computer model of where the CO_2 would go in the formation," says Don White, a geophysicist on the project and senior scientist with the

Soil gas sampling on site with Boundary Dam in the background



Soil gas sampling around Aquistore site

Geological Survey of Canada. "The seismic images created by this week's seismic tests will be compared with that model to see if the CO_2 plume is following our predictions. Any noted differences will help improve the predictive model and indicate whether the CO_2 is staying where we want. That's important for regulators and companies who are responsible for storage."

The Aquistore site has a 650 geophone permanent array to create three dimensional (3D) images of the injection location.

"In addition to the traditional sensors (geophones), a fibre optic cable running down the well and in a trench alongside the injection and observation wells is using DAS to help create subsurface images. From a technical point of view, we want to see how well this fibre optic technology can help us see what's there, and whether it shows more detail than the geophones" notes White. This is the first time DAS has been used for seismic imaging at a CO_2 storage site.

Geophysicist Rob Kendall, Vice President of Research and Special Projects at Tesla Explorations Limited, directed the seismic work at the Aquistore site and notes that many different industries are watching the results of Aquistore seismic testing closely. Aquistore is simultaneously acquiring the VSP survey using an 80 level geophone string and a casing conveyed DAS fibre line. Right now, most wells requiring a VSP use a geophone string down hole.

"The running of geophones down a wellbore is often expensive and requires the suspension of other activities in the well whereas a casing-conveyed fibre line provides a permanent measuring tool over the life of the well. This is a technology of particular interest to oil and mining companies," Kendall notes.

"As just one example, DAS could provide information on background seismicity, micro seismicity, and induced seismicity for horizontal wells conducting hydraulic fracturing, providing instant information without having to stop operations," notes Kendall. "The different distributed acoustic sensors being tested at Aquistore may prove revolutionary not just for CO_2 monitoring."

In addition to the seismic work performed at Aquistore, a round of soil gas sampling was undertaken in and around the site to compare with baselines taken before injection began and additional measurements taken in the past year. With a significant amount of CO_2 now injected at the site, researchers from St. Francis Xavier University (Nova Scotia) used mobile surveying units to measure for soil gas and isotopes around the site and on neighbouring properties.

To follow the publicly available scientific results, follow PTRC's Twitter and Facebook updates (@PTRC_SK, or PTRC on Facebook).

New 'Knowledge Centre' on CCS Established by SaskPower and BHP Billiton, by Tim Dixon IEAGHG

In February SaskPower and BHP Billiton announced the establishment of a new global 'knowledge centre' on CCS in Regina with an investment of C$20 million over 5 years by BHP Billiton. SaskPower will contribute its CCS expertise and experience gained through its world-leading CCS initiatives in the commercial-scale CCS at Boundary Dam, the Carbon Capture Test Facility at Shand Power Station, and Aquistore storage project.

The centre's mission is to help accelerate the development and application of CCS. The work undertaken at the centre will help bring down the costs of CCS technology, assist in the management of development risk and promote greater information sharing around the world.

"We are very pleased to have BHP Billiton as a partner in this centre," SaskPower President and CEO Mike Marsh said. "Talks between our two companies began at a United Nations climate change conference in Peru in late 2014. Just over one year later, we are celebrating a ground-breaking knowledge centre that will offer the world a vehicle to advance the technology and commercial viability of CCS."

Serendipity played a role with those talks at COP-20 in Peru, SaskPower were there because of IEAGHG and the University of Texas in order to be a key part of our Side-event on CCS which was promoting the Boundary Dam project.

IEAGHG looks forward to future involvement with this new 'knowledge centre', through our long-standing relationship with Saskatchewan's CCS activities and through our recent Memorandum of Understanding with SaskPower on collaboration on CCUS research. ●

2nd International Forum on Recent Developments of CCS – the Impact of Impurities on the Whole CCS Chain from Capture to Transport and Storage, by James Craig, IEAGHG

16th – 17th December, 2015, Athens

The 2nd International Forum on Recent Developments of CCS, held between 16th and 17th December in Athens, brought together pan European expertise from SINTEF in Norway, Ruhr-Universität Bochum and BRG from Germany, University of Leeds, Warwick, and Imperial College from the UK, OCAS, from Belgium, the Dutch research institute, TNO, the University of Zaragoza and CIUDEN from Spain, NCSR Demokritos from Greece plus representatives from USA, China and IEAGHG. The two day meeting covered recent research supported by EC 7th Framework under the CO2QUEST and IMPACTS programmes.

