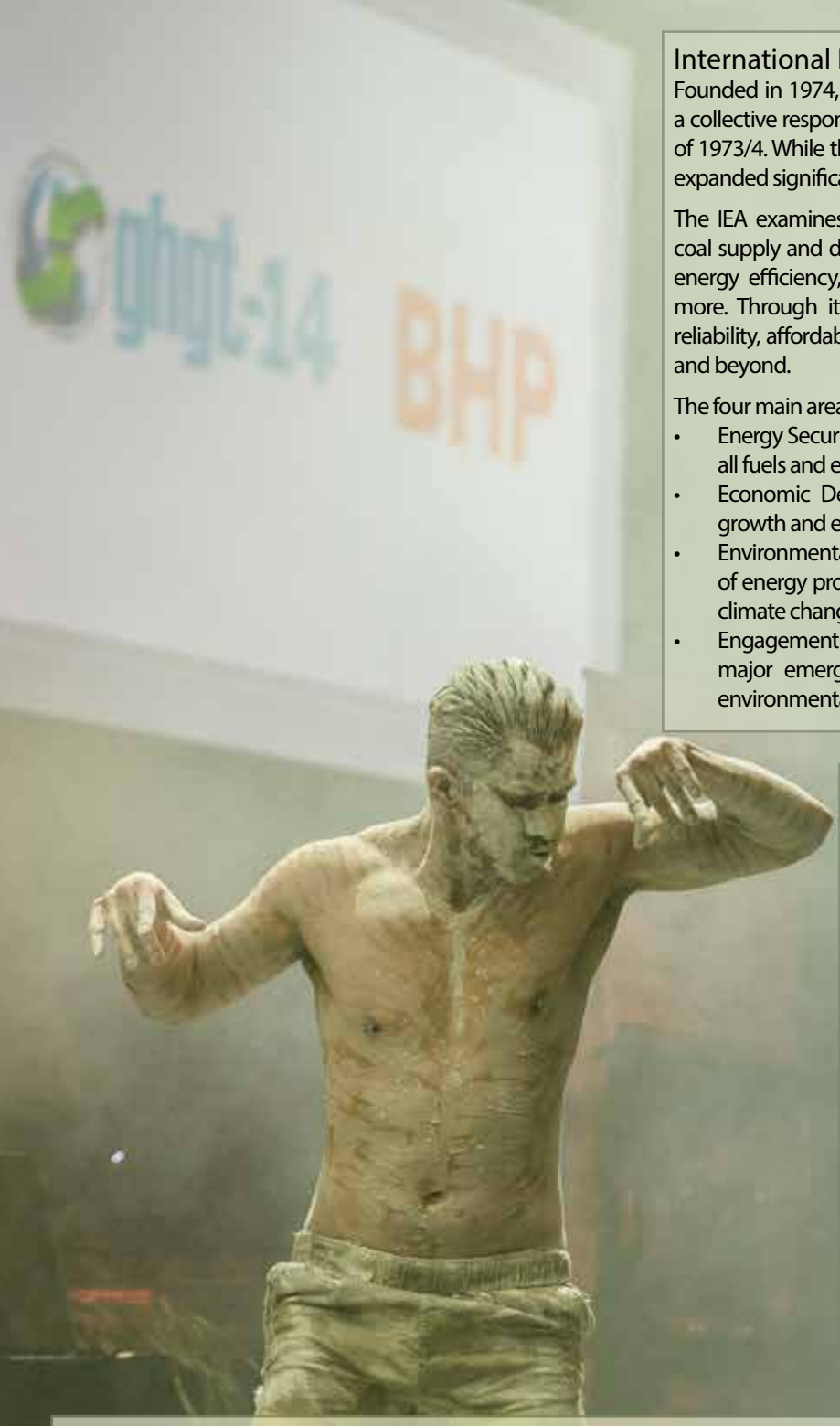
Evaluating technology options to mitigate greenhouse gas emissions

annualreview2018

IEA GREENHOUSE GAS R&D PROGRAMME



International Energy Agency

Founded in 1974, the IEA was initially designed to help countries co-ordinate a collective response to major disruptions in the supply of oil, such as the crisis of 1973/4. While this remains a key aspect of its work, the IEA has evolved and expanded significantly.

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- Economic Development: Supporting free markets to foster economic growth and eliminate energy poverty;
- Environmental Awareness: Analysing policy options to offset the impact of energy production and use on the environment, especially for tackling climate change and air pollution; and
- Engagement Worldwide: Working closely with partner countries, especially major emerging economies, to find solutions to shared energy and environmental concerns.

Further information on the IEA Greenhouse Gas R&D Programmes activities can be found at:
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Review compiled by John Gale, Kelly Thambimuthu, Tim Dixon, Becky Kemp & Suzanne Killick.

Document designed by Becky Kemp.

Inside Cover Image: Welcome to Country - Traditional Dance at the Gala Dinner at GHGT-14, Melbourne, Australia in October 2018

Front and Back Cover Images: Welcome Reception at the NGV, GHGT-14; The 12 Apostles, Australia; Melbourne City Skyline at Night; *Brine storage tanks at the brine extraction and pressure management test site (BEST) near Watford City, North Dakota; Trondheim - Location for the 12th International CCS Summer School*

Annual Review Contents

Attendees at the Field Trip during the IEAGHG Modelling and Risk Management Combined Network Meeting, 2018 (Photo Coutesy of EERC)

Chairman's Message

Climate change mitigation: we need to do more and urgently.....

The Paris Agreement set us on an ambitious pathway to reduce global temperature rise to below 2°C. Such action will not stop climate change but it will prevent catastrophic changes occurring in the future that will severely affect the lives of our children and our children's children. The recent IPCC Special Report on Global Warming of 1.5C sets out quite clearly the risks and impacts that we can expect if we increase temperature rise by another half a degree by the end of the century. The report is a stark reminder that we need to do more to mitigate greenhouse gas emissions and we need to do it urgently.

The IEA has been reporting that, for the past three years, global CO_2 emission had plateaued which gave us cause for optimism that we could soon start to see emissions reductions across the globe. Disappointingly, this year we have seen that global emissions have started to rise again. The Global Carbon Project has recently reported that CO_2 emissions grew by 2% in 2018. This increase they attribute to increased use of fossil fuels, namely coal and oil and gas. The IEA anticipates emissions from industrialized economies will increase by around 0.5% in 2018, ending a five-year decline. The IEA expects that energy-related CO_2 emissions in North America, the EU and advanced economies in the Asia-Pacific are now expected to grow, over the course of 2018, with increased oil and gas use offsetting decreased coal consumption in these countries. All in all this is not good news.

The Montreal Protocol has been a major success and the new Kigali Agreement that starts to phase out HFCs in 2019 is welcomed. It is estimated that by phasing out HFCs we can save 0.5C of temperature rise. However most developing countries will not start phasing out HFCs until after 2024. Whilst this phase out of greenhouse gas emissions is welcomed, we cannot expect it to bail out increasing CO_2 emissions. Rather, it should be additive to global efforts to mitigate CO_2 emissions.

So we are faced with some stark options. More and more academic, green NGOs are calling for the end of the fossil fuel era, but is this achievable? We have seen after COP21 the launch of the Powering Past Coal Alliance. This alliance which now has 80 members (30 national governments, 22 sub-national governments and 28 businesses or organisations) is committed to phasing out unabated coal by 2030. However, it lacks members from the big coal using countries like Australia, China, India and the USA, so can the alliance have a major global impact on phasing out coal? At the other extreme, is the world ready to embrace a scenario that involves significant changes in dietary choices? The 'planetary health diet' has hit the media headlines of late with its claims to improve health and save the planet by a rapid transition to sustainable agricultural practises. However, whilst veganism is trendy in developed countries, can we really expect a radical transition globally from meat consumption to veganism to occur in the next 20 to 30 years. Nice idea, but the likelihood is small. It is more feasible that we will embrace a transition that involves deployment of currently available technology coupled with the development of innovative technology in some areas. Such a transition will include all clean energy options in the energy sector including renewables, nuclear and CCUS coupled with energy efficiency improvements. To meet the Paris goal, however, we need to quickly move on from the circular debate of advocating one particular energy technology against another to embracing the concept of "the need to throw everything at this problem" and get on with financing a now very urgent transition as soon as possible.

Kelly Thambimuthu at GHGT-14, Melbourne

K.V. Thambimuthu.

Kelly Thambimuthu,
Chairman of the IEAGHG Executive Committee

General Manager's Summary

For me personally this has been a year of highs and lows. Any GHGT takes 2 years of hard work and planning and GHGT-14 in Melbourne was no different...

The fact that we had over 1000 attendees at GHGT-14 was a real high. Previous events we have organised "down under" have had lower attendances compared to those in Europe or North America, due to the costs of travel. However, I am pleased to say we bucked that trend with a significant increase in attendees from South East Asia. The increased attendance from that region demonstrates the increase in CCUS research, and development and deployment that is occurring. It is no coincidence that the 18th CCUS demonstration project came on stream this year; the Yangcheng Petroleum CCUS project. There are major CCUS R,D&D activities underway in Japan like Tomakomai, Ministry of Environment BECCS project and in Korea. All this reflects that South East and East Asia is now firmly a player on the CCUS world map.

The low of course, for me, was not being able to attend for personal reasons and having to watch events at GHGT-14 from afar and not being able to support my colleagues in the front line. My first ever GHGT was GHGT-5 held in Cairns, Australia, in 2000. Whilst I have been back to Australia since, there is nothing like the buzz you get from a GHGT event. Also, Melbourne is a favourite city of mine and missing GHGT-14 in Melbourne was a personal low spot. However, I must congratulate my colleagues, the Australian hosts, the sponsors and all those that attended for making GHGT-14 yet another great success in the GHGT calendar. Now we cast our mind forward to GHGT-15 in Abu Dhabi, UAE in 2020.

What came completely unexpectedly to me was to be one of two winners of the Greenman Award for GHGT-14. Whilst I was not personally there I had the great honour to share the stage by video with Susan Hovorka, a truly great scientist in the CCUS field. I have known her since I first started in this field 20 years ago and she is a key international figure in the world of CCUS and she thoroughly deserves the recognition in Melbourne for her contribution. I will proudly hang my Greenman award on the wall at home next to my 2007 Nobel Peace Prize contributor award, another career high. In later years, I can gaze at that wall and think, well somebody must have thought I contributed something to the world of CCUS during my time working in the field.

John Gale,
IEAGHG General Manager

John Gale,
General Manager, IEAGHG

Key IEAGHG Achievements in 2018

GHGT-14 Conference
1012 Delegates from 31 Countries
352 Oral Presentations
430 Posters

External Presentations by IEAGHG Staff

8 Technical Reports
4 Technical Reviews
43 Information Papers
4 Briefing Papers

Meetings
12th IEAGHG Summer School
59 Students

Modelling and Risk Management Network Meeting
Over 70 attendees

3rd International Workshop on Offshore CCS
Over 60 attendees

Published to Online Media

3 Webinars
234 YouTube views

Page Views: 17,175

Views of IEAGHG Website: 7,273 Sessions

IEAGHG Operations Report

Membership remained unchanged in 2018 (33 members in total) giving us an annual income of £1.55m. The budget was spent as illustrated in the graph below.

The Executive Committee that is comprised of our member representatives, which acts as the Governing Body overseeing IEAGHG's activities meet twice in the year. The first meeting was held in May 2018 in Porsgrunn, Norway hosted by Gassnova on behalf of Norway. As well as the normal business of assessing IEAGHG's activities and agreeing new ones, the meeting also afforded members to visit the Norcem cement facility in Brevik and the Yara ammonia plant; both candidates for follow on funding for FEED studies at that time. Members were also given a presentation on the Northern Lights Projects that will build the CO_2 transport and storage infrastructure offshore Norway.

