



# ieaghg

## Greenhouse News

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### Joint Meeting of the IEAGHG Modelling and Wellbore Integrity Networks, by Samantha Neades, IEAGHG

This meeting of the IEAGHG Modelling and Wellbore Integrity networks was held from the 27<sup>th</sup> to the 29<sup>th</sup> of April 2011, in Perth, Australia, hosted by Curtin University and the University of Western Australia. It was sponsored by Shell, Chevron, Curtin University, the University of Western Australia and the Government of Western Australia Department of Mines and Petroleum. 75 delegates attended the meeting, representing 9 different countries.

The three day event looked at the complexity of models, real projects (local and international), geomechanics and wellbore integrity, followed by a field visit to the site of the planned Collie Southwest CO<sub>2</sub> Hub.

Session 1 dealt with the complexity of models and had presentations from Permedia on their new Sleipner Benchmark Model (available through the IEAGHG website to Modelling Network members), Lawrence Berkeley National Laboratory on their Sim-SEQ initiative and NRCan on a recent study with IEAGHG on the effects of impurities. BRGM reported on long-term

processes and rock interactions in modelling and Princeton University presented on the complexities of models and an interesting discussion session from a modellers' perspective on CCS in the Clean Development Mechanism (CDM) followed these presentations.

Real projects (from local and international operators) were reported in the second session at the meeting. Talks were given on reservoir and risk modelling at the (now cancelled) ZeroGen project, on Chevron's findings on the thermal effects on CO<sub>2</sub> injectivity at Gorgon, on CO<sub>2</sub> Sequestration/EGR feasibility in Western Australia and on modelling at Shell's Quest project (Alberta, Canada). PCOR (one of the 7 US Regional Carbon Sequestration Partnerships - RCSP) reported on phase 3 at the Fort Nelson site, CO2CRC presented modelling activities at Otway, Statoil illustrated lessons learnt at Snøhvit and GFZ spoke on history matching at the Ketzin project.

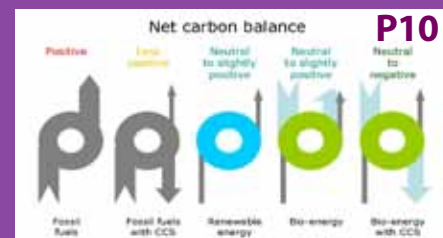
In the third session the topics addressed were geomechanics and coupling with other processes. Pinnacle reported on the modelling of surface deformation at In Salah, CO2CRC presented the results of a recent IEAGHG study on caprocks and delegates were informed about geomechanics at the Weyburn, Redwater and Zama projects in Canada. Shell reviewed their work on key

### In this issue

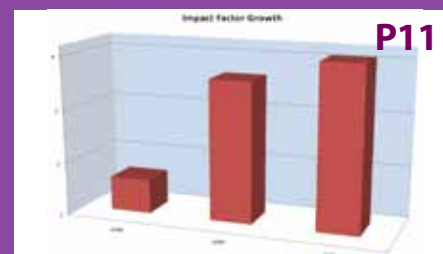
Masdar Joins IEAGHG



New IEAGHG Report

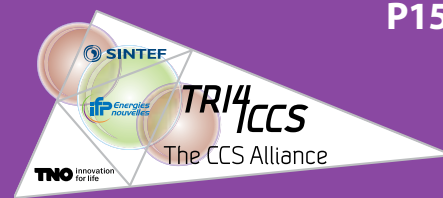


IJCCC Receives New Impact Factor P11



New CCS Alliance

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## Delegates on a field trip to the Collie South-West CO<sub>2</sub> Hub



technical challenges in geomechanics and CCS, and TNO looked at reservoir engineering at In Salah.

Session 4 considered wellbore integrity and included presentations on the results of the recent DNV CO<sub>2</sub>WELLS guideline. Wellbore integrity at the Weyburn project, the effects of CO<sub>2</sub> on cement materials (work carried out by TOTAL) and modelling CO<sub>2</sub> leakage rates (Schlumberger). Talks were also given by Baker Hughes on cementing strategies for effective CO<sub>2</sub> zonal isolation and by NETL on the US Regional Carbon Sequestration Partnerships' recently published best practice manual.

The third and final day of the meeting involved a trip to the site of the planned Collie Southwest CO<sub>2</sub> Hub, located in the Collie area of Western Australia – a major industrial area that generates significant amounts of CO<sub>2</sub>. The total amount of CO<sub>2</sub> available for capture in the area is potentially more than 5-6Mt per year.

A key point recognised during the meeting was that modelling is site-specific and should be done on a project-to-project basis. Simplified models can be useful as they allow exploration of a wide range of scenarios on a short time-scale – but this may not improve the overall understanding of

the reservoir.

There is a trust issue between regulators, operators and the public – more needs to be done in bridging the gaps between all stakeholders, public or otherwise. Modelling should be put into a better context to perhaps help with this communication issue – modelling doesn't necessarily represent reality but is crucial to guide monitoring and risk management strategies. Mitigation is a vital component of risk management strategies that requires early consideration in project planning.

A significant point that was raised on many occasions throughout the meeting is the ongoing need for further, large scale storage demonstration projects to calibrate modelling science and further inform wellbore integrity issues.

The agenda and presentations from the meeting are available in the network members' area of the IEAGHG website ([www.ieaghg.org](http://www.ieaghg.org)). Previous meetings of both the Modelling and Wellbore Integrity networks are also detailed on this website. ●

## Changes at IEAGHG, by John Gale, IEAGHG

After nearly 4 years with IEAGHG Neil Wildgust is leaving to join the Petroleum Technology Research Centre (PTRC) based in Regina, Canada. Neil has been IEAGHG's senior geologist and has taken the lead in developing our knowledge on issues pertaining to geological storage.

Neil is well known to members and others for his technical knowledge and solid technical presentations at ExCo meetings and conferences around the world.

Whilst Neil will no longer directly work for IEAGHG we have not lost him totally. The IEAGHG and PTRC have a longstanding relationship through the Weyburn project. Neil will now manage that project which we hope will move to Phase 3 in the not too distant future so he will keep us apprised of developments in Saskatchewan.

Neil's leaving obviously creates a vacancy at IEAGHG for a Project Manager on Geological Storage. Anyone interested in that position should look at our web site [www.ieaghg.org](http://www.ieaghg.org) for the job description and an application form to download. ●



Neil Wildgust

# The 7<sup>th</sup> IEAGHG Monitoring Network Meeting, by Millie Basava-Reddi, IEAGHG

The 7<sup>th</sup> IEAGHG monitoring network meeting was held in Potsdam, Germany and hosted by the GFZ (German Centre for Geosciences).