Theme of the meeting was the impact of impurities in CO_2 across the entire CCS chain from capture and transport to storage. There were a series of presentations on the thermodynamic properties of CO_2 with varying levels of impurities which clearly highlighted that small amounts of impurities can have a big impact on operational conditions. The gases of interest include N_2, O_2, Ar, CH_4, H_2O, CO, H_2, SO_2. The composition of impurities, and their concentration, can influence viscosity and pressure which are key parameters for the design and operation of pipelines. Much of the research under the IMPACTS Programme has focussed on the development of modelling CO_2 mixtures and subsequent verification from experimental data. Pipeline specifications have also been tested by conducting fracture propagation tests at different scales including external field-scale tests in UK and China. Rupture experiments measured the impact of high pressure releases providing valuable experimental data on the pattern of gas release and rate of fracture propagation. The refinement of model prediction is fundamental for design parameters especially safety. Experiments are also an important technique to observe atmospheric dispersion of gas clouds.

The meeting concluded with a brief review of CO_2 mixtures on storage conditions. The presence of SO_2 as well as CO_2 can form acidic conditions in the presence of water. Calcium rich minerals can be dissolved altering porosity, but sulphate minerals such an anhydrite can be precipitated. Modelling suggests long term impacts are very limited at low SO_2 concentrations, but cement mineralogy in wellbores can be altered. More research is necessary and field tests are planned.

The meeting has successfully highlighted the significance of impurities across the CCS chain and provided some guidance on the thresholds for impurities in CO_2 streams. IEAGHG has an active and ongoing interest in the impact of impurities. A recent study on flexible operation entitled "Operational Flexibility of CO_2 Transport and Storage", as well as previous research, has investigated how impurities affect transport and storage.

IEAGHG Summer School, by Siân Twinning, IEAGHG

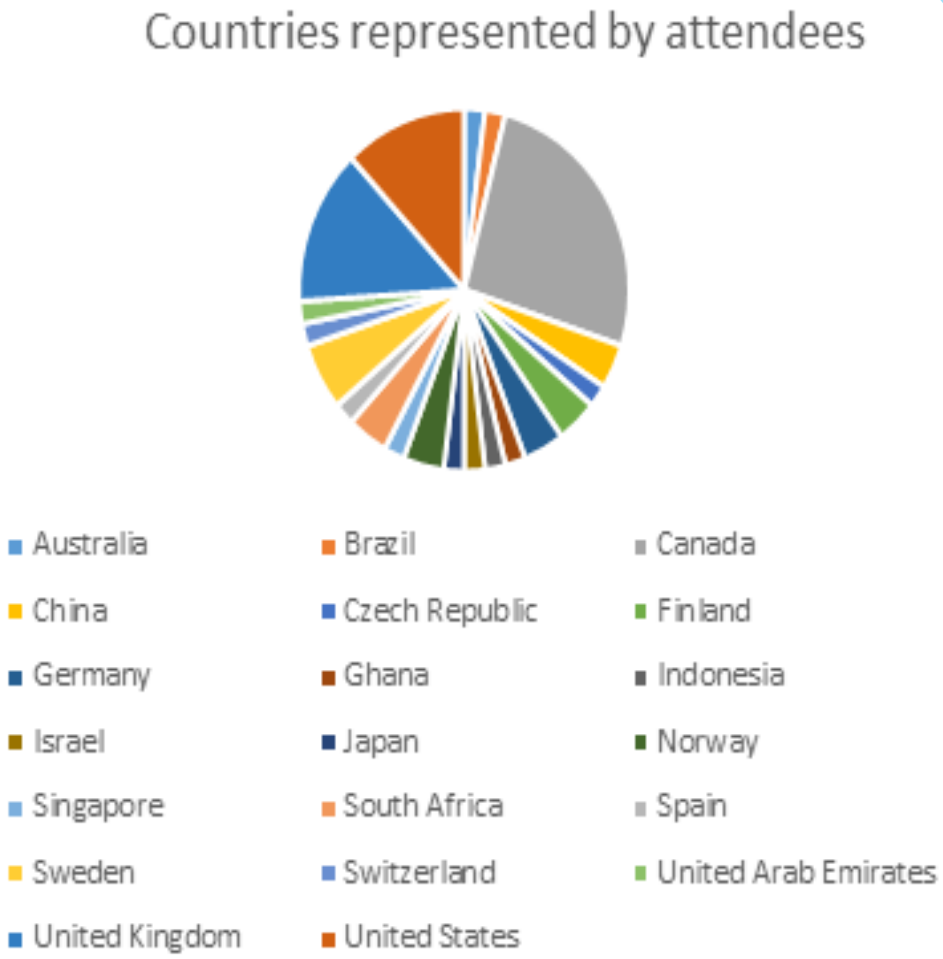
2015 saw a change for the IEAGHG Summer School as this was the first year that students had been required to fund their own travel. We were slightly nervous as to how this may affect the number of applications but is seems the reputation of the event and world class programme on offer was sufficient to send students in search of elusive pots of funding to allow them to attend.