The second Executive Committee meeting was held in October 2018, just ahead of the GHGT-14 conference hosted by our Australian members in Melbourne.

The Executive Committee at the Norcem Cement Plant, Brevik, Norway in May 2018

Facilitating Implementation

The IEAGHG helps to facilitate the implementation and deployment of CCS by contributing the technical evidence-base to policy-makers and other decision-makers. IEAGHG participates in key activities to support CCS policy/implementation strategies and by undertaking studies and workshops to provide information that is needed to assist implementation and deployment...

UNFCCC COP24

COP24 ran from 2nd - 14th December 2018 and had a major objective: to complete the 'rulebook' for all the governance aspects of the Paris Agreement to be able to come into implementation from 2020. These included many issues related to mitigation, adaptation, and support to developing countries. Some of the key issues to resolve in Katowice were:

- the mitigation section of nationally-determined contributions (NDCs);
- the transparency framework of action and support;
- the global stocktake;
- information on future finance provided by developed countries;
- cooperative approaches, including a new market mechanism; and
- common timeframes for countries to submit and/or update their NDCs.
  (list cited from IISD's summary http://enb.iisd.org/climate/cop24/enb/)

All of these areas were completed and agreed, so forming the Paris 'rulebook' and are called the 'Katowice Climate Package'.

The one area that wasn't finalised was Article 6 which deals with international mitigation actions between countries.

UNFCCC CCS Side Event

IEAGHG and partner organisations were again successful in getting an official UNFCCC Side-event on CCS at COP24, in collaboration with the University of Texas, the International CCS Knowledge Centre, Bellona and CCSA. Held on the 6th December, the event was titled "*Can Carbon Capture and Storage (CCS) decarbonise industry in developed and developing countries?*". Being the only UNFCCC Side-event on CCS, we tried to be both relevant to this particular COP and cover as many new developments as possible. Hence it was structured in two discussion panels, Decarbonising Industry and Developing Countries.

The scene-setting was provided by Thelma Krug, Vice-Chair of the IPCC, on what the IPCC 1.5 report says on CCS and BECCS, particularly for industrial applications. We added that the 1.5 report states "removing BECCS and CCS from the portfolio of available options significantly raises mitigation costs".

A theme of COP24 from the Polish host is a 'Just Transition' for workers in industries potentially undergoing change due to climate change. So we had a trade union perspective from Brian Kohler of IndustriALL, on why they support CCS.

We also had the exciting update from Mike Monea of the International CCS Knowledge Centre on the Shand Feasibility Study, showing significant results such as the capital cost reduction of 67%, cost of capture being USD45/tCO_2, and water neutral (very important in the context of the Sustainable Development Goals). Mike also discussed the relevance to Poland with its high coal use.

We had presentations from Heidelberg Cement from Manuela Ojan, and Jonas Helseth of Bellona and ZEP gave the ZEP perspective on CCS for EU industry.

Katherine Romanak of the University of Texas at Austin gave a perspective on learning from the US work on demonstrating security of large-scale injection projects, and encouraging developing countries to learn from this and also to use climate funds to support their capacity building. A very interesting presentation on the potential for CCS in Trinidad and Tobago was provided from Professor Andrew Jupiter of the University of West Indies (and former Ministry of Energy).

The Right Honorable Mark Field, UK Minister for Asia and Pacific, concluded the event, with why the UK supports CCS, including being a very significant international donor to developing countries, and a nice summary of the Global CCUS Summit held last week in Edinburgh (see IEAGHG Information Paper 2018-IP37).

As well as chairing, we presented on the need for CCS, IEAGHG's ongoing work on CCS and Sustainable Development Goals, and highlighted the IEAGHG Summer School as one of the free ways to build capacity in countries considering CCS for future NDCs.

We were very pleased that IISD chose to cover us, which indicates how relevant we were as they have so many Side-events to potentially cover. See their coverage at **http://enb.iisd.org/climate/cop24/enbots/#event-2** . The Side-event was live streamed by UNFCCC outside COP, and the ppts will be available later via UNFCCC.

Judging by the room being near its capacity of 200, the twitter traffic and the IISD coverage, it seems a well-received and successful event to inform COP24 delegates. Thank you to all collaborators and presenters, and especially to the audience. IEAGHG was busy at COP24, including presenting at the following events:

- 5th Dec. Title: "CO_2 Capture Project Study: CCS in Nationally Determined Contributions and Mid-Century Strategies". Location: IETA Hub, COP24 1100-1230.
- 6th Dec. "The Ocean and CO_2: challenges and science responses for seas and society". COP24 UK Pavilion. 1600-1800.
- 10th Dec. "CCUS locally and at European level" . Location: (outside COP24) GIG - square Gwarków 1, 40-166 Katowice. (Organiser CO2GeoNet and GIG). 1400-1600.
- 12th Dec. "Demystifying negative emission technologies". Location COP24 EU Pavilion . 1600-1800 (Organiser: CO2GeoNet)
- 12th Dec. 1745-1900. "Changing Our Future with CCS!" . Location: COP24 Japanese Pavilion. Organisers: METI and JCCS.

The second week felt even busier with CCS-related events. Of note was the GCCSI release of their 2018 Global Status report in a press conference (which was well covered). Also to note, the event by GCCSI on CCS "Not or but and" which had Lord Stern and Julio Friedmann providing strong messages for CCS as well as an IPCC lead author. This was well attended in the IETA pavilion. Also well attended was the UK Pavilion event on the Global CCUS Summit, and the EU Pavilion event on Negative Emission Technologies organised by CO2GeoNet. The Japanese pavilion hosted an event organised by METI and JCCS on CCUS in Japan, with updates from METI and from Toshiba on their BioCCS project under construction at Mikawa power station, with potential storage offshore using ship transport.

L-R: **Thelma Krug**, IPCC Vice-Chair; **Tim Dixon**, IEAGHG; **Jonas Helseth**, Bellona and ZEP; **Manuela Ojan**, HeidelbergCement; **Mike Monea**, ICKC; **Brian Kohler**, IndustriALL; **David Jupiter**, University of the West Indies; **Katherine Romanak**, UT

Photo by IISD/ENB | Natalia Mroz / Diego Noguera (http://enb.iisd.org/climate/cop24/enbots/6dec.html)

Jonas Helseth, Bellona and ZEP

Mike Monea, ICKC

David Jupiter, University of the West Indies

Katherine Romanak, University of Texas

Mark Field, UK

A participant takes a photo during the event

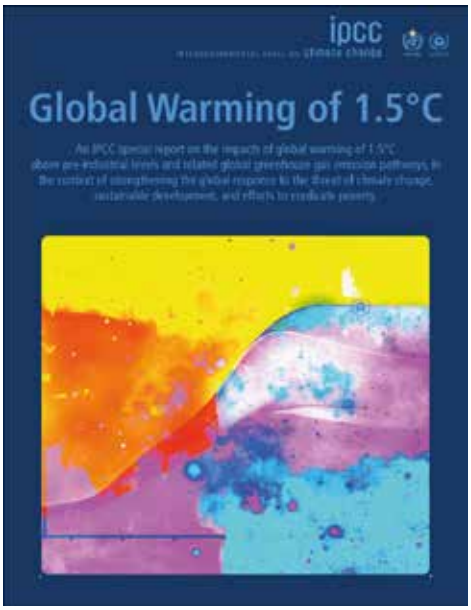
Photos by IISD/ENB | Natalia Mroz / Diego Noguera (http://enb.iisd.org/climate/cop24/enbots/6dec.html)

Mark Field, United Kingdom

Photo by IISD/ENB | Natalia Mroz / Diego Noguera (http://enb.iisd.org/climate/cop24/enbots/6dec.html)

IPCC1.5 Report

The IPCC 1.5 report was generally very well received at COP24 and provided motivation for more urgent action on climate change. IEAGHG were proud to have contributed two Expert Reviewers. Three IPCC speakers spoke of the report's demonstration of the need for CCS on industrial sources (one being in our side-event). Also, it was cited by other senior climate finance figures as a reason that we should look more to use CCS on industrial sources. This positivity was welcome, along with the positive feedback that we got from our Side-event, and the messages from IEA and GCCSI from the Global CCUS Summit the week before in Edinburgh, it felt that CCS was being increasingly accepted along with the more established low-carbon technologies.



And a final message to the Polish hosts for their great hospitality - Dziękuję!

CSLF

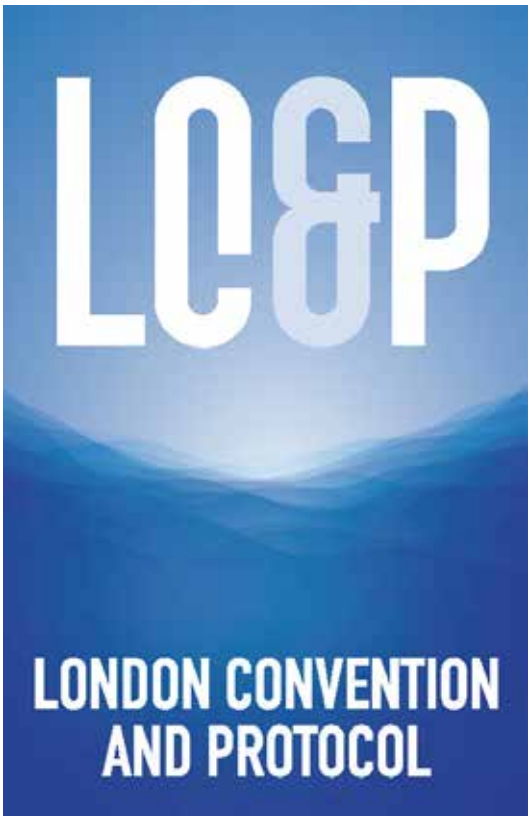
The Carbon Sequestration Leadership Forum (CSLF) is a government-to-government agreement on developing CCS, it started in 2003 and now has 25 member countries and the European Commission, and consists of a Technical Group, a Policy Group, and Ministerial meetings. IEAGHG and the CSLF Technical Group have an agreed 'Collaborative Arrangement' since 2007.

The CSLF Technical Group has the following active task forces: BioCCS; Improved Pore Space Utilisation; Industrial CCS,. CCS and Hydrogen. IEAGHG is one of the co-authors for BioCCS; Improved Pore Space Utilisation; CCS and Hydrogen, and has contributed to Industrial CCS. The Hydrogen and CCS task force produced its report in June 2018.

The CSLF PIRT and Technical Group held meetings in Venice in April, where IEAGHG's James Craig presented an update of activities.

The CSLF meetings of PIRT, Technical Group, and Policy Group were held in Melbourne in conjunction with GHGT-14, from the 16 to 18 October. Tim Dixon attended to present updates on the IEAGHG, on the 3rd Offshore Workshop, and a preview of GHGT-14.

London Protocol



It was the 40th meeting of the London Convention and the 13th meeting of the London Protocol on 5th - 9th November, the global treaties that protect the marine environment. The detailed work on transboundary CCS was completed in 2012 (see IEAGHG 2013-IP26 and 2014-IP19) but outstanding is the ratification of the 2009 amendment for CO_2 export which would remove a barrier to transboundary CO_2 storage projects offshore. Whilst the 2009 export amendment was adopted in 2009, to come into force, two thirds of the now 50 Parties to the London Protocol need to ratify the amendment (ie 33). In terms of ratification progress, there were no new announcements at this meeting. Previously, Norway, UK, Netherlands, Iran and Finland have ratified. At this meeting Norway urged Parties to make progress with ratifications with a strong argument that CCS is needed for climate change mitigation as shown by the most recent IPCC 1.5C report, and the export prohibition is a barrier to CCS. The London Convention Chair supported this and also urged progress by Parties.