The theme for this year's meeting centred on the 3 criteria for responsibility transfer within the EU directive:

- Actual behaviour of the injected CO<sub>2</sub> conforms with the modelled behaviour,
- No detectable leakage,
- Storage site is evolving towards a situation of long-term stability.

While the directive is European, the criteria are applicable and necessary to all worldwide storage projects. There is no information yet from experience for the 3<sup>rd</sup> point, also it will derive from the first two, so the focus was on the first 2 criteria.

The agenda was structured in accordance with the 3 criteria and had 8 sessions. The introductory session including welcomes from IEAGHG and GFZ and included a short history of the GFZ, there was also a summary from the last meeting and a talk describing the aims of this meeting. The 2<sup>nd</sup> session was a review of performance monitoring tools. The aim of this session was to look at the capabilities of each technology

reviewed and compare this across different sites. The session was split in three parts with the first part dealing with seismic and electrical monitoring, with talks on Otway, Nagaoka and Ketzin. Much of the discussion focussed on the difficulty around 4D seismic surveys, getting a good timelapse signal and the signal to noise ratio. The second part looked at pressure monitoring, with talks on Cranfield and Ketzin. The third part of the session dealt with InSar and included two talks on In Salah which showed the different interpretations that can come from the same set of data.

The third session covered data integration and demonstrating monitoring data conforms with predictive modelling, the aim of which was to consider monitoring tools that can be used in conjunction with each other and to compare models to monitoring data. There were talks on geophysics and geochemistry, pressure and temperature measurements, modelling and monitoring data and history matching.

The fourth session was on developing protocols and strategies to form a monitoring plan and Monitoring of the outer envelope – Demonstrating no leakage. This session included

a presentation on the measuring monitoring and verification in Shell CCS projects, which outlined the approach used followed by a more general overview talk on developing protocols and strategies to form a monitoring plan.

There was also a discussion session on CCS in the CDM and what modelling is required for monitoring. This covered discussions on how stringent monitoring plans need to be.

The seventh session was on updates and permanent Installations; current and future activities. This session covered the planned gas membrane sensors at Ketzin, which are in-situ geochemical sensors to detect distribution of CO<sub>2</sub> in the observation wells. The CO<sub>2</sub>Field Lab project in Norway will test monitoring methods (leakage detection and quantification) in the shallow subsurface by controlled injection into permeable rocks. The CO<sub>2</sub>Care project will review and test site abandonment and closure across a range of projects.

The meeting ended with a review of the main learnings taken from the meeting and discussion on conformance to the 3 criteria of the EU directive. ●

## New Members, by John Gale, IEAGHG



The IEAGHG is pleased to announce that membership formalities are complete and that Masdar are the latest sponsor member to join the IEAGHG. Masdar will be represented by Bader Al Lamkir on the Executive Committee.

This new member means that IEAGHG now has 47 member organisations including 19 countries, the EU and OPEC and 26 sponsors. ●

# 6<sup>th</sup> Workshop of the IEAGHG Risk Assessment Network, by Ameena Camps, IEAGHG



Participants of the 6<sup>th</sup> IEAGHG Risk Assessment Network Workshop outside Le Palais Beaumont, Pau, France

In June the IEAGHG Risk Assessment Network held its 6<sup>th</sup> network meeting, hosted by BRGM in Pau, France, sponsored by BRGM and the International Performance Assessment Centre for the Geological Storage of Carbon Dioxide (IPAC-CO<sub>2</sub>).

The three day workshop highlighted the latest international CO<sub>2</sub> storage risk assessment developments by bringing together experts from various disciplines and from 15 different countries to share knowledge and experience; building on recommendations from last year's meeting. The workshop was opened by the BRGM Research Director, Dr Catherine Truffert; a welcome and overview presentation by our very own Tim Dixon, and introductory information by Olivier Bouc and Ameena Camps. The introductory welcome session was followed by six technical sessions.

Session One, Risk Communication and Regulatory Developments, included presentations by Suzanne Brunsting of ECN who highlighted lessons learnt on risk communication from Barendrecht; Rick Chalaturnyk from the University of Alberta providing an update on CSA standards development; and Raphael Sauter of The European Commission, presenting the EU CCS Directive and the final Guidance Documents. Presentations were followed by a dedicated Panel Discussion on Risk Assessment to satisfy the Cancun Decision on CCS in the CDM chaired by Tim Dixon raising the importance of non-specific guidance in reference to methodologies and the importance of a network of experts in risk assessment which can be easily accessed for input and advice to such decisions.

The second session, Understanding Potential Groundwater Impacts, provided presentations from Elizabeth Keating from Los Alamos National Laboratory, Julie Lions from BRGM, Angeline Kneppers from GCCSI and Julia West of the British Geological Survey. This session highlighted the geochemical and hydrogeological heterogeneity present in the subsurface which is difficult to characterise and highly site

specific; greater observations are needed as is data integration from natural analogue, controlled release and laboratory experimental studies; in-situ CO<sub>2</sub>-water-rock interactions may not be as important for groundwater impacts as reactions elsewhere, for example as a result of migrated brine interactions; buffering and scavenging processes may control trace element mobility, and microbial activity can have both physical (e.g. porosity) and chemical impacts (e.g. catalysis of mineral reactions) hence should be considered in CCS operations.

The first day of the workshop concluded with Session three, Methodologies, with presentations from Matt Gerstenberger of CO<sub>2</sub>CRC/GNS Science, Yann Le Gallo of Geogreen with preliminary results from MANAUS which plans to develop a common rational and operational methodology of analysis and of management of risks for CO<sub>2</sub> geological storage within the French regulatory context, Adrian Bowden of URS discussing biosphere risk assessment, Maxwell Watson of BP highlighting the BP quantitative risk through time concept and tool, integrating changes in the CO<sub>2</sub> storage system relative to risk mechanisms through time and space; Elizabeth Keating on behalf of Grant Bromhal of US DOE/NETL discussing the National Risk Assessment Partnership (NRAP) and Ken Hnottavange-

Telleen of Schlumberger Carbon Services questioning how we deal with uncertainty and thoroughness or completeness in risk identification.