With the event still oversubscribed, we selected 30 students to join us and 19 International experts in Perth, Australia at the beginning of December. With students from 14 different countries attending, one of the major outcomes from the week is the networking, not only with their peers but also with the expert speakers and mentors. The series sponsors (DECC UK, Statoil, CLIMIT, Shell and the Swiss Federal Office of Energy) and local sponsors (Global CCS Institute, Anlec R&D, National Geosequestration Laboratory, The University of Western Australia, CSIRO, Curtain University, Shell Australia, the Government of Western Australia Department of Mines and Petroleum, Energy & Minerals Institute, The University of Adelaide and CO2CRC) not only provide the financial assistance for this event to happen, but also extend this support by donating the time of their leading experts as speakers and mentors for which we are extremely grateful.

We would like to extend our thanks also to our hosts, the Australian CCS Community, without whom, the event would not have been possible.

The week was as successful as ever with both classroom learning and a visit to the Collie South West Hub wells (www.dmp.wa.gov.au/South-West-Hub-CCS-1489.aspx) where

we learnt of the array of monitoring and seismic detection technologies being used at the site and the efforts to involve the community and gain acceptance for the project from local residents. Supporting this was the group work which occupied students during the evenings, posing questions for them to address and present to the remaining groups and mentors on the final day. Rounding off with a 'Graduation Dinner' on the banks of the Swan River, students departed with a greater knowledge of CCS and a new network of peers providing a lasting legacy from the week.



A 'students eye view' of the week will be included in our Annual Review provided by three students from the UK.

For the 92 applicants to the IEAGHG 10th International CCS Summer School, the 29th February brought news of the status of their application. Additional sponsorship gained for this year's event, means we have been able to accommodate 50 students and these will represent 20 different countries.

As anticipated, the links with SaskPower, the newly formed BHP Billiton/SaskPower Knowledge Centre and opportunity to visit Boundary Dam brought applications from many Post Combustion researchers with over 50% of applications coming from this discipline. The programme, however, will remain a balanced overview to include both technical and non-technical aspects about all parts of the CCS chain ensuring all students will leave with an understanding of the global CCS scene and knowledge of how their research contributes to the future full scale deployment of the technology.

CLIMIT-Workshop on "Emerging CO_2 Capture Technologies" – Focus on Energy Intensive Industry, by Svein G. Bekken, Gassnova SF

A major part of Norway's land based sources of CO_2 emissions originate from energy intensive industry. Gassnova, on behalf of the Norwegian Government, carried out a prefeasibility study in 2015 on full-scale demonstration of CCS, which identified three possible locations, all different energy intensive industries: one cement, one ammonia and one waste incineration plant. These three plants are now taking part in a feasibility study to be completed in June 2016. CCS in energy intensive industries is thus of special interest for Norway.