So as this export amendment is still very slow towards coming into force, should alternatives be investigated and progressed as suggested by the IEA Working Paper in 2011 "CCS and the London Protocol: Options for Enabling Transboundary CO_2 Transfer"? These alternatives have more recently been presented and discussed at the 3rd Offshore CCS workshop in June 2018 (IEAGHG Report 2018-TR02) and at GHGT-14 session 11C.

Under the CCS agenda item in this London Convention meeting, Norway gave an update on the Northern Lights project, and IEAGHG gave an update on activities relating to offshore CCS, including the STEMM-CCS project, the 3rd Offshore CCS workshop, and the two new US projects in the Gulf of Mexico.

At this 40th meeting, the IMO issued a new brochure on the response of the London Convention and Protocol to climate change "How Global Regulation Can Help Unlock Climate Change Technologies". It described their action to allow and regulate offshore CCS, and to restrict and regulate marine geoengineering. It also encourages ratification of both the CO_2 export amendment. For more information contact **olcp@imo.org** , and public information on the overall London Convention and Protocol is available at **http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx**

There is continuing interest in offshore CCS. Norway and IEAGHG continue to be the primary information sources on CCS for the London Protocol.

ISO TC/265

This ISO committee was proposed by Canada and set up in 2012 with a Canadian Chair and Canadian and Chinese Secretariat. There are 21 participating countries, 10 observer countries, and 6 Liaison organisations. A new chair IEAGHG is a Liaison Organisation to TC265, and a member of WG 3, WG 4 and WG5. It has published standards on: Pipelines transport (ISO 27913:2016); Geological storage (ISO 27914:2017); Vocabulary (ISO 27917:2017) and 4 more are under development. It has published TR reports on: Capture systems (ISO 27912:2016); Quantification and verification (ISO 27915:2017); and 2 more are under development.

The 11th TC265 was held over 1st - 6th July 2018, Paris. Lydia Rycroft attended to present the IEAGHG update in TC265 Plenary.

See **http://www.iso.org/iso/iso_technical_committee?commid=648607** for more information.

GHGT-14, written by Suzanne Killick, IEAGHG

Finally, after many months of conference planning, hitting those author deadlines and of course, the last minute packing, the premier conference on carbon capture and storage - GHGT-14 arrived in the marvellous city of Melbourne, Western Australia.

More than 500 of the early arrival registered delegates were able to join us on Sunday 21st October in the magnificent Great Hall of one of Melbourne's iconic National Art Galleries for an evening of finding friends, forming new ones, drinks and entertainment. The GHGT-14 Welcome drinks reception, hosted by Gold sponsor CarbonNet, was the perfect start to the week.

In the packed 1000 seater Goldfields Theatre on Monday 22nd October, the GHGT-14 Conference got underway with welcome addresses from our conference hosts; David Byers CEO of CO2CRC, Kelly Thambimuthu of IEAGHG, Tim Finnigan Director of CSIRO Energy, Richard Bolt of the Victorian Government and James Johnson representing the Australian Government.

Moving swiftly on, we were honoured to have presentations from our keynote speakers and began these with Thelma Krug – Vice Chair of the IPCC, Jerome Schmitt of the OGCI Executive Committee, Fiona Wild - Vice President Sustainability and Climate change of BHP and Laszlo Varro - Chief economist of the IEA. All our keynote speakers are recognised in the field by their specialist areas of expertise and all delivered imaginative and informative information, which was well received by our eager audience.

A highlight of the GHGT-14 conference, for me, was the spectacular branding created especially for the event by in-house graphic designer Ros Paonin from CO2CRC. Her vibrant use of the GHGT-14 logo combined with famous Melbourne landmarks created a striking backdrop for the speakers and delegates as well as the perfect "selfie" photo opportunity.
The exhibition at GHGT-14 took on a fresh new look with freestanding branded stands including built in monitors and furnishings. This was a big change from the usual faceless enclosed booths used at previous conferences, and offered a more engaging, open showcase for the exhibitors and sponsors, which proved effective especially during the breaks and poster sessions. With eighteen stands, a 450-poster board area and all conference catering, the exhibition zone proved incredibly popular, and there was a real buzz and liveliness as delegates queued up to try the virtual reality headsets on the CSIRO stand or had an Arabic version of their name created by the calligrapher on the Kalifa University stand.

Also a success this year and complimenting the printed GHGT-14 Conference programme was our GHGT-14 conference App. This now "must have tool" for all conferences was communicated prior to the start of GHGT-14 and was downloaded by more than 700 delegates, allowing us to instantly reach out with messages or reminders as well as providing agenda scheduling for the presentations. A lost laptop was retrieved within 30 minutes of the message going out asking delegates to double check their conference bags, and an offsite drinks reception was filled to capacity thanks to a push notification via the app, which shows how effective a tool it was and how much we now rely on our mobile phones for communication.

The social highlight of the GHGT-14 conference week was our gala dinner, which took place in the Melbourne suite of the conference centre. Sponsored by Gold Sponsor BHP and hosted by their CEO Graham Winkelman, nearly 900 guests sat down to watch a breath taking performance by the Wurundjeri indigenous group who presented a "Welcome to Country".

After dinner, we heard from guest speaker Prof Peter Doherty, before handing out the traditional Greenman award to individuals whose vital contribution towards progressing CCS technologies and enhancing our understanding of the process of mitigating greenhouse gas emissions is recognised. We had two recipients, Susan Hovorka from the University of Texas at Austin, and our own General manager John Gale of IEAGHG.

The evening finished with live band the "Mad hatters" as those that still had the energy took to the dance floor to show off their moves and grooves!

GHGT-14 Statistics

The conference stats speak for themselves and we are all incredibly proud to have been able to deliver such a great conference. IEAGHG look forward now to the planning and delivery of GHGT-15. The bar has definitely been raised so let us see what we can bring for you in "amazing Abu Dhabi".

GHGT-14 Statistics

1010 Delegates from 40 Countries

352 Oral Presentations

4 Keynote Speakers
3 Technical Plenaries

12 Themes
116 Sub-Themes

143 Reviewers

71 Technical Sessions

7 Panel Discussions

430 Posters

1074 Abstracts Received

20 Side Events

GHGT-14 Conference Technical Summary,

written by James Craig, IEAGHG

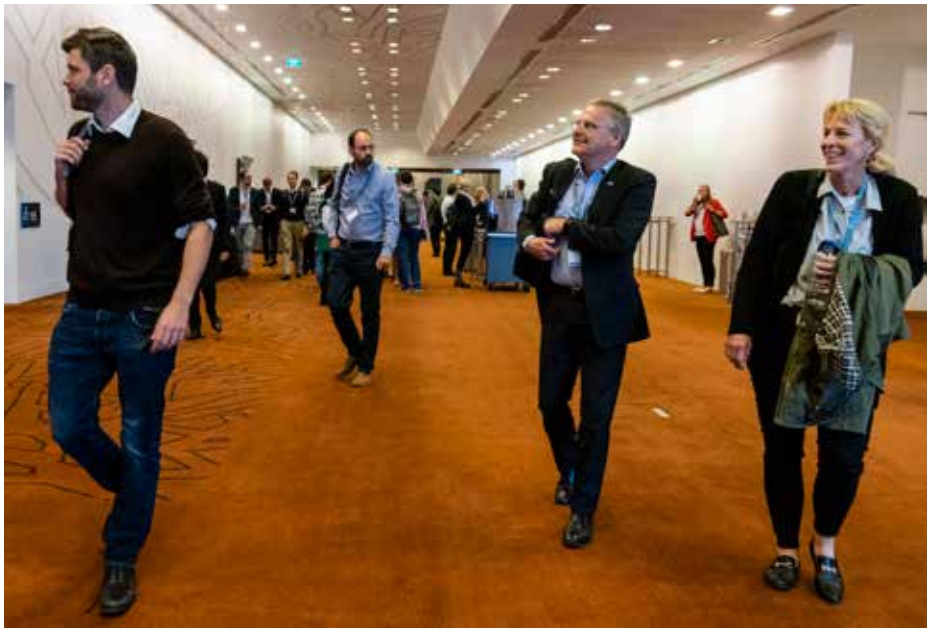
The host nation, Australia, is at the forefront of CCS research, development, supportive scientific investigation and is now gearing-up for full-scale demonstration through the CarbonNet project. This very broad spectrum of influential work on all aspects of CCS was well represented throughout the conference plenary, panel and technical sessions. Australia is a resource-rich country especially in fossil-fuels and metals, but the nation is turning its attention, and skills, on how to reduce and minimise carbon emissions from the extraction and use of these resources. Excellent examples of this national initiative include Gorgon, the world's largest CCS project, as well as the Gippsland Basin in Victoria, the Surat Basin in Queensland and the SW Hub project in Western Australia. The challenge faced by the modern industrialised economies, and particularly the rapidly growing economies of the developing regions of Asia, Africa and the Americas, is how to balance the energy and resource demands to meet the aspirations of the global economy whilst avoiding deleterious environmental impacts.

The GHGT-14 conference opened soon after the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C was published. Its significance was highlighted by several speakers, notably in a Keynote by Thelma Krug who is Vice Chair of the IPCC. The key conclusions from this latest IPCC report have highlighted the scale of carbon emission reduction that needs to be achieved by mid-century to avoid potentially catastrophic climate change and CCS's key role in that goal. Growing evidence, in the form of heat waves across the northern hemisphere in 2018, and an increase in the magnitude, number and frequency of other extreme weather events such as hurricanes, is indicative of anthropogenic climatic alteration.

Thelma Krug, Vice Chair of the IPCC

IEA projections based on technology assessments of carbon emission options show that CCS, in combination with other low carbon technologies, has a key role in meeting the below 2°C target (B2D). Despite the growth and success of renewables for electricity generation, most primary energy is still derived from fossil fuels especially for transport, heat and many industrial processes. CCS in particular can address carbon emissions from industry particularly process emission from iron, steel and cement. The prospect of developing a hydrogen based economy, linked to CO_2 storage, also offers a very real, and practical, alternative to the conventional use of fossil fuels. This was a major theme of the GHGT-14 conference which highlight the genuine investment of leading industrial companies in the CCS – H_2 supply chain.

Representatives from many leading industrial entities including Shell, Total, BHP, Glencore, Kawasaki Heavy Industries and Equinor summarised the significant progress and achievements of large-scale CCS demonstration projects that they are actively engaged in. A great example was the work by the International CCS Knowledge Centre in transferring the learnings from Boundary Dam to a feasibility study to retrofit the Shand power station, with very significant cost reductions as well as no increase in water consumption. The conference also included a series of sessions on different aspects of post-combustion carbon capture especially solvent use as well as chemical looping, membrane technology and oxy-combustion. Geological storage covered site characterisation, trapping mechanisms, wellbore integrity, all aspects of monitoring, and modelling from pore-scale to field-scale. The conference also included CO_2 capture in the cement and iron and steel sectors as well as different forms of utilisation which included calcification and re-use of concrete. Other novel forms of carbon sequestration such as direct air capture and mineralization were covered.



Following the 71 Technical Sessions containing 355 Oral presentations and the 460+ Poster Presetations, the conference concluded with a panel discussion on a 'New Narrative' for CCS, which was interesting and thought provoking. We need CCS ambassadors!

Following the conference some delegates were treated to a visit to the CO2CRC Otway research site close to the spectacular Victorian coast scenery featuring the 12 Apostles. Otway is a depleted natural gas field that is used to separate and reinject CO_2 into a reservoir at 1,500m where in is monitored and track by a suite of sophisticated seismic techniques.