A bright and early start after the evening entertainment and gala dinner at Villa Navarre welcomed all delegates to Session four, Risk and Incident Management, beginning with a presentation on The IEAGHG Weyburn Midale CO<sub>2</sub> Monitoring and Storage Project Response to Claims of a CO<sub>2</sub> Leak by Rick Chalaturnyk on behalf of Norm Sacuta from PTRC, demonstrating the importance of baseline measurements and a response/communication plan. The session also introduced

the BRGM risk treatment knowledge base, presented by Thomas Le Guenan and the DNV CO<sub>2</sub>WELLS project with a developed process specific to well integrity risk assessment, presented by Mike Carpenter. Session five on Induced Seismicity, provided presentations from Joelle Hy-Billiot of TOTAL on seismic monitoring at the Lacq project, and Nicholas Deichmann of ETH-Zurich highlighting lessons learnt from cases of induced seismicity connected to the exploitation on deep geothermal energy.

The final technical session of the workshop on monitoring performance, provided a link with the IEAGHG

Monitoring Network through a report from this year's meeting, and presented the latest results from the CO<sub>2</sub>ReMoVe project provided by Ton Widenborg of TNO; the results from the IEAGHG study on Quantification of Leakage, presented by Anna Korre of Imperial College London; and Stephen Bourne of Shell presented an update of the QUEST carbon capture and storage project and risk based measurement, monitoring and verification.

To conclude the meeting, Charles Jenkins of CSIRO/CO2CRC and IEAGHG's Ameena Camps chaired an open discussion session to determine the workshop's learnings, knowledge gaps

*Participants of the workshop all dressed up at the TOTAL Lacq-Rousse project storage field site.*



and recommendations. Key recommendations included the need for translation of risk assessment outputs to a common easily understandable language; the need for benchmarking of outputs of methodologies; a community asset value should be included in risk assessment, and further work is needed on the evolution of risk through time.

Following the two fascinating technical session days, the workshop participants were fortunate to visit the TOTAL Lacq-Rousse project, including the oxycombustion capture site in the morning, a TOTAL sponsored lunch typical of the region in South-West France, and the storage site in the afternoon; hosted by Joelle Hy-Billiot of TOTAL and her TOTAL colleagues.

Presentations from the Workshop and the detailed agenda are available on the IEAGHG Risk Assessment Network member's website, see [www.ieaghg.org](http://www.ieaghg.org). There will not be a Risk Assessment Network meeting next year, but in its place there will be a Joint IEAGHG Storage network meeting which is proposed to be in Santa Fe, U.S. in the summer of 2012.

Keep an eye out for Network announcements. ●

# 5<sup>th</sup> IEAGHG International CCS Summer School, by Ameena Camps, IEAGHG



*This year's Summer School students, speakers and mentors at the Illinois Basin-Decatur Project (IBDP) in Decatur, Illinois. Thanks to Daniel Byers of ISGS for this photograph*

From the 17<sup>th</sup> to the 23<sup>rd</sup> of July, IEAGHG held its fifth International Interdisciplinary CCS Summer School, hosted by the Sequestration Training and Education Program (STEP) and the Midwest Geological Sequestration Consortium (MGSC) at the University of Illinois, in Champaign, Illinois, USA in the red hot sun of an Illinois heatwave; where experts and students met to learn about and discuss carbon dioxide capture and storage.

Fifty three students, from over twenty five different countries, including Malaysia, Israel, Thailand, Brazil and Romania; and from a wide variety of different backgrounds including oceanography, social and environmental psychology, engineering and law; were fortunate to be selected and participate in this international Summer School. The students were supported by 29 experts throughout the week, mentoring the students well into the night, and without whom this Summer School would not be possible.

These experts included our two outstanding students from last year's IEAGHG International CCS Summer School in Svalbard: Warren Riemer from The University of Regina, Canada, and Gosia Stein-Brzozowska from The University of Stuttgart in Germany; who both worked extremely hard, enriching this year's summer school experience.

The Summer School provided students with lectures covering the full chain of carbon dioxide capture and storage, including technical information on capture technologies, storage site selection, capacity and modelling, wellbore integrity and transport; as well as non-technical issues such as regulations and policy, health and safety, public communication, and technical writing. This year's Programme also included presentation and discussion on China CCUS developments, an NGO perspective and two dedicated panel discussions on project integration and an industry perspective on the potential sector growth with reference to careers and future needs. The Summer School began with a welcome by Donald McKay, the Illinois State Geological Survey Director and State Geologist, and William Shilts, Executive Director of the Prairie Research Institute.

The first day of storage lectures was followed by a team building dinner sponsored by Alstom, outside in Gateway

Park in the grounds of The University of Illinois. Here experts and students alike were astounded by the assault course spread before them! Students and mentors were divided into groups to accept the challenge of three activities: the blow up assault course, the bucking bronco and the walk-like-a-cowboy race. All the excitement was followed by a traditional U.S. dinner whilst watching the fireflies glowing over the scattered drained water bottles.

The team spirit created on this evening, continued throughout the week, as in addition to the full lecture Programme, the students were again placed into





Top image: Students in Group Session,  
Middle image: Winning Group,  
Bottom image: Students take part in a  
Cowboy Race



these groups to work on a group topic which they presented at the end of the week. This year's group winner was Group Six, presenting on the topic: Should CCS be mandatory in the developed world? What are the pros and cons? Group four were also highly commended for presentation of the topic: How can CCS be made part of a commercially viable integrated, sustainable and secure energy system? As well as selecting the best group on the final day of the Summer School, the experts were gathered together to select the outstanding students of the week, based upon their performance on a variety of aspects during the week, including their contribution to lecture

discussions, the group work and the social programme. This year's two outstanding students were Viktor Andersson from Chalmers University of Technology, Sweden and Carrie Petrik-Huff from The University of Massachusetts, USA, who will be joining the 2012 IEAGHG International CCS Summer School in China.

The students and experts were also fortunate to visit the Illinois Basin – Decatur Project (IBDP), where they were taken to various different stations showing the surface

monitoring facilities, the local geology and importantly the Mt Simon sandstone reservoir rock, the compression facility and the injection well which will soon be injected CO<sub>2</sub>.

The summer school was sponsored by signature sponsors: I<sup>2</sup>CNER and the US DOE; collaborating sponsors: the Department of Commerce and Economic Opportunity in the State of Illinois and Duke Energy; sponsors: Denbury, Alstom, Illinois State Geological Survey, and Schlumberger Carbon Services, and IEAGHG Summer School Series Sponsors: GCCSI, Schlumberger Carbon Services, Alstom, CIUDEN, DECC, Shell, Statoil, Gassnova, RWE, ZEP and Elsevier. We would like to thank all the experts and our student mentors who participated in the Summer School; the Local Organising Committee, the International Organising Committee and the International Steering Committee; all of whom worked tirelessly to ensure the success of this year's IEAGHG International CCS Summer School.