CLIMIT, the Norwegian national programme for research, development and demonstration of CCS, organized a workshop on emerging CO_2 capture technologies with a special industry focus, in Oslo January 26th - 27th. The purpose of this event was to get an overview of the status regarding new "third-generation" CO_2 capture technologies and to bring together participants from industry, R&D and academia in order to create new alliances and hopefully new CLIMIT projects developing cost efficient CO_2 capture technologies for the industrial segments.

The workshop had 55 participants from Norwegian and international R&D, academia, technology suppliers and industry, and was organised with presentations from various developers of capture technology as well as the future buyers, i.e. the


Participants at the Meeting

industry. The complexity of the concept of "Emerging Technologies" was clearly shown through presentations, panel debate and group work.

A preliminary conclusion from this workshop would be that, although amine based capture technology is mature and ready for deployment, it is still necessary to do further optimisation in parallel with large scale deployment. Another conclusion is that at present it is not possible to pick "the winner" among the emerging capture technologies.

The ECCSEL RI is Operative and Access / Transnational Access to the ECCSEL RI has Started

ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure) has established and provides access to a world-class research infrastructure (RI) in Europe for CO_2 capture, transport and storage (CCS) technologies research.

The mission of ECCSEL is "Opening access for researchers to a top quality European RI, devoted to next generation CCS technologies in an efficient and structured way, to help enabling low to zero CO_2 emissions from industry and power generation to combat global climate change".

The ECCSEL consortium teams up selected Centres of Excellence on CCS from 9 countries across Europe. 14 partners are currently part of this project: Project Leader NTNU (Norway), PGI-NRI (Poland), SOTACARBO (Italy), TNO (The Netherlands), OGS (Italy), ETH Zurich (Switzerland), BGS (United Kingdom), SINTEF Energy Research (Norway), GIG (Poland), SINTEF Materials and Chemistry (Norway), CERTH (Greece), SINTEF Petroleum (Norway), CIUDEN (Spain) and BRGM (France).

To attract the best researchers from across the world, ECCSEL has created generous opportunities to carry out scientific research. This includes a commitment to grant effective access pursuant to a sub-set of pre-defined criteria. Effective access means among other things that a significant part of the access and/or available time will be kept open to researchers from other institutions than the facility owner institutions.

Access to a facility of the ECCSEL RI can be applied for in 2 ways:

- The researcher applies for access through the EU funded ECCSEL Infradev-3 Transnational access programme (travel, subsistence and research facility costs funded by the EU) – see below
- The researcher applies for access to a facility with own funding for research facility costs as well as for travel and subsistence.

The ECCSEL Horizon 2020 Infradev-3 project provides funding for a Transnational Access (TA) program that offers free access to 43 research facilities, which are part of the ECCSEL CCS RI in Europe.

Over a 2-year period will there be 3 open TA calls for research projects to apply for Transnational Access. The first call is now closed but future TA calls are anticipated for June/July 2016 and November/December 2016.

Transnational Access offered by the participating research facilities within ECCSEL includes:

- Free access for eligible users / user groups to research facilities
- Support for travel and accommodation for 1 user per research project and for logistics
- Free access to information and data in the public domain held in the future at the ECCSEL Research Infrastructure

The procedure for granting access to use a laboratory facility is:

1. A scientific advisory committee evaluates submitted proposals for user access projects according to pre-defined selection criteria.
2. Evaluation of the funding plan for the proposals.
3. Final evaluation based on availability of the specific research facility.

Fact sheets for the various research facilities are accessible on the ECCSEL website, www.eccsel.org as well as online procedures for applying for access to them.

For background and more information, please visit: www.eccsel.org/NewsData.aspx?IdNews=28&ViewType=Actual&IdType=316 . ●

New IEAGHG Studies / Meeting Reports

2015-07 Monitoring Network meeting 2015, James Craig

We were very pleased to hold our 10th Monitoring Network meeting at Lawrence Berkeley National Laboratory in California on 10th - 12th June 2015. The venue provided great views over the San Francisco bay area, which complemented the technical programme of presentations and discussions inside.