The papers from the conference will be available on SSRN and some in the International Journal of Greenhouse Gas Control.

Many thanks to the Technical Programme Committee for selecting and organising the technical content of the conference.

Over one thousand delegates attended, and the feedback was strongly positive on the overall conference and on the technical advances, learnings and messages they took away. Despite the considerable challenges that lie ahead in ensuring deployment at the scale required, the conference ended on an optimistic note.

3rd International Workshop on Offshore CCS

The 3rd International Workshop on Offshore CCS took place on 3rd - 4th May, organised by the Bureau of Economic Geology (BEG) in collaboration with IEAGHG and others, and hosted by the Research Council of Norway in Oslo, with support from SANEDI and CSLF.

The aim of the workshop series is to facilitate sharing of knowledge and experiences among those who are doing offshore storage and those who are interested and to facilitate international collaboration on projects. Over 60 attendees from 8 countries participated in this 3rd workshop.

The agenda included: How to learn from learnings?; Value Chains for Offshore; Infrastructure re-use; Monitoring offshore CO_2 storage/EOR; Offshore CO_2 storage resource assessment; Project updates; Standards and Regulatory Frameworks; and Brainstorming towards an international collaborative project.

Notable points arising from the presentations and discussions were the first 4D seismic images of the CO_2 plume at Tomakomai, the potential funding opportunities for developing countries from the Green Climate Fund and other sources, value chain opportunities being created by the new 45Q extension in the USA and by hydrogen in EU, Japan and Australia, and a new appreciation by many of the issues to be considered in the re-use of infrastructure. Key conclusions and recommendations were agreed.

Many thanks to the Research Council of Norway for hosting and to them and Equinor and the Ministry of Petroleum and Energy for sponsoring.

IEAGHG has published the report of the workshop as IEAGHG 2018/TR02.

IEAGHG Modelling and Risk Management Network Meeting

IEAGHG, together with hosts the Energy and Environmental Research Center (EERC), held a combined Modelling and Risk Management Network meeting, in Grand Forks, North Dakota, 18th - 22nd June 2018.

EERC is part of the University of North Dakota, and is an active participant in CCS research, notably the lead organisation of the PCOR Regional Carbon Sequestration Partnership. The meeting attracted over 70 delegates from six countries including Australia, Canada, France, Japan, the Netherlands, Norway, the UK as well as the USA.

This event covered a wide variety of topics including modelling at reservoir and formation scale and upscaling from core to reservoir. Modelling pressure management in the near wellbore environment was also covered. The introduction of new topics is a feature of network meetings and during this meeting modelling risks associated with untraditional reservoirs fell into this category. These formations include CO_2 enhanced oil recovery (CO_2-EOR) and CO_2 storage in Residual Oil Zones. EERC have a special interest in the low permeability oil producing Bakken Formation that extends across the west of North Dakota. The research organisation has begun pilot tests to explore the potential for CO_2 storage in this organic rich formation. Other new themes included Bayesian modelling and associated risk assessment, approaches to early stage project development, induced seismicity plus active pressure management at basin scale.

EERC has been an important contributor to IEAGHG's portfolio of research reports particularly in CO_2 storage capacity estimates in formations that extend across entire basins.

A highlight of this Network meeting was the inclusion of a keynote address from Lynn Helms, who is the head of North Dakota's Industrial Commission. Lynn's contribution was exceptional because the state's Industrial Commission now has Primacy for all six classes of wellbore disposal and is the only state in the Union to have this delegated authority. A unique feature of land ownership in the USA is the ownership of the mineral rights and the pore space beneath properties. This facet of land ownership has important implications for the development of subsurface CO_2 storage that Lynn was able to convey. The Industrial Commission needs to be aware of the distribution of any plume created by injected CO_2 and its Area of Review. In North Dakota a minimum of 60% of all pore space owners within the plume area must agree to any proposed injection site. The other 40% have to concede that their pore space is relinquished but they must also receive compensation. Significantly, CO_2 subsurface storage is classified as a public interest initiative and, as such, the pore space is treated as a resource not as a waste disposal option. At the cessation of injection the site operator must be able to prove beyond reasonable doubt that CO_2 is stable and not leaking. A financial resource to cover the cost of post-closure monitoring or remediation will be raised from a trust fund on each tonne of CO_2 stored. Lynn's address was positively received by all the delegates particularly as network meetings do not often include a regulator of this statute who is directly responsible for CO_2 storage.

The network hosts concluded the meeting by organising a field trip to a brine extraction and pressure management test site (BEST) near Watford City, North Dakota. Brine extraction can be used to control pressure but the fluid has to be treated or re-injected into other formations. At this site the extracted brine will be used as one of several water supply sources for treatment. The intention of this project is to be able to produce water qualities that will be representative of water produced at other CO_2 storage sites. In the future other disposal options or treatment including desalination may be possible with the aim of reducing the volume of produced brine. The BEST project partners for this site are the US Department of Energy, NETL, EERC, Nuverra Environmental Services, CMG and Schlumberger Carbon Services.

12th IEAGHG Summer School

In June 2018, we were very pleased to have our 12th International CCS Summer School hosted by the Norwegian CCS Research Centre in Trondheim, with 58 students from 24 countries.

NORWEGIAN CCS RESEARCH CENTRE
Industry-driven innovation for fast-track CCS deployment

The week covered all aspects of CCS presented by leading international experts, this year the students also had group exercises in communication and designing monitoring plans, as well as an interactive careers session, and the usual group project work. Particularly because of the hosts and venue, the students were given very up-to-date information on the development of the new Norwegian storage site and the industrial sources of CO_2, representing state-of-the-art work-in-progress by a leading CCS country. Overall the week consisted of 4 days of lectures and a fieldtrip on the Wednesday to the CO_2 Laboratory at Tiller and a tour of SINTEF's lab facilities at NTNU.

A sincere thank you to the sponsors NCCSRC, UK BEIS, SFOE, CLIMIT, Shell, Total and RCN. Thank you also to the experts and mentors who came to give their time and share their knowledge. And the biggest thank you to all the students who were excellent, enthusiastic, full of energy, and asked great questions of the experts and mentors. The Best Group Award went to Group 3 who tackled "Is CCS Viable for Developing Countries?" The Best Poster Awards went to Charlotte Mitchell (University of Edinburgh) and to Tjerk Lap (University of Groningen). An even harder task was to decide on the awards for the two Most Outstanding Students and this year, these were awarded to Corey Myers (Waseda University) and Pooya Hoseinpoori (Imperial College). Congratulations to all! And finally a big thank you to our hosts the NCCSRC and SINTEF for such an excellent week!

The 2018 Summer School took our alumni to nearly 600 representing 60 countries in total over the twelve years. We also enjoyed seeing many of this year's students at the GHGT-14 Student Reception which hosted over 150 students attending the conference, nearly 30 of which were Summer School alumni.

The 2019 Summer School will take place in Regina, Canada to be hosted by the International CCS Knowledge Centre. It will be taking place in July and we look forward to another exciting week with CCS students from around the world!

More information about the IEAGHG Summer School can be found by visiting the IEAGHG website www.ieaghg.org

Students during a presentation at the Summer School. Photo courtesy of Hana Mandová (PhD researcher at the University of Leeds, part of the Bioenergy Centre for Doctoral Training

Students during a presentation at the Summer School. Photo courtesy of SINTEF

2018-01 Enabling the deployment of industrial CCS clusters,

report managed by Jasmin Kemper

It is widely considered that deployment of CCS for clusters of energy intensive industries (EIIs) will become vital for meeting long-term greenhouse gas (GHG) reduction targets, and is a cost effective way for doing so, according to organisations such as the International Energy Agency (IEA) and Intergovernmental Panel on Climate Change (IPCC).

In addition, it will be important to develop the related finance mechanism quickly to prevent carbon leakage, i.e. businesses transferring operations to places with less stringent GHG emission standards. Recent evidence highlights there might be different needs and challenges in deployment of industrial clusters, compared to those involving power generation. IEAGHG's Technical Report 2015-03 "Carbon capture and storage cluster projects: review and future opportunities" reviews 12 CCS cluster projects and finds that the most successful clusters are currently based on CO_2-EOR in North America. This is to be expected as EOR provides a commercial benefit to investors in such activities.

Further requirements for ICCS clusters include: generating confidence for per-investment in CCS infrastructure, new methods to attract international investment and systematic development of CCS cluster business plans. However, more information is necessary regarding the transferability of conclusions for CCS clusters based on power generation incentives, such as a UK Contract for Difference (CfD), to those involving multiple industry sectors, and especially EIIs.

This study examines the economic and commercial arrangements needed to enable the global deployment of industrial CCS clusters. Over a period of eight months, with significant input from stakeholders from industry, government and the investment community, the project has identified the key enablers to unlock private investment in industrial carbon capture and storage (ICCS) and developed four business models, which are expected to work in various regions around the world including North America, Europe, Australia and China. The contractors for this work were Element Energy.

Key Messages

- The aim of this study is to assess economic and business related issues with ICCS clusters.
- The results of this study will be of interest to ICCS project developers and governments looking to support ICCS cluster development.
- ICCS is not yet commercially mature. Private investment is likely to occur if the following four key enablers are addressed:
  - » Mitigate the risk of carbon leakage
  - » Provide the emitters with margin certainty through appropriate subsidies
  - » Decouple the business cases for capture and infrastructure
  - » Share the key risks with government through guarantees
- The necessary level of government support is high. However, without ICCS, governments might need to rely on more expensive solutions to meet decarbonisation targets.
- ICCS plays an important role in supporting local industrial jobs and industrial markets.
- The study investigated four different ICCS cluster business models:
  - Public transport and storage (T&S) company
  - T&S as regulated assets (i.e. regulated fees for T&S access)
  - Anchor CCS project with third party access
  - CO_2 enhanced oil recovery (CO_2-EOR)
- The quantitative assessment shows that guarantees on loans, storage and CO_2 volumes are the key prerequisites for achieving investment.
- The expected costs for governments for an illustrative CCS cluster in Europe are between £29-53 per tonne of CO_2 abated. However, upward movements or regulation of the CO_2 price and provision of grants can significantly reduce these costs.

- At least one of the business cluster models is relevant in each of the focus areas (North America, Europe, China and Australia).
- Recommendations for further work include a cost-benefit analysis for ICCS considering its wider benefits, a comparison of decarbonisation options across all sectors, the development of regional ICCS strategies and refinement of ICCS business models, and a further investigation of some of the key risk mitigation strategies.

2018-02 CO_2 Storage Efficiency in Deep Saline Formations – Stage 2,

report managed by James Craig

A key determinant for CO_2 storage in deep saline formations (DSFs) is dynamic efficiency (E factor) – that is the effect that increased pressure caused by fluid injection has on the storage capacity of a formation.

The storage capacity will always be limited by the pressure limit imposed by the geomechanical strength of the caprock, which is defined as the fracture pressure. If a formation is bounded by faults or other low permeability barriers, then excess pressure could limit the dynamic efficiency, a condition referred to as a closed boundary. In contrast formations that extend over several 100 square kilometres without significant barriers can enable pressure to be dissipated, a condition known as an open boundary.

In a previous study commissioned by IEAGHG the effects of dynamic efficiency were compared between two contrasting onshore basins (one open and the other closed), but over a long hypothetical time-scale of 2,000 years. Although the previous study showed the effects of boundary conditions, the dynamic efficiency was based on very large areas extending of several thousands of square kilometres. The results did not reflect the more likely conditions of much shorter timescales and injection over limited areas that would be experienced in early CO_2 storage sites. The aim of this second study is to improve the estimated dynamic storage of DSFs based on a modelled 50 year injection period and over comparatively limited areas of ~1,000 km^2. Two well researched formations were selected: one from an onshore basin (the Minnelusa Formation in the USA) and the other form an offshore basin (the Bunter Formation in the North Sea). This study also includes a cost development model to determine how the number of wells affects the cost-effectiveness of each storage site.