We would also like to thank all of this year's students



*Viktor Andersson and Carrie Petrik-Huff receiving the traditional IEAGHG coin from the host country, passed on from last year's outstanding students: Gosia Stein-Brzozowska and Warren Riemer*

for making this a successful Summer School – it was a pleasure to meet you all and work with you in Illinois, and we wish you well in your future.

Next year's 2012 IEAGHG International CCS Summer School will be held in Beijing, China hosted by Tsinghua University. Registration for applications will open in January 2012, so keep an eye on our website for the announcement.

You can find further information on the IEAGHG International CCS Summer School on the IEAGHG website, or you can contact Dr Ameena Camps on [Ameena.Camps@ieaghg.org](mailto:Ameena.Camps@ieaghg.org) ●

## IEAGHG Caprocks Study Report, by Neil Wildgust, IEAGHG

In terms of geological storage of CO<sub>2</sub>, caprocks are layers of low permeability rock that overlay the storage formation, forming a seal to ensure that buoyant CO<sub>2</sub> does not leak into overlying strata and towards sensitive environmental receptors. CO2CRC of Australia was commissioned by IEAGHG to provide a comprehensive review of caprocks for CO<sub>2</sub> storage, in terms of required properties for storage integrity and predictive modelling of performance.

Assessment of caprock systems will be highly site-specific and rely on a multi-disciplinary

approach, utilising a combination of seismic surveys, exploration wells, wireline log data, stratigraphic and sedimentological analyses, well tests and laboratory scale testing of caprock samples.

The study report presents a qualitative methodology for assessment of seal potential at the basin scale. Seal potential may be defined as the capacity, geometry and integrity of the caprock. Seal capacity refers to the maximum CO<sub>2</sub> column height that can be retained in the underlying reservoir, before pressure exerted by buoyancy exceeds capillary entry pressure, thus allowing CO<sub>2</sub> to migrate through the caprock. Seal geometry refers to the thickness and lateral extent of the caprock. Seal integrity refers to caprock geomechanical properties, in the context of ambient stress fields that may be modified by CO<sub>2</sub> injection and any associated

abstraction of reservoir fluids.

Key knowledge gaps identified for further research include: wettability and interfacial tension effects on supercritical CO<sub>2</sub>-water-rock systems; hydrodynamic effects of large scale injection in deep saline formations (DSF); effects of faults on caprock performance; and coupling of flow, geochemical and geomechanical effects on caprocks in predictive modelling. There is also a case for the compilation of a comprehensive database on caprock systems, including mineralogical and petrophysical properties, to provide analogue data in storage site assessment. A compendium of caprock properties at existing CO<sub>2</sub> storage sites would also prove useful. ●

# IEAGHG Impurities Study Report, by Neil Wildgust, IEAGHG

Capture technology represents the major cost element of the CCS chain and the required purity of CO<sub>2</sub> can have a major bearing on actual capture costs. Impurities in the CO<sub>2</sub> stream have the potential to affect the efficiency and safety of transport and storage systems, for example through increased risks associated with corrosion, or changes in the phase behaviour of the CO<sub>2</sub> stream.

IEAGHG has published a report on the potential effects of impurities on CO<sub>2</sub> geological storage, following a study undertaken by Natural Resources Canada and funded by the Global Carbon Capture and Storage Institute (GCCSI).

The study comprised a literature review and theoretical modelling, and considered both physical and chemical effects that impurities could have on storage reservoirs (principally deep saline formations) and caprocks for typical ranges of impurities anticipated from various capture processes, with a 'worst-case' scenario of 15% impurities from an oxyfuel process.

The most significant physical effect of impurities would be a reduction of storage capacity. Non-condensable impurities such as argon, may cause reduction of CO<sub>2</sub> storage capacity by a degree greater than their simple proportion with the CO<sub>2</sub> stream. The study found that a maximum reduction of storage capacity (for any given stream composition with respect to pure CO<sub>2</sub>) can be anticipated at a certain pressure for a given temperature; for example, capacity can drop to by 60 % for the 15% impurities case compared to pure CO<sub>2</sub>. Injectivity of CO<sub>2</sub> streams could also reduce as a result of impurities, albeit in a less marked way than for capacity. In the studied scenarios using the 15% impurities case, the average reduction of injectivity across all storage scenarios was calculated to be 6%, with the largest reduction at 26%. The higher buoyancy of impure CO<sub>2</sub> streams could also theoretically reduce the efficiency of CO<sub>2</sub> dissolution and trapping, although quantification of this would depend on site-specific reservoir heterogeneity.

With regard to chemical effects on rocks, the most significant species are SO<sub>x</sub>, NO<sub>x</sub> and H<sub>2</sub>S. NO<sub>x</sub> can catalyze the oxidation of SO<sub>2</sub> to sulphuric acid, but the impact of SO<sub>2</sub> on injectivity appears limited, because contact with water will be limited with the development of the dry-out zone. If H<sub>2</sub>S and SO<sub>2</sub> are co-injected, deposition of elemental sulphur, in the pores over the whole injection period could be a concern. The study found that expected concentrations of SO<sub>x</sub> and NO<sub>x</sub> are unlikely to affect caprock integrity.

The study concluded that for typical ranges of impurities anticipated from capture processes, reduction of reservoir capacity and injectivity are likely to be the most significant effects, but recommended further experimental and field based study of the topic. CCS project developers will need to understand likely stream compositions and associated effects on capacity and injectivity, in the context of the site-specific aspects of storage. ●

## Large Global Potential for Negative CO<sub>2</sub> Emissions, by Ameena Camps, IEAGHG

The main findings of the recently published IEAGHG report: *Potential for Biomass and Carbon Dioxide Capture and Storage (BE-CCS)*, a study commissioned by IEAGHG to the energy consultancy company Ecofys, has identified an annual global potential of up to 10 gigatonnes of negative CO<sub>2</sub> emissions in the year 2050 through deploying BE-CCS technologies. Compared to the IEA ETP (2010) estimate of 43 Gt of global CO<sub>2</sub> emissions reductions required from the energy sector by 2050, or the almost 31 gigatonnes of global energy-related CO<sub>2</sub> emissions in 2010, this potential represents a large CO<sub>2</sub> emissions reduction potential.