The 45 presentations and 17 posters covered a range of topics, with sessions on cost-effective monitoring of large projects, permit requirements, induced seismicity, shallow monitoring, geophysical monitoring and CO_2 relationships, pressure monitoring applications, monitoring tools for shallow, surface and deep monitoring, update on projects, and post-closure monitoring. As well as the new results and developments, new at this meeting was a group-work exercise created by Sue Hovorka of the University of Texas. This involved the groups designing monitoring plans for fictional but realistic storage sites, and then these being actually tested with leakage scenarios. The groups were able to apply what they had learnt in the meeting as well as their own expertise, and I'm pleased to say that all the monitoring plans 'caught' the various leakage scenarios!

Also of particular note were the international research collaborations being created around the Aquistore storage site in Saskatchewan and around the CMC controlled release in overburden being developed in Alberta. The Aquistore project has just started injecting CO_2 captured from the Boundary Dam coal power station into a deep saline formation, some 7,000 tonnes injected so far. PTRC has monitoring research collaborations with 26 organisations from 7 countries at this 'field laboratory', and the first monitoring data was shared at this meeting from downhole pressure, seismic, and pulsed-neutron logging measurements.

The overall conclusions of the meeting included identifying the value of pressure based monitoring for assessing reservoir behaviour and in the overburden for leak detection, the potential in fibre-optic distributed acoustic sensing (DAS) and permanent sources, the benefits of good engagement with regulators, the importance of geomechanical analysis using the monitoring data, and the feasibility of offshore monitoring for leak detection and quantification.

2016-02 5th Social Research Network Meeting, Samantha Neades

The most recent meeting of the IEAGHG Social Research Network, titled 'Energy Transformations and the Role of Social Sciences' was held in Cambridge, UK in July. Kindly hosted by the University of Cambridge at the beautiful St Catharine's College, and sponsored by the UK CCS Research Centre, this one day meeting on Monday 6th July 2015 was packed with captivating talks from all aspects of the topic of social research and science in relation to CCS and energy technologies.

The meeting kicked off with a wonderful dinner in the Senior Combination Room at St Catharine's, where attendees were addressed by Lord R. Oxburgh, member of the House of Lords and also President of the Carbon Capture and Storage Association (CCSA), who gave a

brief welcome talk on energy transitions and the importance of CCS.

Sessions at this year's SRN meeting – the 5th in the series – included an in-depth look into social science and the energy domain across the UK and Europe; recent research findings from the Asia Pacific region; risk and perceptions of CCS (and other energy technologies); and an insight into the history of energy transformations. Over 26 delegates attended the meeting, from 6 different countries.

Delegates were treated to a spectacular meeting dinner on the Monday evening, held at the prestigious Trinity Hall, where discussions from the day flowed into the dinner, allowing for yet more fruitful conversations to take place around the recent developments and importance of social research in CCS.

On Tuesday the 7th July, the UKCCSRC held a related workshop on the issues in governance and ethics of CCS. For more information on this please see the UK CCS Research Centre's website.

2016-TR1 Evaluation of Barriers to National CO_2 Geological Storage Assesments, James Craig

Background to the study

The first step in assessing national CO_2 storage capacity is usually the preparation of a national, country-level inventory of potential storage options and large sources of CO_2 emissions. This report describes a review undertaken by the CO_2 Storage Team of the British Geological Survey on behalf of UK Department of Energy and Climate Change and the Korean Clean Energy Ministry, to support the work of the Carbon Sequestration Leadership Forum (CSLF). The report includes a review of internationally used methodologies for estimating geological storage capacity and the analysis of results from a survey of national storage capacity assessment experience. We conclude with recommendations of practical steps that could be taken to support and improve national assessments of CO_2 storage capacity.

The report gives a high level summary of the main barriers to national storage assessments identified through the survey (Chapter 2) and discusses advantages and disadvantages of storage methodologies commonly utilised for national storage assessments (Chapter 3). Detailed results of the survey are given in Appendix 2 (questionnaire results) and Appendix 3 (summary from follow-on interviews). Detailed analysis on the storage assessment methodologies is given in Appendix 4.