Key Messages

- The impact of water extraction on the Minnelusa over a 50 year period raised the storage efficiency from 4.7% to 5.9%. This is equivalent to an estimated increase in storage capacity from 242 Mt to 302 Mt of CO_2. Extending injectivity for a further 50 years would increase storage capacity to over 400 Mt of CO_2.
- The impact of water extraction on the Bunter was profound raising storage efficiency from 4.7% to 7.4%. This is equivalent to raising the estimated storage capacity from 1,770 Mt to 2,806 Mt of CO_2. The difference between these two formations in terms of storage capacity can be attributed to the highly favourable permeability across the Bunter compared with the Minnelusa.
- As the number of injection wells increases in a designated storage system, more of the wells become influenced by pressure interference from their neighbours and the injectivity rate per well declines.
- The closer a DSF approaches full development, the more its efficiency approaches that of a closed system, even if it has open boundaries.
- The differences between open and closed boundaries clearly signifies the importance of defining or conducting a careful preliminary assessment of boundary conditions.
- Well configuration and structural settings can have a significant influence on storage efficiency.
- The annual injection rate profile is a critical parameter in the design of an optimised injection plan for a multiwell project. The rate of injection will gradually decline with time.

- In both cases 20% of all the wells in the cost model were able to deliver more than 60% of the total CO_2 injected. In both modelled formations the number of wells was the primary variable in determining the cost factor. Delivering the amount of injected CO_2 by increasing the number of wells becomes proportionately less cost-effective.
- The E factor only applies to the modelled areas, as in these cases, and cannot be extended to the full aquifer unless the model boundaries are coincident with the periphery of the formation.
- There are variations in modelled predictions based on the model grid cell size for the same level of salinity which is a significant parameter that controls CO_2 solubility.
- Heterogeneity and different model projections can substantially influence the quantity of injected CO_2. It is important to understand and separate the effects of the choices of simulation parameters from the physical effects in a storage formation.
- It is recommended that key parameters used for initial dynamic storage estimates are clearly stated and should include: domain dimensions, formation boundaries, caprock threshold limits and the duration of injection.

2018-03 5th CCS Cost Network 2017 Workshop,
report managed by Keith Burnard

The fifth meeting of the CCS Cost Workshop was held on September 13th - 14th, 2017 at Imperial College London (South Kensington Campus) under the auspices of the IEA Greenhouse Gas R&D Programme.

The meeting was organised by a Steering Committee chaired by Howard Herzog (Massachusetts Institute of Technology), along with representatives from: Carnegie Mellon University (Ed Rubin), Electric Power Research Institute (George Booras), IEA Greenhouse Gas R&D Programme (Keith Burnard), Lawrence Livermore National Laboratory (Sean McCoy), USDOE National Energy Technology Laboratory (Jeff Hoffmann), NaturalGas Fenosa (John Chamberlain), Shell Global (Wilfried Maas) and the University of Sheffield (Jon Gibbins). In addition, the participation of the UK CCS Research Centre and Imperial College London were critical to the planning and success of this meeting.

The purpose of the CCS Cost Workshops is to share and discuss the most currently available information on the cost of carbon capture and storage (CCS) in electric utility and industrial process applications, as well as the outlook for future CCS costs and deployment.

The workshop also seeks to identify other key issues or topics related to CCS costs that merit further discussion and study.

As in past workshops, Day 1 was devoted to a plenary session addressing four general topics. Each session included two invited presentations, followed by a discussion among workshop participants. The second day began with a fifth plenary session topic, followed by three parallel breakout sessions pursuing selected topics in more detail. Reports of the breakout groups were presented in a concluding a plenary session, followed by general discussion and planning for future events.

This report presents brief summaries of the five plenary session topics, together with the full set of presentations by invited speakers. The proceedings of this and all previous CCS Cost Workshop are available at: **www.ieaghg.org/networks/costsnetwork/125-networks/costs-networkmembers-area/423-costs-network-membersarea.**

2018-04 Effects of Plant Location on the Costs of CO_2 Capture,
report managed by Keith Burnard

The cost of CO_2 capture is often cited as a single value or as a range, regardless of design, ambient conditions or location. For many, greater granularity on the regional differences in costs would be of value. Incomplete information can lead to flawed analysis and result in poorer decision making.

With a hypothetical site in the Netherlands as the reference location, IEAGHG has published several studies that address the application of CCS to coal and natural gas-fired power plants. However, while Europe is one region where large-scale power plants with CCS must be deployed, there is even greater potential for CCS in regions, for example, where coal consumption is high and increasing or where emission reduction targets would require CCS to also be considered for gas-fired power stations. While, very often, the cost of CO_2 capture is cited as a single value or as a range, the performance and costs of plants with CO_2 capture will be different at different locations – and there is currently a shortage of information calculated on a consistent basis, particularly for emerging economies. Considering this, a study was commissioned to investigate how the cost of CO_2 capture varied for different locations.

The performance and costs of the power plants were assessed across a number of locations. Nineteen case studies covering 11 countries were undertaken on coal-fired plant and 17 case studies covering 12 countries on gas-fired plant. Variations in the performance and costs of these plants were quantified according to local and site specific conditions. The impact on plant performance and costs by physical criteria, such as ambient conditions, fuel analysis, water availability and emission limits, were explored, as were the effects on costs of economic criteria, such as labour costs and productivity, construction materials and equipment costs, and fuel prices. The study focused on supercritical pulverised coal and natural gas combined-cycle power plants, with and without CO_2 capture. Post-combustion capture based on solvent scrubbing was the only capture technology considered in the study. The reference plant configuration was based on current, commercially-available, state-of-art technologies.

The study provides a comprehensive assessment of the performance and costs of supercritical pulverised coal and natural gas combined-cycle power plants, with and without CO_2 capture, in geographical regions that exhibit a wide variety of local conditions. It is an excellent reference document, with insights of value to decision makers, project developers and the broader CCS community. In particular, the results of the study will provide a valued source of input data for the integrated assessment model community, whose outputs often serve to inform energy policy decisions and the direction of energy funding.

2018-05 The CCS Project at Air Products' Port Arthur Hydrogen Production Facility,
report managed by Tim Dixon

In April 2013, the first commercial-scale, steam methane reformer hydrogen production facility incorporating vacuum-swing adsorption carbon capture gas separation technology began full-scale operation at Air Products' facilities located on the site of the Valero Port Arthur Refinery in Texas, USA. This report summarizes the experience of Air Products and its partners that will provide valuable insights to other petroleum refining and petrochemical industrial facilities that wish to reduce their lifecycle greenhouse gas emissions through CCUS.

This project was a remarkable achievement. To date, carbon capture industrial facilities that have been constructed elsewhere have primarily utilized amine absorption carbon capture technology. This facility stands alone as a leading example of a pioneering alternative technology that was developed at record speed to enable carbon capture from steam methane reformers.

This report details the project undertaken by Air Products and Chemicals Inc. (Air Products), in partnership with Valero Energy and Denbury Onshore, LLC, as part of the US Department of Energy's Industrial Carbon

Capture and Storage (ICCS) Program, to capture carbon dioxide from Air Products' hydrogen plants located at the Valero Port Arthur Refinery and transport it via pipeline to the Denbury CO_2-EOR operation at West Hastings, Texas, just south of Houston. Air Products entered into a long-term carbon dioxide supply arrangement with Denbury prior to beginning construction of the carbon capture retrofitting project. The CO_2 capture project was co-funded by Air Products and the US Department of Energy (DOE) under the American Recovery and Reinvestment Act of 2009 (ARRA), an economic stimulus program enacted by the US Congress under the US President Obama Administration. The project funding was managed by the National Energy Technology Laboratory (NETL) on behalf of DOE.

2018-06 Re-Use of Oil & Gas Facilities for CO_2 Transport And Storage,
report managed by James Craig & Lydia Rycroft

One perceived advantage for the use O&G fields for first generation CO_2 storage is the potential reduction in costs for CO_2 transport and storage by re-using existing O&G facilities, especially offshore. This report aims to review the potential re-use of the related infrastructure and assess the suitability of certain infrastructure for re-use.

The decommissioning of large-scale O&G infrastructure associated with depleted fields in some regions of the world is approaching and is already occurring in the North Sea. This means it is important to understand the potential for re-using existing infrastructure for CO_2 storage, prior to scheduled decommissioning in the near future. Not only might this option be cost-effective for early deployment of intermediate scale CO_2 storage (enabling long term infrastructure of CCS in the future), the re-use of existing O&G infrastructure could also potentially defer decommissioning costs.

This report includes 5 case studies in the North and Irish Seas (Camelot, Atlantic & Cromarty, Hamilton, Goldeneye and Beatrice) and a re-usability index was developed to indicate the potential each element of restructure had for re-use.

The study concluded that the key attributes determining whether any item of infrastructure could be re-used are integrity and life extension options. In general, all elements of infrastructure have the potential to be re-used for CO_2 operations. However, all specific cases need to be evaluated on a project by project basis. Additional generic studies about the potential for re-use are unlikely to add significant new knowledge to the sector.

Key Messages

- An infrastructure reusability index has been developed for the purpose of this study and applied to 5 case studies in the North and Irish Seas (Camelot, Atlantic & Cromarty, Hamilton, Goldeneye and Beatrice).
- It is not feasible to define a generic functional specification for re-use of a depleted oil or gas field because its suitability depends on the specific requirements of the project such as longevity, CO_2 injection rate, CO_2 phase and capacity.
- The production strategy used on oil or gas reservoirs influences their suitability for storing CO_2.
- Elements of O&G infrastructure have potential to be re-used for CO_2 but must be evaluated on a case by case basis.
- Suitability for re-use depends primarily on the characteristics of the intended CO_2 supply to the store.
- Integrity and life extension options are key attributes of suitability for re-use.
- O&G derived practices, processes and tests exist to assess suitability of existing infrastructure for re-use.
- From an infrastructure perspective, the primary functional specification is one of sufficiency. The equipment must have a pressure rating and material specification sufficient for the proposed project, the remaining longevity must be sufficient, and, if a platform is required, the installation must have sufficient space, power and weight bearing capability.
- Recommendations for further work include examining options for extending the life of infrastructure assets and considering regulatory processes in other regions.

2018-07 IEAGHG Modelling and Risk Management Combined Network,
report managed by James Craig, Lydia Rycroft & Tim Dixon

IEAGHG's combined Modelling and Risk Management Network, hosted by the EERC, took place in Grand Forks, North Dakota between 18th and 22nd June 2018. These meetings bring together leading experts from research and industry to discuss the latest work and developments, with over 30 speakers and 71 attendees representing 8 countries.



The theme for the meeting was 'How advances in modelling and risk management improve pressure management, capacity estimation, leakage detection and the prediction of induced seismicity'. Sessions included project updates, the application of oil and gas production experience, modelling capacity, unconventional reservoir risk assessments and active pressure management. The third day focused on conformance and regulation with a keynote presentation by Lynn Helms from the North Dakota Industrial Commission on Class VI well regulations.

Key findings from the meeting included further refinement for a global capacity estimation methodology needs to be agreed. SPE SRMS provides a solid foundation although further refinement is necessary. Geological heterogeneity still remains very difficult to simulate. The development of models based on a diversity of analogues would improve model predictability. Capillary pressure simulations can help to explain the pattern of CO_2 plume migration better than porosity/permeability simulations alone. Fluid events can now be simulated at pore-scale.