Biomass use for energy production in processes such as combustion and gasification; and its use to produce biofuels such as bioethanol; results in emissions of CO<sub>2</sub>. This CO<sub>2</sub> produced during

combustion is approximately the same quantity consumed during biomass growth; therefore emissions from biomass combustion are considered to be CO<sub>2</sub> neutral. Capture and long-term storage of these CO<sub>2</sub> emissions would effectively result in net removal of atmospheric CO<sub>2</sub>; and Biomass with CCS is potentially one of the few options for 'negative emissions'.

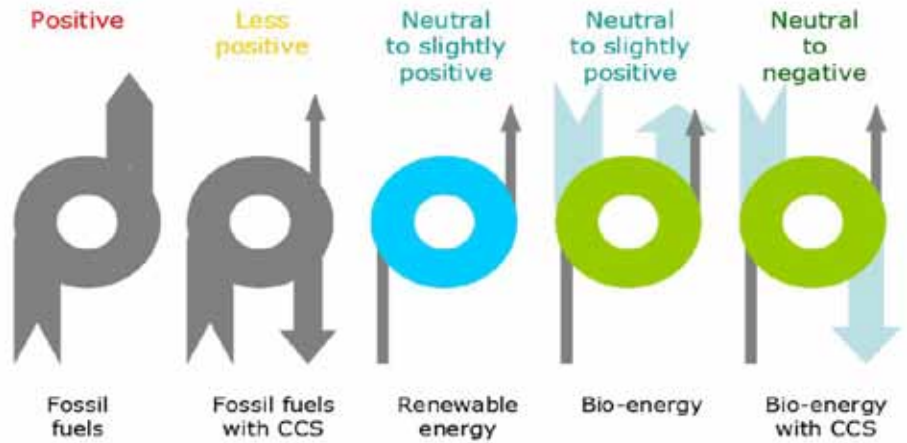
Several mitigation scenarios show biomass in combination with CCS is likely to be required to meet low stabilisation concentrations, and as biomass use is expected to increase, the potential application of CCS will also increase; hence highlighting the importance of studies dedicated to further understand potential.

This study performs a first order techno-economic assessment of BE-CCS technologies up to 2050, providing global and regional technical potential, and focussing on six promising technology BE-CCS routes, from the large-scale electricity generation sector and the biofuel production sector, including biomass combustion and gasification for power production, and biomass conversion

to bio-ethanol and biodiesel. Taking only technical limitations into account, the maximum annual potential is calculated to be approximately either 10 gigatonnes of negative emissions in the power sector or 6 gigatonnes in the biofuel sector; or more conservatively the economic potential of biomass and CCS that can potentially compete with fossil technologies amounts to negative emissions of either up to 3.5 gigatonnes in the power sector or 3.1 gigatonnes in the biofuel sector. In the short term, bio-ethanol production is identified to be the most promising option, which produces a high purity CO<sub>2</sub> stream, and allows CO<sub>2</sub> capture at relatively low cost.

Market drivers and obstacles are also considered in the study, as well as recommendations made, and the key obstacle to the implementation of the technology is identified as the absence of a price for stored biomass based CO<sub>2</sub>, hence an economic value on 'negative emissions', in for example the EU ETS; and inclusion into the CDM if this option is to be taken up by developing countries such as Brazil where early opportunities exist. There is therefore,

## Net carbon balance



Carbon balance for different energy systems (adapted from [www.ecofriendlymag.com](http://www.ecofriendlymag.com) 2010 by Koorneef for IEAGHG, 2011).

a need for policy developments in this area to assist global take-up of the technology. Of course, CO<sub>2</sub> price and policy developments are also key drivers relevant to CCS in general.

The secure supply of low cost sustainable biomass is also shown as a likely limiting factor to the deployment of BE-CCS technologies; however the study shows globally sustainable biomass availability exists to be able to achieve negative emissions.

The results of this study report show the importance of further detailed research of the potential for BE-CCS and negative emissions, as the potential may be considerably large, especially given the number of potential technologies not yet explored such as the within the pulp and paper sector; and increasing our understanding of such for deployment will be crucial to meet worldwide CO<sub>2</sub> emissions reduction targets. ●

## GHGT-11 Update, by Toby Aiken, IEAGHG

The Call for Papers for GHGT-11 has been announced. The Call for Papers should be enclosed with your issue of Greenhouse News, but if it isn't, or you are receiving this electronically, please visit [www.ghgt.info](http://www.ghgt.info) to view a downloadable copy.

Also, the Technical Programme Committee (TPC) has been selected and are now active in their roles. Details of the TPC can also be found on the GHGT-11 website.

The GHGT conference series has established itself as the principal international platform for exhibiting and discussing new greenhouse gas mitigation technologies. This series has become a focal point for international research on CO<sub>2</sub> Capture and Storage (CCS), and it is anticipated that this 11<sup>th</sup> event will continue to live-up to the reputation as the premier event of its type. Following on from the GHGT-10 theme of 'From research, to reality', the theme for GHGT-11 is confirmed as: 'CCS, ready to move forward.'

### Sponsors Still Required

The GHGT conference series is a non-profit event that traditionally attracts significant government and industrial sponsorship. We are inviting key companies and organisations in CCS to join in sponsoring the conference. As well as providing exposure at the conference for your organisation, supporting this international conference will help in advancing the understanding, development and deployment of CCS.

Funding for the GHGT-11 meeting will come from three major sources: sponsors (gold, silver and bronze), supporters, and delegate fees. For gold and silver sponsors, we offer the option of 'add-ons' so they can sponsor individual items or events related to the conference. Further sponsored items will be identified throughout the planning for the conference, but

examples of sponsored items are: badge lanyards, registration desks, the GHGT-Times daily newspaper, travel cards, lunches (which will include the opportunity for a keynote talk at the sponsored lunch), and dinner sponsorship. The individual costs for these items are negotiable, and should be discussed on an individual basis with the conference organisers.