Summary

Decision makers need information on their national carbon dioxide (CO_2) storage resource to assess the potential contribution that deployment of CCS could make to national targets for reducing CO_2 emissions. The first step in assessing national CO_2 storage potential is usually the preparation of a country-level inventory of potential storage options and large sources of CO_2 emissions. This report summarises an assessment of potential barriers to national geological storage assessments and includes an analysis of common methodologies for performing such an assessment.

The main barriers were identified through responses to an online questionnaire and follow-up interviews which targeted key stakeholders in more than fifteen countries. Stakeholders were selected where the potential for CCS deployment has already been explored, to a greater or lesser extent.

2016-03 IEAGHG/CSLF Workshop on LCA in CCUS, Jasmin Kemper

IEAGHG and the Carbon Sequestration Leadership Forum (CSLF) jointly organised an interactive workshop discussing issues and challenges surrounding Life Cycle Assessment (LCA) methodology in the context of Carbon Capture, Utilisation and Storage (CCUS). This workshop built upon an earlier report by IEAGHG "2010/TR2: Environmental evaluation of CCS using Life Cycle Assessment" and addressed a request from CSLF to IEAGHG for further work on this topic. The workshop took place 12th – 13th November 2015 at the British Medical Association in London and brought together 23 participants from different backgrounds (i.e. academia, industry and NGOs) and with varying levels of LCA experience (i.e. LCA practitioners as well as users of the results).

After a welcome from Lars Eide (CSLF/Research Council of Norway) and Jasmin Kemper (IEAGHG), the first day started off with a keynote presentation from Bhawna Singh (NTNU) on the state-of-the-art and recent developments in LCA for CCUS. This was followed by a series of stakeholders' perspectives from Aïcha El Khamlichi (ADEME), Christoph Balzer (Shell) and Sean McCoy (IEA), who shared their organisations' and/or their personal interest in LCA and what they currently see as the main challenges. The next three sessions then dived deeper into the issues and challenges of the different parts of an LCA. Tim Skone (US DOE NETL) opened the discussion on "Goal and Scope Definition", Arne Kätelhön (RWTH Aachen) kick-started a debate on "Inventory Analysis" and Jasmin Kemper (IEAGHG) provided some initial questions for "Impact Assessment and Interpretation".

The second day addressed topics beyond

environmental aspects of LCA, namely Social LCA (sLCA) and Life Cycle Costing (LCC), where Andrea Ramirez (Utrecht University) and Anna Korre (Imperial College London) provided the food for discussion.

The workshop closed with main conclusions of the discussions in the sessions, highlighting the importance of communicating uncertainties and differences, as well as improving transparency when undertaking LCAs. However, transparency does not automatically equal high quality. In addition, a clearer distinction of LCA from GHG accounting and/or carbon footprinting will be necessary. There was no consensus on harmonisation and weighting. Both can be useful tools but need to come with a statement of underlying assumptions and intentions, and thus should only be used with care (also keeping in mind that "no weighting" means to assign equal weights). Bio-CCS and more recent CCU pathways require a lot more research, as they introduce new issues and increased complexity. LCC and sLCA are less mature than their environmental counterpart, so both should be taken out in parallel rather than integrated for now. The participants felt no need for formal guidelines prescribing specific frameworks, methodologies and tools but welcomed the development of a guidance document including: a) how to document and communicate LCA results for LCA practitioners, and b) how to read and interpret LCA results for non-experts and end-users.

The presentations of the meeting and a summary report are available for download on IEAGHG's website (**www.ieaghg.org/ccs-resources/technical-workshops/19-ccs-resources/technical-workshops/620-lca-in-ccus-workshop**). Based on the outcomes of this workshop, IEAGHG will revisit the need for producing a guidance document and for future meetings/activities on this topic.

2016-04 Operational Flexibility of CO_2 Transport and Storage, James Craig

One of the advantages of CCS as a means of CO_2 abatement is that several industrial processes, as well as fossil fuel power generation, can be captured and connected to a pipeline network. Multiple sources of CO_2 can then be transported to suitable geological reservoirs and injected to ensure secure storage. Many industrial operations, and power generation, can generate intermittent and variable amounts of CO_2 with some impurities. These factors can affect pipeline transport and potentially storage conditions. IEAGHG commissioned a study to investigate the extent to which intermittent supply and transport might influence storage and EOR. Experience from the United States shows that large point sources CO_2 with a high level of purity (~99.7%) can be effectively and safely delivered using integrated pipeline networks. Moreover, these pipeline networks can act as a buffer by supplying CO_2 from several sources. CO_2 can also be temporarily compressed or 'packed' into pipelines as a short term measure.