There are numerous IAMs, many of them with CCS represented in them to various levels of detail. For user confidence, it is important to gain an understanding of the assumptions, data and calculations that underpin the models.

2018-08 Well Engineering and Injection Regularity in CO_2 Storage Wells,
report managed by Lydia Rycroft & James Craig

This report aims to highlight the key differences, and well engineering implications, for handling CO_2 in EOR and deep saline storage locations. These options are compared with conventional oil and gas wells and the best practice for CO_2 operations and the current understanding on handling CO_2 are also covered in detail.


This report focuses on collecting industry experience on the drilling, completion, regularity and interventions of CO_2 wells. The aim for the report was to compare methodologies and techniques used for handling CO_2 compared with those required for hydrocarbon extraction. This has allowed for a comparison to be made to the research already conducted on CO_2 well integrity and monitoring techniques. The study will investigate whether conditions experienced during CO_2 handling operations were predicted from modelling and experimental work and the effectiveness of linked risk assessments.

The differences between hydrocarbon and CO_2 operations are driven by acidification of drilling muds, the high expansion factor of CO_2 (going from liquid to gas phase), the effect of CO_2 on elastomeric seals and finally the cooling behaviour of CO_2 (which under uncontrolled depressurisation could chill equipment to temperatures below minus 70°C). Furthermore there is the potential to form CO_2 hydrates if water is present. Also, temperature and pressure cycling due to phase-wise injection (e.g. if CO_2 is delivered by boat) can strain the well equipment. Other wellbore integrity issues were also identified during a recent IEAGHG Modelling and Monitoring network meeting in July 2016. These included: timing and frequency of integrity log requirements; an improved understanding of cement pathways and a different (non-Darcy) approach to modelling flow in open wellbores. The choice of completion fluids could also be impacted by the presence of CO_2 in the injection tubing and the potential of acidification of annular fluids should a tubing leak occur.

Key Messages

- The ability to inject CO_2 regularly needs to be addressed in the planning stages of storage projects to assess future well performance. For wells exposed to formations containing supercritical CO_2 it is important to identify the procedures and equipment that have to be tailored for the specific characteristics of CO_2 (as opposed to hydrocarbon gas, oil or water).
- Industry experience with CO_2-EOR wells (both for CO_2 continuous injection as well as for CO_2-WAG) shows that new CO_2 injection wells can be suitably designed to allow well integrity to be maintained in the long-term. Concerns from cement degradation and corrosion can be suitably addressed in the design and construction of these wells. Industry experience also indicates that CO_2 storage injection wells can also maintain wellbore integrity if designed, constructed, operated and monitored as per current state-of-the-art design specifications and regulatory requirements.
- Risks from legacy wellbores can also be adequately addressed as long as sound engineering practices and compliance with current and more stringent regulatory requirements are complied with.
- The handling and managing CO_2 wellbore operations safely is well established from CO_2-EOR projects. Initial industry concerns about CO_2 injection, especially during the water-alternating-gas (WAG) process in terms of controlling the higher mobility gas; water-blocking, corrosion, production concerns, oil recovery, and loss of injectivity have been addressed with careful planning and design along with good management practices.
- Although there are a number of common areas between CO_2-EOR and CO_2 storage wells, the differences can be grouped under five broad categories: (1) operational, (2) objectives and economics, including CO_2 supply, demand and purity, (3) legal and regularity, (4) long-term monitoring requirements, and (5) industry's experience. There are no specific technological barriers or challenges per se in converting or adapting a pure CO_2-EOR operation into a concurrent or exclusive CO_2 storage operation.
- The costs associated with CO_2-EOR and CO_2 storage projects are site and situation-specific. In general, oil prices have by far the larger impact on the economic viability of a CO_2-EOR project, with the second largest impact being the cost of CO_2.

2018-TR01 GHG Accounting for CCU Technologies - Characterising CCU Technologies, Policy Support, Regulation and Emissions Accounting report managed by Jasmin Kemper

Over recent years, interest in CO_2 capture and utilisation (CCU) from policy-makers, industry and academics has increased dramatically, although uncertainty remains regarding the technology's true potential to contribute towards wider greenhouse gas (GHG) emissions reduction goals.

A range of views have been expressed in these contexts, but on the whole it remains largely speculative and unproven. Consequently, it is difficult to provide firm opinions on whether CCU technologies can make a meaningful and lasting contribution to tackling climate change. This report provides an assessment of the range of views presented by various stakeholders, and attempts to establish an empirical evidence base upon which to qualify the views and opinions expressed.

Additionally, the key way to gain a clearer understanding of the potential for CCU technologies to reduce GHG emissions is to assess the overall energy and carbon balances for different CCU processes, and to take a view on how and whether these could make a contribution to GHG emission reductions. In other words, as noted by the Intergovernmental Panel on Climate Change (IPCC) in its 2005 Special Report on Carbon Dioxide Capture and Storage (SRCCS) 'further study of the net energy and CO_2 balance of industrial processes that use the captured CO_2 could help to establish a more complete picture of the potential of this option'. Such detailed studies have, at best, only partially been carried out and are heavily reliant on the assumptions made in the analysis. Thus, IEAGHG has commissioned Carbon Counts (UK) Ltd to characterise CCU technologies, as well as their policy support, regulation and emissions accounting.

Key Messages

- CCU activities with potential GHG benefits are currently limited in scale. Excluding those commercial activities such as CO_2-EOR which make use of CO_2 for enhanced commodity production only, CCU projects are currently extremely small-scale (e.g. utilising hundreds or thousands of tCO_2 per year) in comparison with other GHG mitigation technologies.
- Potential GHG benefits are proven but are highly dependent on circumstances. The case studies that claim net GHG reduction benefits have been able to clearly demonstrate the capacity to deliver real emission reductions. However, notwithstanding forthcoming LCA analysis of up-stream and downstream issues, it is clear that these are highly predicated on certain conditions. For example, the highly electro-intensive production process for certain technologies means that GHG benefits are contingent on the availability of a reliable low-carbon electricity source at a suitable price. The scale-up potential of CCU may be constrained by such niche conditions and limit the ease of replicability for some technology applications.
- Monitoring, reporting and verification (MRV) of facility-level energy and carbon flows is well established. Current procedures and systems for the MRV of energy, material and carbon flows at all facilities are advanced and adequate to meet requirements under most regulatory support schemes. Operators are undertaking high quality MRV across their sites as part of R&D and/or commercial activities and have an extremely high level of data handling and analysis. In respect of site-level energy and carbon flows, MRV requirements for most GHG reduction schemes (both economic and non-economic instruments) would pose few, if any, technical challenges to operators.
- GHG reduction policy is not yet a major driver for CCU activities. Notwithstanding the potential for the scale-up of CCU technology to deliver real and significant GHG benefits, emission reduction incentives are not significantly driving CCU activities. CCU-derived fuels production remains at demonstration stage subject to increased incentives and/or proven economics, whilst for mineralisation and CO_2-EOR, the commercial drivers for the activities are not at all related to climate policy; CO_2 supply is effectively an operational cost.

2018-TR02 3rd International Workshop on Offshore Geologic CO_2 Storage,
report managed by Tim Dixon

This workshop took place on 3-4 May 2018, organised by the Bureau of Economic Geology (BEG) in collaboration with IEAGHG and others, and hosted by the Research Council of Norway in Oslo, with support from SANEDI and CSLF.

The aim of the workshop series is to facilitate sharing of knowledge and experiences among those who are doing offshore storage and those who are interested, and to facilitate international collaboration on projects. Over 60 attendees from 8 countries participated in this 3rd workshop.

The agenda included: How to learn from learnings?; Value Chains for Offshore; Infrastructure re-use; Monitoring offshore CO_2 storage/EOR; Offshore CO_2 storage resource assessment; Project updates; Standards and Regulatory Frameworks; and Brainstorming towards an international collaborative project.

Many thanks to the Research Council of Norway for hosting and to them and Statoil and the Ministry of Petroleum and Energy for sponsoring.

The presentations are available at **http://www.beg.utexas.edu/gccc/research/goi** .

2018-TR03 Cost of CO_2 Capture in the Industrial Sector Cement and Iron and Steel Industries, report managed by Mónica García

Several studies on the technical and economic feasibility of carbon capture technologies in the cement and iron and steel sectors have been published. However, most of those do not contain detailed information on the cost methodology and/or the data and assumptions underlying the analysis.

Transparent communication of cost of CO_2 capture systems in the industrial sector is essential for organizations involved in policies, investments, research, development and manufacturing. In this regard, IEA and IEAGHG have joint efforts in a common technical document to review the cost of CCS in the cement and iron and steel industries. The work was divided in three phases: 1) screening of high-quality information; 2) implementation of a cost-review method; and 3) techno-economical assessment of the selected cases.

Firstly, the literature review showed a wide range of assumptions in the design of CO_2 capture systems, their heat integration with the manufacturing plant, and the energy or steam sources. Additionally, economic parameters were different between studies, what had a significant impact on the results. Consequently, there was a wide range of costs per technology, what gave a more positive or negative view on the implementation of carbon capture systems.

Secondly, after homogenization of economic data through our cost-review method, the range of costs was reduced. It was observed that detailed cost estimations tend to present higher costs, whereas the opposite is seen with less detailed studies. Moreover, level of details is often linked to the technology readiness level (TRL).

Thirdly, results can be summarised as follows:

- In the cement sector, calcium looping and indirect calcination configurations are promising. However, those are highly dependent on a maximum heat integration and sale of energy surplus to the electricity grid. Membranes and oxyfuel systems show a lower CO_2 avoidance cost than chemical absorption with traditional solvents. Nevertheless, chemical absorption is at a more advanced development stage and has a high cost reduction potential by the use of advanced solvents. Hybrid systems are expensive, although the information on those technologies is limited and more experience is needed.
- In the iron and steel industry, VPSA is promising for the steelmaking processes considered (blast furnace, TGRBF, HIsmelt and COREX). In this sector, chemical absorption is not much more expensive than other carbon capture options as in the case of the cement sector. Again, advanced solvents would be key to reduce costs, and large projects are still needed.

It is difficult to determine the "best" technology for each sector, mainly due to the overlap of CO_2 avoidance cost ranges and lack of large-scale experience to identify operational issues and the optimum integration with the manufacturing process. This technical review is part of the IEAGHG concern on CCS in the industrial sector, where we have covered several industries and technical aspects through our previous reports. We will continue monitoring this sector and the forthcoming developments on CCS systems.

2018-TR04 Flaring Emissions and Quantification,
report managed by Lydia Rycroft

This review aims to assess the current understanding on reducing emissions from flaring in the oil and gas industry and to review literature on both the quantification of emissions and current mitigation strategies. IEAGHG published a technical review 2017-TR07 (October 2017) which studied emissions along the natural gas supply chain but flaring emissions were not included. This review aims to follow on from 2017-TR07 as a supplementary review on flaring emissions.

The flaring mitigation strategies currently in place are reviewed in this report including those by individual countries, company strategies and global schemes such as 'Zero Routine Flaring by 2030'. This review summarises the current standing of quantification methods and concludes further research is needed on direct measurement from flaring stacks to support global satellite estimates. Annual data is being collected by World Bank and the GGFR which is greatly improving the global database on flaring emissions. Current mitigation plans are ambitious and progress is being made with GGFR data showing flaring has been in moderate decline from 2015-2017. Approximately 54% of global gas flaring is represented within the 71 governments that have to date signed up to the "Zero Routine Flaring by 2030" initiative.