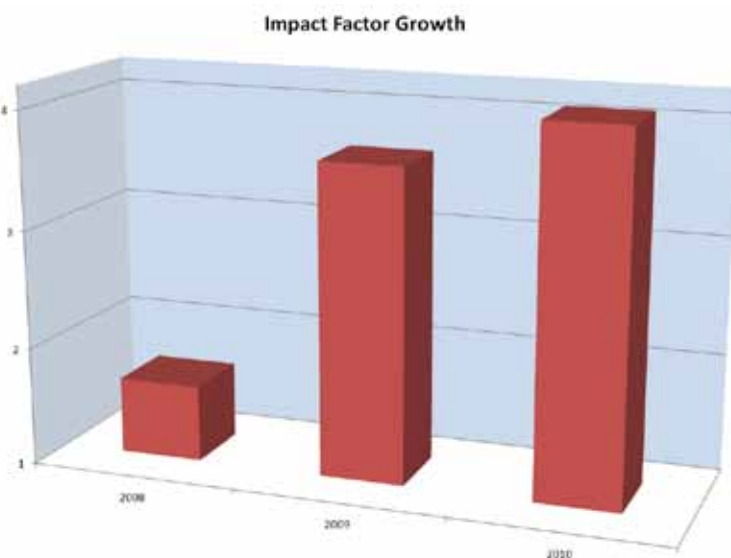
Anyone wishing to discuss sponsorship or support of the conference should approach Toby Aiken ([toby.aiken@ieaghg.org](mailto:toby.aiken@ieaghg.org)) in the first instance, or view the Sponsor Prospectus online at: [www.ghgt.info](http://www.ghgt.info) ●

## IJGGC Impact Factor Continues to Grow – 4.074, by Toby Aiken, IEAGHG

In June of this year the new Journal Citation Reports®, containing the 2010 Impact Factors, were released by Thomson Reuters. According to Thomson Reuters the journal performance metrics offer a systematic, objective means to critically evaluate the world's leading journals. They also help to determine a publication's impact and influence in the global research community.

For the third year running, International Journal of Greenhouse Gas Control (IJGGC) has been included in the JCR category: Engineering, Environmental, with the journal receiving an impressive Impact Factor in 2010 of 4.074.

The IJGGC covers developments in greenhouse gas control in the power sectors and in the major manufacturing and production industries. It aims to cover all greenhouse gas emissions and the range of abatement options available, and comprises both technical and non-technical related literature in one volume. ●



Impact Factor Growth 2008-10

## IJGGC Special Issue on Oxyfuel Combustion, by John Gale, IEAGHG & Editor in Chief, IJGGC

Elsevier and IEAGHG are pleased to announce a Supplementary Issue of the International Journal of Greenhouse Gas Control (IJGGC) on Oxyfuel Combustion. This issue, entitled "Oxyfuel Combustion Technology: Working Towards Demonstration and Commercialisation", is the world's first collection of peer reviewed papers on Oxyfuel Combustion Technology in a single issue journal. The issue covers developments in Oxyfuel boilers and burners, oxygen production, flue gas cleaning processes and CO<sub>2</sub> processing units.

The supplementary issue consists of a preface from the Board of Guest Editors, forewords from Dr. Chris Spero, Prof. Lars Stromberg and Dr. John Topper, and 23 papers from various stakeholders who are actively conducting research work in the area of Oxyfuel.

The Supplementary Issue is an outcome of the successful Oxyfuel Combustion research network that IEAGHG has been operating for several years and draws upon research results presented at that network and the first Oxyfuel Combustion Conference organised by IEAGHG in September 2009. This supplementary issue journal of IJGGC also complements the activities of the 2nd Oxyfuel Combustion Conference to be held in Yeppoon, Australia from the 12<sup>th</sup> to 16<sup>th</sup> September 2011.

IEAGHG would like to acknowledge the coordinating efforts of the Board of Guest Editors – Stanley Santos (Managing Guest Editor, IEAGHG), Marie Anheden (Aker Clean Carbon), Prof. Alfons Kather (Hamburg University), Prof. Terry Wall (Newcastle University), Prof. Jost Wendt (Utah University), Jinying Yan (Vattenfall R&D AB). IEAGHG would also like to thank the contributions of all the authors and peer reviewers of this Supplementary Edition.

This Supplementary Edition can now be accessed through the Elsevier Science Direct website.

<http://journals.elsevier.com/17505836/international-journal-of-greenhouse-gas-control/> ●

# IPIECA are Pleased to Announce their Upcoming Workshop, by Robert Siveter, IPIECA

IPIECA are pleased to announce their upcoming workshop  
"Addressing the remaining gaps in knowledge for CCS"  
September 20<sup>th</sup> - 21<sup>st</sup>, Four Points Sheraton, Washington DC

In order to develop carbon capture and storage (CCS) technology in a timeframe commensurate with targets being discussed, a significant number of demonstration projects at full-scale are needed to prove and test various facets of the technology. This workshop will consider gaps in knowledge and barriers to CCS, which will help to inform where future demonstration projects might concentrate their efforts.

Speakers, and participants, from across the expert community including the oil and gas, and energy industries, academia, governments, and relevant organisations will be brought together for this workshop.

The workshop agenda, and further details can be found from the event webpage: <http://www.ipieca.org/event/20110506/addressing-remaining-gaps-knowledge-ccs>

If you wish to express interest in attending this event, you will need to register on the IPIECA website. ●

## B&W's New Greenhouse Gas Technology to get Test, by Jim Mackinnon, Beacon Journal Business Writer

**Babcock & Wilcox researchers in Barberton say they've hit a milestone that was six years in the making. As a result, B&W Power Generation Group's prototype technology that removes the greenhouse gas carbon dioxide from coal-fired power plant emissions will soon get a close-to-real-world test down South.**

B&W Power Generation says it will be the first company at the Department of Energy's National Carbon Capture Center to test a highly specialized solvent that can remove carbon dioxide from power plant smokestacks. The company has between 15 and 20 people devoted to the project.

B&W is trucking 5,000 gallons of the chemical, which it calls OptiCap, to the Wilsonville, Ala., facility.

The solvent will be used for three months in what the facility calls the Post-

Combustion Carbon Capture Center — meaning the solvent removes carbon dioxide after the coal is burned. While B&W has paid the technology development expenses to date, the testing at the National Carbon Capture Center will be funded in part by the federal government.

B&W has been working at least six years to develop processes, including mixing and testing solvents, that can remove carbon dioxide from coal flue gas, said George Farthing, B&W technical consultant at the Barberton R&D facility.

The work is being done at what B&W calls its Regenerable Solvent Absorption Technology (RSAT) test facility.

The OptiCap solvent developed there, when it comes into contact with the smokestack gases, bonds with and "captures" the carbon dioxide and is then piped away. The solvent then undergoes another process that removes the carbon dioxide. The gas can then be stored in places such as deep underground so that it does not enter the atmosphere. "You can prevent the CO<sub>2</sub> from impacting the climate system," Farthing said.

Conventional scrubbing processes, when applied to removing carbon dioxide from a coal-fired power plant, are currently expensive and use a lot of energy, he said.