Impurities particularly H_2O and O_2, can have negative impacts on pipelines including fracture propagation, corrosion, non-metallic component deterioration and the formation of hydrates and clathrates. The density and viscosity of fluids can also be affected. Non-condensables like N_2, O_2, Ar, CH_4 and H_2 should be separately limited to <4% because their presence increases the amount of compression work. Compression and transport of CO_2 for CO_2-EOR use in the United States has shown that impurities are not likely to cause transport problems provided CO_2 stream composition standards are maintained and pressures are kept significantly over the critical point (≥10.3 MPa).

CO_2 storage in deep saline formations can be managed by using multiple wells and water pumping to control and releave excess pressure, and control plume geometry. The use of CO_2 for EOR relies on controlling pressure and flow rate conditions to optimise oil recovery. Restricted injection caused by wells being shut in can result in deleterious changes in reservoir pressure and oil miscibility.

Provided that adequate levels of purity can be achieved, and large point sources of CO_2 can be connected to a managed pipeline network, the evidence from this study shows that secure storage can be achieved and integrated with EOR.

News from the IEACCC, by Debo Adams, IEACCC

IEA CLEAN COAL CENTRE

Where is coal demand heading?

Population and economic growth are the two main drivers for increasing energy demand. Most population growth is in developing countries. Coal remains a major fuel for power generation worldwide. In 2014, coal provided >30% of global primary energy requirements, ~40% of the world's electricity generation and ~68% of steel production. Asia consumes 63% of the total coal used, followed by North America with a 14% share.

More stringent legislation for coal combustion means that in some parts of the world, notably the EU, coal-fired power providers must either construct state-of-the-art, advanced power plants, invest in retrofitting pollution control technologies for existing facilities, or shut down plants altogether.

Pollution control technologies ensure the continued, reliable supply of coal-fired electricity with a reduced environmental impact. Relevant legislation and consequent investment has resulted in reduced emissions of air pollutants (SO_2, NO_x and particulate matter) in many regions over the last few decades. However, coal combustion has relatively high GHG emissions compared to gas.

In her latest report for the IEA Clean Coal Centre, New regulatory trends: effects on coal-fired power plants and coal demand, Herminé Nalbandian-Sugden discusses many international, bilateral, multilateral, regional and national regulations and agreements that have been introduced and adopted for the control of air pollutant emissions, as well as GHGs, from coal combustion.

The latest development in the process to reduce global GHG emissions was, of course, the 21st Conference of the Parties (COP21). At the end of the meeting, on 12th December 2015, the Paris Agreement on Climate Change was adopted, in which 195 Nations agreed to set a path (based on their historic, current and future responsibilities) to keep the global temperature rise well below 2°C.

Coal retained about 30% share of global primary energy supply in 2014. This trend is forecast to continue for the medium term mainly due to the continuing growth in coal-fired power generation in China and India and, to a lesser extent, the ASEAN countries.

By 2040, forecasts indicate that the share of coal in global primary energy will decline to 24%. But projections show that global coal demand will increase 15% by 2040, as total energy demand grows. Coal use will differ dramatically by region. Coal demand is forecast to decline in all OECD regions, particularly in the USA. Conversely, coal demand in developing countries is forecast to increase by about one-third by 2040, with significant growth in Southeast Asia, India, Africa, and Brazil. Coal demand in China is expected to peak in 2030.

The long-term future of coal as a major energy source is often seen as being in jeopardy due to regulations, market forces and environmental pressures. However, there are currently no viable, immediate, substitutes to match the relatively low-cost, availability, reliability and scale of electricity production provided by coal-fired power plants, globally.