Key Messages

- Even though oil production is still increasing annual global flaring emissions have been seen to reduce by approximately 20 billion m^3 from 2004-2017.
- The 'Zero Flaring by 2030' initiative has led to large emitters publically pledging the significantly reduce their emissions in the near future although some large companies and governments are yet to join.
- Global estimates of greenhouse gas emissions associated with flaring have significantly improved since 2013 due to the work of NOAA and the GGFR and new satellites more accurate satellites being utilised.
- Some improvements are still required but as direct measurements improve this in turn will allow for better calibration of current satellite data. Local direct quantification is driven by the host country's policies and legislation. This still varies largely from country to country but for those already regulating many standards are available on how to accurately measure the flow rate from flaring stacks.
- Calculating the emissions along the natural gas supply chain and incorporating flaring is challenging as flaring emissions are very site specific. When flaring is undertaken it is likely to produce a majority of the emissions across the supply chain and hence its mitigation is important in reaching long-term climate goals.
- The 'Zero Routine Flaring by 2030' will be publishing annual summaries of emissions by each of its endorsers which alongside the GGFR global satellite data will provide an ongoing global database of flaring emissions. The progress of this initiative is important and will hopefully drive more stringent quantification, reporting and mitigation measures for local host countries.

IEAGHG and Social Media

IEAGHG have a number of publications that are disseminated regularly to the Executive Committee and released into the public forum – including technical reports, technical reviews, information papers and one-off informative publications.

In 2018, 8 technical reports and 4 technical reviews were published (see page 18 for overviews or 30 for the list); three of these reports/reviews were on IEAGHG Network activity.

The IEAGHG Blog

https://ieaghg.org/ccs-resources/blog

The IEAGHG blog, live since December 2011, features both IEAGHG and external contributors, reporting on any and all IEAGHG activities – workshops, network meetings and conferences, promoting to its readers when a new technical report is published and also giving overviews of any significant external events that may be attended by us or our colleagues. The blog is still proving very popular! The Programme published 44 blogs during 2018.

Information Papers

https://ieaghg.org/ccs-resources/information-papers

In 2012, IEAGHG began producing and publishing Information Papers (IPs) as an additional communication tool. These continue to be extremely popular, both with IEAGHG Members and the public. The IPs are short summaries of new research developments in CCS, developments with other mitigation options and summaries of policy activities around the world on low carbon technology, and are an ideal way of satisfying the Programme's broader remit of reviewing all greenhouse gas mitigation options. If there are interesting developments from the IPs we would then undertake a technical review to understand better the issues and the political landscape, then if necessary, propose a detailed study to our members.

The majority of our IPs are free to access and are publicly available as soon as they are published. Occasionally, however, an IP will be deemed 'Confidential' or 'for the Executive Committee only' – in which case the document will not be available to download. We welcome Members and other external parties to submit relevant ideas to be made into an IP. IEAGHG published 43 IPs in 2017.

IEAGHG Social Media

https://twitter.com/IEAGHG
www.linkedin.com/groups/IEAGHG-4841998
https://www.facebook.com/IEAGHG/

The Programme's Twitter, LinkedIn and Facebook pages are thriving and being kept updated and current with regular posts on IEAGHG activities and other relevant news.

Since the publication of the 2017 Annual Review....

1764 Followers (22.59% increase)

facebook
1493 Likes (3.25% increase)

LinkedIn
846 Group Members (8.9% increase)

IEAGHG Webinars

Webinars have now become a staple in our knowledge sharing cupboard. Despite the nail biting moments that doing anything live via technology can provide, these have continued to prove a popular source of communication and allow us to get information out quickly and to a broad audience. Each event is recorded and placed on our YouTube channel as an ongoing freely available resource.

This year's offerings of webinars can be seen in Table 1 with the number of attendees and the number of YouTube views along with a brief description. Details of our webinars are sent out via our mailing list. If you do not receive our emails, please contact **Becky.Kemp@ieaghg.org or** signup via **http://eepurl.com/du7fkH** to be included.

Webinar Title & Description	Date	No. Attendees	No. YouTube Views to Date
Enabling industrial CCS Clusters It is widely considered that deployment of CCS for clusters of energy intensive industries (EIIs) will become vital for meeting long-term greenhouse gas (GHG) reduction targets, and is a cost effective way for doing so, according to organisations such as the International Energy Agency (IEA) and Intergovernmental Panel on Climate Change (IPCC). In addition, it will be important to develop the related finance mechanism quickly to prevent carbon leakage, i.e. businesses transferring operations to places with less stringent GHG emission standards. Recent evidence highlights there might be different needs and challenges in deployment of industrial clusters, compared to those involving power generation. IEAGHG's report 2015-03 "Carbon capture and storage cluster projects: review and future opportunities" reviews 12 CCS cluster projects and finds that the most successful clusters are currently based on CO_2-EOR in North America. This is to be expected as EOR provides a commercial benefit to investors in such activities. IEAGHG's new report 2018-01 "Enabling the deployment of industrial CCS clusters" examines the economic and commercial arrangements needed to enable the global deployment of industrial CCS clusters. Over a period of eight months, with significant input from stakeholders from industry, government and the investment community, the project has identified key enablers to unlock private investment in ICCS and developed four business models, which are expected to work in various regions around the world including North America, Europe, Australia and China. This webinar will present the key findings from both reports. This webinar was presented by Jasmin Kemper. IEAGHG	26/03/18	119	137
CO_2 Data Share Consortium - an International Platform for Sharing Data related to CO_2 Storage Projects The CO_2 Data Share Consortium is an initiative to facilitate the sharing of quality datasets from CCS operations worldwide, for the purpose of accelerating CCS research and development. The project will establish and operate a consortium-driven repository and online platform for sharing reference datasets that have been individually selected and curated for quality. Through a web interface, users will be able to identify, learn about and access individual datasets. The project also seeks to address the multiple barriers that currently discourage data owners from sharing their data by providing a unified technical solution and streamlined data preparation procedures. The participants of the project are SINTEF, University of Illinois, Statoil and IEAGHG. It is funded by Gassnova/CLIMIT and USDOE. In this webinar we will present the objectives and goals of the CO_2 Data Share Consortium, outline the technical solutions, answer questions and encourage input though online discussion. This webinar was presented by Odd Anderson (SINTEF), Philip Ringrose (Equinor) and Grethe Tangen (SINTEF).	24/05/18	70	78

Webinar Title & Description	Date	No. Attendees	No. YouTube Views to Date
Shaping the functionality of the CO_2 Data Share platform The CO_2 Storage Data Consortium aims to facilitate the sharing of quality datasets from CCS operations worldwide. The project CO_2 Data Share will establish and operate a consortium-driven repository and online platform for sharing reference datasets that have been individually selected and curated for quality. Through a web interface, users will be able to identify and access individual datasets. The project also seeks to address the multiple barriers that currently discourage data owners from sharing their data by providing a unified technical solution and streamlined data preparation procedures. The participants of the project are SINTEF, University of Illinois, Equinor and IEAGHG. It is funded by Gassnova/CLIMIT and USDOE. This webinar was presented by James Craig, IEAGHG	20/09/18	89	24

Table 1: List of 2017 Webinars

If there is a subject you would like to see presented, please send ideas and suggestions to suzanne.killick@ieaghg.org.

Technical Reports, Technical Reviews, Information Papers and Blogs

Report No.	Technical Report Title	Issue Date
2018-01	Enabling CCS Clusters	19/02/2018
2018-02	CO_2 Storage Efficiency in Deep Saline Formations – Stage 2	11/01/2018
2018-03	5th Cost Network Meeting Proceedings	26/03/2018
2018-04	Effects of Plant Location of Plant Location on the Costs of CO_2 Capture	24/04/2018
2018-05	The CCS Project at Air Products' Port Arthur Hydrogen Production Facility	11/01/2019
2018-06	Re-Use of Oil & Gas Facilities for CO_2 Transport and Storage	01/07/18
2018-07	IEAGHG Modelling and Risk Management Combined Network	28/11/18
2018-08	Well Engineering and Injection Regularity in CO_2 Storage Wells	28/11/18

Table 2: List of 2018 Technical Reports

Review No.	Technical Review Title	Issue Date
2018-TR01	GHG Accounting for CCU Technologies - Characterising CCU Technologies, Policy Support, Regulation and Emissions Accounting	05/07/2018
2018-TR02	3rd International Workshop on Offshore Geologic CO_2 Storage	08/08/2018
2018-TR03	Cost of CO_2 Capture in the Industrial Sector: Cement and Iron and Steel industries	05/09/2018
2018-TR04	Flaring Emissions Quantification and Mitigation	17/12/2018

Table 3: List of 2018 Technical Reviews

IP No.	Information Paper Title	Author	Issue Date
2018-IP01	Global Risk Report 2018 highlights	JG	26/01/2018
2018-IP02	2017 Status of Carbon Pricing in 2017	JG	31/01/2018
2018-IP03	EASAC Report on Negative Emissions Technologies (NETs)	JK	07/02/2018
2018-IP04	CONFIDENTIAL	JC	09/02/2018
2018-IP05	International Amine Workshop Oganized by the Japan's Ministry of Environment	MG	21/02/2018
2018-IP06	Industry Working Towards a 2-Degree Target Featuring the LEILAC Plant Official Ground-Breaking Event	MG	21/02/2018
2018-IP07	UKCCSRC- Delivering the new CCS Agenda (26th - 27th March 2018, University of Cambridge)	MG	03/04/2018
2018-IP08	Extent of Underwater Melting of Antarctic Ice Causes Concern	JG	04/04/2018
2018-IP09	2017 Energy Efficiency at a Cross Roads	JG	11/04/2018
2018-IP10	A critical look at the Cement Industry	JG	11/04/2018
2018-IP11	IEA Report on Global Energy and CO_2	JG	11/04/2018
2018-IP12	Shells Vision of a Zero Emission World	JG	12/04/2018
2018-IP13	BECCS is like Marmite – You Either Love it or Hate it!	JG	18/04/2018
2018-IP14	Strategy to Reduce Shipping Emissions Agreed	JG	19/04/2018
2018-IP15	IPCC Special Report on Cities and Climate Change	JG	25/04/2018
2018-IP16	Cement Technology Roadmap Plots Path to Cutting CO_2 Emissions 24% by 2050	JG	25/04/2018
2018-IP17	Port of Rotterdam Making Great Strides to Cut its Industrial CO_2 Emissions	JG	26/04/2018
2018-IP18	CO2GeoNet Annual Meeting 24th – 25th April, 2018, Venice	JC	11/05/2018

Staff Abbreviations:
JC: James Craig JG : John Gale JK: Jasmin Kemper KB: Keith Burnard LR: Lydia Rycroft
MG: Mónica García TD: Tim Dixon