"We are trying to find more efficient, lower cost ways to do that," Farthing said.

B&W's process scrubs carbon dioxide gas in a similar way that power plants now use "scrubbers" to remove the pollutant sulfur dioxide from coal-fired smokestacks.

"With CO<sub>2</sub>, the quantities are so large that there isn't a solvent available that we can afford to throw away," Farthing said. The OptiCap can remove about 90 percent of the carbon dioxide from the smokestack emissions. Farthing also commented that B&W's process also means the solvent can be reused over and over again at a power plant.

The researchers at B&W have been looking at and developing the right blend of chemicals, Farthing said.

"We here are not inventing new molecules, necessarily. But we're looking at different kind of blends of existing chemicals and chemicals we could conceivably use in the process," Farthing said.

The OptiCap mixture that B&W developed has a good balance trading off being able to absorb the gas while not using excessive energy in the process, he said.

"Of all the ones we've looked at, we think this is the best," Farthing said. "That's why we're moving it on to the demonstration at the National Carbon Capture Center."

The OptiCap technology will be used to remove carbon dioxide from flue gases emitted by the Gaston electric power plant, owned by electric utility Southern Company, that is part of the National Carbon Capture Center in Wilsonville.

After the three-month-long test, B&W and others will review how well OptiCap performed.

"We need to come back here and figure out what it all means," said Christopher Poling, principal engineer at B&W Power Generation.

They hope the process will prove that OptiCap has the benefits B&W researchers believe it has, he said.

And then B&W will seek a larger, commercial-size demonstration, Poling said. "That's something that is currently expensive but that's what we need to

happen in order to have this technology commercialised."

B&W has committed a significant number of people and capital to the carbon-capture technology, Poling said.

"Our work to date at the [Barberton] research center has all been paid by the company," Farthing said. "It's been a major development effort at the company for many years now."

Jim Mackinnon can be reached at 330-996-3544 or [jmackinnon@thebeaconjournal.com](mailto:jmackinnon@thebeaconjournal.com)

## Member Updates

### **NRCAN, by Malcolm Wilson, CEO, Petroleum Technology Research Centre**

#### ***New CCS activities***

- Development of the Aquistore Project has continued – ensuring a good land position for the drilling pads and the fixed seismic array.
- Weyburn-Midale project – the first draft of the Best Practice Manual currently under production

#### ***Other activities regarding CCS?***

- Saskatchewan continues to develop its guidelines for CCS offsets under the Climate change Act.
- Alberta continues its review of CCS legislation.

### **Instituto de Investigaciones Eléctricas, by Dr. Jose Miguel Gonzalez Santalo, Director, Mechanical Systems Division**

#### ***New CCS activities***

- A workshop to introduce the topic of CCS in Academia, with the support of the CSLF is being planned to take place in March

#### ***Other activities regarding CCS?***

- The construction of a small, laboratory scale, CO<sub>2</sub> separation system with amines continued. The system is expected to be operational this year

### **Eni e&p, by Bruno Boiardi**

#### ***Other activities regarding CCS?***

- Eni is developing a pilot plant for CO<sub>2</sub> geological storage in Northern Italy, as part of an integrated pilot project for CO<sub>2</sub> Capture, Transportation and Storage in cooperation with Enel.

### **U.S. Department of Energy, by George Guthrie; US-DOE National Energy Technology Laboratory**

#### ***National Risk Assessment Partnership***

The National Risk Assessment Partnership (NRAP) held its first Stakeholder Group meeting in Washington DC in July to present its technical plan for predicting risk profiles at CO<sub>2</sub> storage sites.

NRAP is a new initiative within the U.S. Department of Energy to utilize a broad array of multiscale techniques to build a platform for quantification of both risk profiles and associated uncertainties. NRAP is also exploiting a variety of field data for reducing uncertainties in parameters and for confirming the validity of the model components with respect to real-world behaviour. In addition, NRAP will incorporate strategic monitoring and mitigation protocols to lower both uncertainties and magnitudes in the profiles.

NRAP's initial focus is on groundwater protection, long-term storage integrity, and ground motion. Methodologies for the initial risk profiles and uncertainty quantification are expected by end of 2011, with targeted research to reduce uncertainties as risk profiles are updated in 2012 and 2013.

NRAP is led by the National Energy Technology Laboratory and includes research teams at four other DOE national labs (Lawrence Berkeley National Lab, Lawrence Livermore National Lab, Los Alamos National Lab, and Pacific Northwest National Lab).



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## IEA Clean Coal Centre Database Update, by Debo Adams, IEACCC

One of the databases maintained by the IEA Clean Coal Centre is Coal Power, which covers the world's coal-fired power plants, their units, the environmental controls in place for each unit and the addresses of utilities and suppliers. The database is maintained daily and the online version is updated quarterly.

It has proved extremely popular and is much sought after by government agencies, engineering consultants, plant manufacturers, coal suppliers and others in many countries around the world. Coal Power and the other databases maintained by the IEA Clean Coal Centre can be found at the website: [www.iea-coal.org](http://www.iea-coal.org). Coal Power is free to access for members and an annual subscription is required for others. Alternatively, individual searches can be undertaken at an hourly rate. More details about the Coal Power database and how to subscribe can be found on the website, or contact [Xing.Zhang@iea-coal.org](mailto:Xing.Zhang@iea-coal.org) the database manager, for further information.

A 'Sum' function has just been added to the database so that users can calculate the total capacity for a country, a particular technology or a certain status of plants or units. In addition, we have changed the country field from a text box to a dropdown list to simplify searches. These new improvements make the database more user friendly and improve the value of the information retrieved. ●



## CCS European Heavyweights form Alliance TRI4CCS

Norway, TNO in the Netherlands and IFP Energies nouvelles (IFPEN) in France have joined forces in the newly established "Tri4CCS Alliance", which aims to make the capture, transport and storage of CO<sub>2</sub> (CCS) safer and more cost-effective.

### *Ready to tackle the coming CCS research challenges*

IFPEN, SINTEF, TNO are supporting the efforts of energy utilities, equipment suppliers and authorities via their research and innovation efforts related to CCS - i.e. the future capture, transport and underground storage of CO<sub>2</sub> from fossil-fuelled power stations and process industry. They are major contributors to international research on clean energy and have regularly cooperated during the past 15 years for their own national and regional authorities, the European Commission and industry. The Alliance members contribute to full-scale CCS on the Sleipner and Snøhvit gas fields off the coast of Norway, and in the onshore projects of In Salah in Algeria and Lacq in France.