Short-term forecasts to 2020, mid-term to 2035 and 2040, and long-term ones indicate that coal consumption will increase but the share of coal-based power generation will gradually decline in the global generation mix. The consensus seems to be that coal will remain an essential fuel, especially when addressing the current lack of access to electricity in many regions.

New regulatory trends: effects on coal-fired power plants and coal demand CCC/262 by Herminé Nalbandian-Sugden, 116 pp, December 2015 is available 2015 is available for download from the IEA Clean Coal Centre Bookshop **http://bookshop.iea-coal.org.uk/site/uk/clean-coal-technology-research-reports**. Residents of member countries and employees of sponsoring organisations can download the report at no charge after a one-off registration.

Forthcoming events

- 1st Workshop on High Efficiency Low Emissions Coal-fired Plant, 23th - 25th May 2016, Tokyo, Japan.
- Provisional programme available. **http://hele.coalconferences.org**
- 6th Workshop on Cofiring Biomass with Coal, 14th - 15th September, Carbonia, Sardinia, Italy. Call for abstracts open. **http://cofiring6.coalconferences.org**

Visit our website **www.iea-coal.org**

Conferences & Meetings

This is a list of the key meetings IEAGHG are holding or contributing to throughout 2016. Full details will be posted on the networks and meetings pages of our website at www.ieaghg.org.

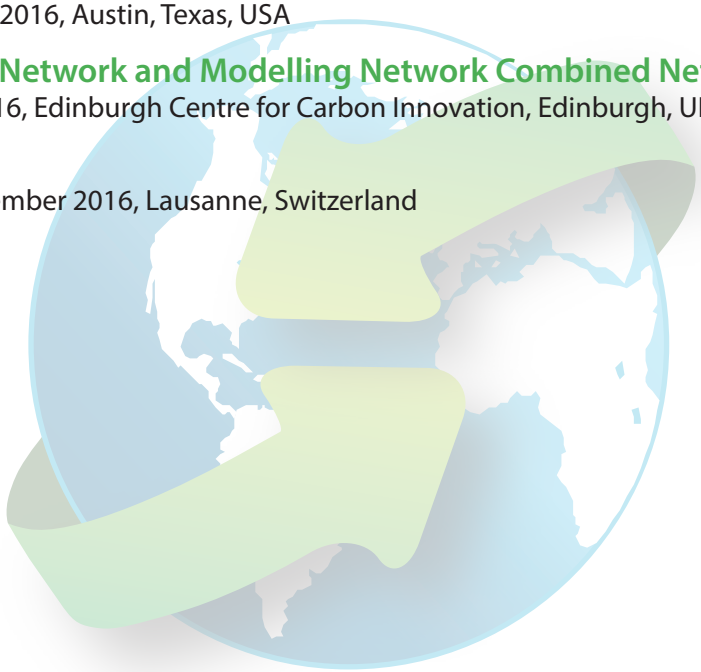
If you have an event you would like to see listed here, please email the dates, information and details to: becky.kemp@ieaghg.org.

Please note that inclusion of events in this section is at the discretion of IEAGHG.

Offshore CCS Workshop
19th - 21st April 2016, Austin, Texas, USA

Monitoring Network and Modelling Network Combined Networks Meeting
5th - 8th July 2016, Edinburgh Centre for Carbon Innovation, Edinburgh, UK

GHGT-13
14th - 18th November 2016, Lausanne, Switzerland



Greenhouse News
ISSN 2047-2218 (Online)

Greenhouse News is the newsletter of the IEA Greenhouse Gas R&D Programme (IEAGHG). IEAGHG is funded by member contributions from IEA member countries as well as other developed and developing countries and industrial organisations that have an interest in implementing technical options for GHG mitigation. A list of this membership can be found on the website. Greenhouse News provides information on worldwide developments in the field of GHG abatement and mitigation. It is published four times a year and is free of charge. Mailing address changes and requests for copies of this newsletter should be sent to the address below. For further information about IEAGHG and suggestions for articles, please email or write to the :

IEAGHG ● Pure Offices ● Cheltenham Office Park ● Hatherley Lane ● Cheltenham, Glos. GL51 6SH ● United Kingdom.
Tel: +44 (0) 1242 802911 ● mail@ieaghg.org ● www.ieaghg.org