Table 4: List of 2018 Information Papers

IP No.	Information Paper Title	Author	Issue Date
2018-IP19	Water-energy-CCS Nexus: Water Consumption is not a Constraint to Implement CCS in Power Plants	MG	31/05/2018
2018-IP20	CONFIDENTIAL	JK	19/06/2018
2018-IP21	International Conference on Negative CO_2 Emissions	JK	19/06/2018
2018-IP22	SaskPower's Decision to Retire Boundary Dam Units 4 and 5	TD	10/07/2018
2018-IP23	South Asia is Vulnerable to Climate Change and it's only Going to Get Worse	JG	23/07/2018
2018-IP24	UK CCUS Taskforce Report – Delivering Clean Growth	TD	23/07/2018
2018-IP25	Update of Technical Review: "2017-TR07 Reducing Emissions from Natural Gas Supply Chains"	LR	24/07/2018
2018-IP26	Fully Decarbonising Europe's Energy System by 2050	JG	25/07/2018
2018-IP27	CCUS is Critical to Achieving a Net-Zero Emissions Europe	JG	02/08/2018
2018-IP28	CONFIDENTIAL	MG	09/08/2018
2018-IP29	2018 NETL CO_2 Capture Technology Project Review Meeting	MG	21/08/2018
2018-IP30	2018 NETL CO_2 Capture Technology Project Review Meeting: Advances in membranes	MG	21/08/2018
2018-IP31	2018 NETL CO_2 Capture Technology Project Review Meeting: Solvents	MG	21/08/2018
2018-IP32	CONFIDENTIAL	TD	10/09/2018
2018-IP33	IPCC's Special Report on Global Warming of 1.5°C (SR1.5)	JK	08/10/2018
2018-IP34	World Energy Outlook 2018	JG	14/11/2018
2018-IP35	Results from the CEMCAP Project	MG	19/11/2018
2018-IP36	Update on the Shand Power Station CCS Feasibility Study by the International CCS Knowledge Centre	MG	28/11/2018
2018-IP37	New Developments on CCUS in UK	JG	29/11/2018
2018-IP38	IEA-CCC Webinar: The Outlook for CCS in the Coal Sector"	MG	13/12/2018
2018-IP39	CONFIDENTIAL	TD	14/12/2018
2018-IP40	BD3 Status Update: November 2018	N/A	14/12/2018
2018-IP41	ICEF Roadmap 2018 on Direct Air Capture of Carbon Dioxide (DAC)	JK	14/12/2018
2018-IP42	World-First Carbon 'Net-Zero' Hub of Heavy Industry to Help UK Seize Global Economic Opportunities of Clean Growth	N/A	14/12/2018
2018-IP43	GCCSI - The Global Status of CCS 2018	N/A	17/12/2018

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Table 4: List of 2018 Information Papers (Continued)

Blog Title	Author	Issue Date
Do you enjoy a sandwich? Then you Need to Think about the GHG Impact!!	JG	26/01/2018
Report from UTCCS-4 – A Four Year Review of GCCC Achievements	TD	12/02/2018
Economic Boost for CCS and CCUS in the USA	TD	20/02/2018
Astronauts and Climate Change	TD	23/02/2018
Developing Environmental Monitoring for Offshore CO2Storage Projects	TD	19/03/2018
UKCCSRC Biannual Meeting: Delivering the New CCS Agenda	MG	03/04/2018
Fourth Seismic Imaging completed across the Aquistore CO_2 Storage Site	JC	09/04/2018
BD3 CCS Integrated Facility - Technical Capabilities	MG	12/04/2018
CCS : Essential for our Future or a Trojan Horse for Big Oil	TD	16/04/2018
Mission Innovation Carbon Capture Challenge	TD	24/05/2018
Clean Energy Ministerial Launches CCUS Initiative: "A Second Birth for CCUS"	TD	25/05/2018
UK Back in the CCUS Game	JG	04/06/2018
The Keeling Curve Frightens Me	JG	08/06/2018
CCUS at ADB - ADB Centres of Excellence workshop	TD	11/06/2018
CATO Conference - Implementing CCUS in the Netherlands	MG	11/06/2018
100% Renewables, Really?	JG	14/06/2018
Norway's Electric Surge	JG	21/06/2018
IEAGHG Modelling & Risk Management Network Meeting 18th – 22nd June 2018, Grand Forks, North Dakota	JC	28/06/2018
IEAGHG Modelling and Risk Management Network Meeting, Field Trip to the BEST Site Western North Dakota	JC	28/06/2018
IEAGHG Modelling and Risk Management Network Meeting includes an Keynote address on Class VI specifications from Lynn Helsm, of the North Dakota Industrial Commission	JC	28/06/2018
IEAGHG CCS Summer School 2018	LR & TD	09/07/2018
Previous Trends in Global GHG Emissions Reversed in 2017	JG	25/07/2018
Doubts cast on benefits of Geoengineering	JG	09/08/2018
Two synergies for CCUS witnessed at NETL Storage and Capture Meetings in Pittsburgh	TD	16/08/2018

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Table 5: List of 2018 Blogs

Blog Title	Author	Issue Date
2018 NETL CO_2 Capture Technology Project Review Meeting	MG	20/08/2018
Machine Learning for CO_2 Storage Applications	TD	22/08/2018
Update on National Carbon Capture Center (FE0022596)	MG	22/08/2018
New IEAGHG Technical Review; 2018-TR03 Cost of CO_2 Capture In The Industrial Sector: Cement and Iron and Steel Industries	MG	06/09/2018
Telling the Norwegian CCS Story, Part I: The Path for Sustainable and Emission Free Waste Management	MG	09/10/2018
Progress on Ratification of the London Convention's Export Amendment for CCS	TD	11/10/2018
What's in an Abbreviation? More than you Think!!!	JG	11/10/2018
CO2STCAP project	MG	13/10/2018
GHGT-14. Wednesday's Plenary	KB	24/10/2018
GHGT-14. Opening Plenary	KB	25/10/2018
Otway Site Visit	JC	27/10/2018
GHGT-14. From Projects to Infinity	KB	28/10/2018
Panel Discussion on CCUS in Developing Countries: Current Activities and Future Potential	TD	05/11/2018
BHP CCUS Partners Discussions	TD	06/11/2018
Visit to the Glenhaven Storage Test Site	MG	09/11/2018
London Convention	TD	09/11/2018
Second ECRA/CEMCAP Workshop - CCS in the Cement Industry	MG	22/11/2018
GHGT-14 Closing Panel	LR	21/11/2018
Update on the Shand Power Station CCS Feasibility Study by the International CCS Knowledge Centre	MG	28/11/2018
COP24 Katowice Starts	TD	03/12/2018
COP24 Side-Event on CCS	TD	07/12/2018
Accelerating CCUS Conference, Edinburgh	KB	10/12/2018

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Table 5: List of 2018 Blogs (Continued)

IEAGHG Presentations Made in 2018

Date	Location	Presentation Title	Speaker
January	BEG, University of Texas	Update on the Paris Agreement and Carbon Capture, Utilization and Storage (CCUS)	TD
January	NAESB	Impact of the Gulf Coast Carbon Center (and IEAGHG) on the Global CCUS Scene – Offshore example	TD
February	NAESB	ISO TC 265 – 'Carbon Dioxide Capture, Transportation and Geological Storage'	TD
February	International Amine Emissions Workshop, Tokyo	Environmental Impact of Amine-Based Plants	MG
March	Bioenergy Lecture, Imperial College London	Biomass with Carbon Capture and Storage (BECCS/Bio-CCS)	JK
March	Total CCUS Short Conference	Overview of IEAGHG CCUS Activities & CCUS Developments in Europe	JG
April	Cascadia Project Regulatory Workshop New York (by remote)	Regulatory Transboundary Developments for CCS	TD
April	CSLF Technical Group, Venice	Update Report from IEAGHG	TD & JC
April	CO2GeoNet Open Forum, 24-25 April 2018, San Servolo Island, Venice	Progress towards the Paris Agreement targets and the CO_2 storage contribution	JC
May	3rd International Workshop, Oslo, Norway	Welcome to Meeting	TD
May	3rd Offshore CCS Workshop	London Protocol and Norway and EOR. Some reflections	TD
May	Addressing the Energy-Water Nexus through R&D Planning & Policies - Experts' Group on R&D Priority Setting and Evaluation (EGRD)	Overview of the Water-Energy-CCS Nexus	MG
June	74th WPFF	GHG TCP Status Report	JG
June	Modelling and Risk Management Network Meeting	Introduction	JC
June	Modelling and Risk Management Network Meeting	Summary of Meeting	JC
July	ISO 2018, Paris	Update Report from IEAGHG	LR on behalf of TD
August	2018 NETL CO_2 Capture Technology Project Review Meeting	Global Update on CCUS and Higher Capture Rates	TD
September	NETL Carbon Storage Technology Meeting	3rd International Workshop on Offshore Geologic CO_2 Storage	TD

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Table 6: List of 2018Presentations

Date	Location	Presentation Title	Speaker
December	UNFCCC Side Event, COP24, Katowice, Poland	Can Carbon Capture and Storage Decarbonise Industries in Developed and Developing Countries?	TD
December	CCP Event, COP24, Katowice, Poland	Perspectives from IEAGHG CCS in NDCs and in Long-term Strategies	TD
December	UNFCCC Side Event, COP24, Katowice, Poland	CCS and Sustainable Development Goals	TD
December	The Ocean an CO_2: Challenges and Science Responses, UK Pavillion Side-Event, COP24, Katowice, Poland	Carbon Capture and Storage and the Marine Environment	TD
December	Can CCS Decarbonise Industries in Developed and Developing Countries?	UNFCCC Side Event, COP24, Katowice, Poland	TD

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Table 6: List of 2018Presentations (Continued)

Members of the Programme

AUSTRALIA

Mr Lincoln Paterson (M) | Dr Kelly Thambimuthu (Chairman)

AUSTRIA

Mr Theodor Zillner (M) | Mr Ernst Goettlicher (A)

CANADA

Dr Eddy Chui (M)

EUROPEAN COMMISSION

Dr Vassilios Kougionas (M) | Mr Jeroen Schuppers (A) | Mr Wolfgang Schneider (A)

FINLAND

Mrs Pia Salokoski (M) | Dr Kristin Onarheim (A)

FRANCE

Mr Michel Giora (M) | Ms Aïcha El Khamlichi(A)

INDIA

Dr Atul Kumar (M)

JAPAN

Mr Ryozo Tanaka (M) | Dr. Ziqui Xue (A)

KOREA

Jeom–In Baek (M)

NEW ZEALAND

Mr Mark Pickup (M)

NORWAY

Dr Åse Slagtern (M & VC) | Mr Hans Jorg Vinje (A)

OPEC

Mr Moufid Benmerabet (M) | Dr Eleni Kaditi (A)

SOUTH AFRICA

Dr Anthony Surridge (M)

SWEDEN

Svante Soderholm (M)

SWITZERLAND

Dr Gunter Siddiqi (M & VC)

Dr – Ing Peter Jansohn (A)

Prof Lyesse Laloui (A)

UNITED KINGDOM

Mr Brian Allison (M)

Mr Will Lochhead (A)

USA

Jarad Daniels (M)

John Litynski (A)

Ms Anhar Karimjee (A)

Chevron

Mr Arthur Lee (M)

CIAB

Mr Peter Morris (M)

Mr Mick Buffier (A)

Karl Bindemann (A)

Doosan Babcock

Mr Stuart Mitchell (M)

David Fitzgerald (A)

EPRI

Mr Robert Trautz (M)

equinor

Britta Paasch(M)

Mr Henrik Solgaaard Andersen (A)

ExxonMobil

Mr Ganesh Dasari (M)

INSTITUTO NACIONAL DE ELECTRICIDAD Y ENERGÍAS LIMPIAS

Eduardo Preciado (M)

Dr Antonia Diego Marin (A)

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Mr Natsuo Tashiro (M)

Mr Tsukasa Kumagai (A)

J-POWER

Seiji Hongo (M)

Takashi Kuroki (A)

JÜLICH FORSCHUNGSZENTRUM

Jurgen Friedrich Hake (M)

Eric Busche (A)

جامعة خليفة Khalifa University

Mohammad Abu Zahra (M)

Miss Ana Paula Musse (M)

Dr Reinhold Elsen (M)

Mr Wilfried Maas (M)

Richard Esposito (M)

Mr Dominique Copin (M)

Samantha McCulloch

Kenneth Michaels

Diana Louis

Welcome to Country: GHGT-14

Evaluating technology options to mitigate greenhouse gas emissions

IEA Greenhouse Gas R&D Programme

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