In a nutshell: TRI4CCS offers a unique gathering of resources, expertise and labs. It relies on a shared vision of the CCS technologies development, a win-win cooperation flexible and reactive to tackle the future CCS market.

### *R&D services on the entire CCS chain*

The aim of TRI4CCS is to serve the research needs of industry while developing innovative solutions and products that cover the entire CCS chain. TRI4CCS possess a great deal of expertise on each individual link in the CCS chain, which enables it to offer an integrated approach to CO<sub>2</sub> capture, transport, storage

*“By bringing together some of the world’s top CCS experts, TRI4CCS is creating a centre for innovation that will boost new ideas and developments beyond today’s possibilities.”*

and utilisation.

#### Capture

The Alliance is studying a number of novel CO<sub>2</sub>-capture technologies that aim to halve energy use and substantially reduce the cost of capturing CO<sub>2</sub>. These new technologies encompass solvents, membranes and sorbents, both singly and in combination. Transformational technologies such as chemical looping combustion (CLC) as well as market-nearer technologies such as amine solvents are embedded in our expertise and resource base.

#### Transport

The Alliance’s expertise includes the technical design and safety analysis of CO<sub>2</sub> transport by pipeline and marine transportation of CO<sub>2</sub>, including liquefaction. We are thus able to couple the thermodynamics of CO<sub>2</sub> transport with pipeline integrity and safety issues in the event of leaks or ruptures. Flow assurance and the impact of impurities constitute an integral part of our competence and R&D capabilities.

The Alliance possesses a wide range of expertise in technical evaluation of injectivity, storage capacity, containment and monitoring, in addition to risk analysis and the environmental impact of CO<sub>2</sub> storage in subsurface geological structures. The development of monitoring techniques for long-term storage integrity assessment is an integral part of our portfolio, as are remediation methods and tools. IFPEN, SINTEF and TNO have developed dedicated software based on our experience in those fields.

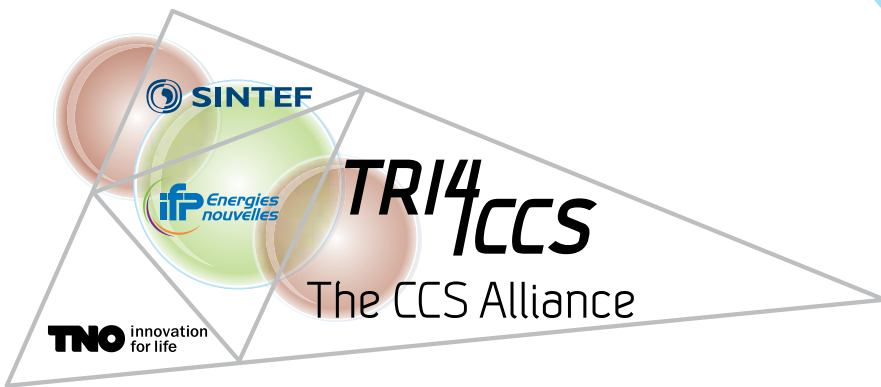
#### Utilisation

The Alliance also offers R&D services to promote the use of CO<sub>2</sub>, starting with EOR (Enhanced Oil Recovery) but also studying the use of CO<sub>2</sub> as feedstock for new products and industrial applications.

#### The CCS value chain and the social acceptance of CCS

TRI4CCS can address all the integrated phases of CCS systems, including life-cycle assessment and public perception and dialogue.

As a group, the Alliance is large enough to tackle the scientific challenges that will emerge when in the course of a few years planned demonstration and full-scale CCS plants are commissioned. ●



*“The three institutes employ a total of 450 scientists in these fields, with a R&D portfolio in CCS of some €60 million a year.”*

## Book Review – Capturing Carbon, The New Weapon in the War Against Climate Change, by Toby Aiken, IEAGHG

**Capturing Carbon** is a wide ranging book that introduces the various technologies that are involved in CO<sub>2</sub> Capture and Storage (CCS) and the processes involved in capture and storage.

The book carries out a thorough analysis of the entire process, starting with an assessment and explanation of the need to capture carbon dioxide, and the reality of the climate change threat. The subsequent chapters then provide an insight into the capture technologies; the different methodologies used, and the second generation techniques now available. Transport and storage are also addressed, with assessments of the different storage formations, and the hazards and mitigation options relating to any leakage.

The book also contains direct comparisons of CCS to biological sequestration in soils and forests before looking at the economics involved in the processes, and the policies needed and in force around the world.

The book concludes that CCS is a ‘realistic contender for a leading role in fighting climate change.’ It assesses CCS in a range of mitigation options, ‘scoring’ it on various aspects such as technical maturity, potential, cost and public acceptance (see figure 1 for more detail). In this analysis, CCS is seen as having a vital role to play, but importantly, shows the role and need for other measures as well.

Capturing Carbon by Robin M. Mills is published by Hurst & Co. ISBN 978-1-84904-033-4 (Hardback) 978-1-84904-034-1 (Paperback) ●

# Conferences & Meetings

This is a list of the key meetings IEAGHG are holding or contributing to throughout 2011. Full details will be posted on the networks and meetings pages of our website at [www.ieaghg.org](http://www.ieaghg.org).

If you have an event you would like to see listed here, please email the dates, information and details to: [toby.aiken@ieaghg.org](mailto:toby.aiken@ieaghg.org).

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

## 2<sup>nd</sup> Oxyfuel Combustion Conference, OCC2

12<sup>th</sup> - 16<sup>th</sup> September 2011; Yeppoon, Queensland, Australia

## CO2CRC Free Public Lecture: "CCS and Australia's Low Emission Future

Monday 19<sup>th</sup> September 2011 at 6pm; University of New South Wales, Australia

## IPIECA "Addressing the remaining gaps in knowledge for CCS Workshop

20<sup>th</sup> - 21<sup>st</sup> September 2011; Four Points Sheraton, Washington DC, USA

## Iron and Steel Industry CCS Workshop

8<sup>th</sup> - 9<sup>th</sup> November 2011; Steel Institute VDEh Auditorium. Düsseldorf, German

## U.S. Department of Energy (DOE), Carbon Storage Program Infrastructure Annual Review Meeting

5<sup>th</sup> - 17<sup>th</sup> November 2011; Pittsburgh, USA

## 7<sup>th</sup> CO<sub>2</sub> GeoNet Open Forum and CGS Europe Workshop

17<sup>th</sup> - 19<sup>th</sup> April 2012; Venice, Italy



## Greenhouse News

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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 :

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