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Greenhouse News

• the official newsletter of IEAGHG and its members •

September 2017 • Issue 127

IEAGHG Summer School, by Lydia Rycroft, IEAGHG

Students listening intently to a presentation at the Summer School

36 students from 15 countries travelled to the University of Regina, Canada to take part in the 11th IEAGHG International CCS Summer School, hosted by the International CCS Knowledge Centre, a collaboration between BHP Billiton and SaskPower.

This year I was lucky enough to be able to attend the Summer School and experience the program as a student which gave me direct insight into the enormous benefit the week provides to all the attendees in the early stages of their careers. A highlight of the week for all involved was a day at Boundary Dam which included a visit to the Shand testing facilities and Aquistore storage site, hosted by SaskPower. For a lot of the students, being able to see a fully operational CCS site and all the research behind carbon capture and storage being put into action was a very engaging and rewarding experience. Personally, I feel it has given me a better standing to talk to people and spread the word of CCS, knowing I have seen all of the CCS technologies utilised successfully and seen for myself that these technologies really can work.

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Acorn CCS Project

Osaki CoolGen Project

Students on a site visit to SaskPower's Boundary Dam 3

With the help of the Series and Local Sponsors, all accommodation, meals, course and field trip are provided free of charge to the students with many sponsors providing not only a financial contribution but also providing Experts to deliver the course material. We will always remain extremely grateful to the sponsors and experts who have the foresight to invest now in the future generation of CCS scientists, engineers, advocates and policy makers.

The Expert Mentors were a great benefit to the summer school with 2 mentors available for every 5 students. Throughout the week there is plenty of opportunity for discussion and questions both formal and informally giving students the chance to learn more on both technical questions but also as about career development within the world of CCS.

The week began by getting straight into the technical presentations providing overviews of the CCS chain to include technologies, policy considerations and status as well as social and economic factors. In addition to the presentations provided by the Expert Mentors, the students are formed into groups at the beginning of the week and given a question on CCS to address during group work sessions through the evenings and present the results to their peers on the final morning. This teamwork element of the summer school was crucial in allowing the students to get to know each other better stimulating more informal debates on CCS as well as allowing team members to learn more about their peers research and early careers.

The format of the presentation is open for the students to decide and this year did not disappoint in creativity. Presentations included mock trials, UN conferences and even a CCS Broadway show. As is traditional, the two Most Outstanding Student Awards were given for demonstrations of teamwork, leadership, engagement and support to colleagues. We are pleased to congratulate Ken Prabowo (Lapi LTB, Indonesia) and Anne Menefee (University of Michigan) on being nominated and selected for the awards this year. As in the past, the summer school got local and national media attention, including some of the students being interviewed for local news.

The feedback from the students was very appreciative and having been able to attend as a student myself I can safely say it was another successful International CCS Summer School. Many thanks to the International CCS Knowledge Centre for providing such a great experience and thanks to all those involved for your hard work! Under the advice of Mike Monea everyone there was involved, passionate and curious and will undoubtedly take their Summer School experiences back their institutions further developing our alumni database and spreading positive news about the IEAGHG Summer School!

7th High Temperature Solid Looping Cycles Network (HTSLCN), by Jasmin Kemper, IEAGHG

Delegates at the meeting dinner

The high temperature solid looping cycles (HTSLC) network meeting covers technology developments in fields where a solid material is cycled between multiple reactors at elevated temperatures. The scope of the IEAGHG HTSLC Network is to discuss recent progress in solids looping cycles such as calcium looping and sorption enhanced reforming for selective CO_2 transport and chemical looping combustion and reforming with selective oxygen transport by the solids. It brings together well-known technologies used in Fluid Catalytic Cracking, Circulating Fluidized Beds and Combined Cycles, in new ways, to increase efficiencies and provide opportunities to decrease the carbon-footprint of energy intensive processes.

IEAGHG's 7th HTSLCN Meeting took place 4th – 5th September in Luleå, Sweden. 50 delegates attended the meeting, which was hosted by Swerea MEFOS in the Kulturens Hus in the town centre.

The first day started off with a welcome from the organisers IEAGHG and Swerea MEFOS and a keynote presentation from Matteo Romano (Politecnico Di Milano) on the application of high temperature sorbents in industrial and power plants. The following technical sessions covered calcium looping modelling and testing, chemical looping fundamentals and economics and environmental impacts of both technologies in detail. After a short panel discussion summarising the main conclusions of the first day, delegates enjoyed a delicious dinner. All while taken in the stunning sunset over the Luleå archipelago and listening to a couple of Anders Lyngfelt's (Chalmers University) famous live songs on climate change and chemical looping.

The second day started similar to the first one with a keynote presentation. Paul Cobden (ECN) briefed everyone about the STEPWISE project, which aims at demonstrating sorption enhanced water gas shift technology for CO_2 reduction in the iron and steel industry. Valuable information for the site visit in the afternoon but more on this later. Participants again split up to attend technical sessions on either sorption enhanced reforming fundamentals and testing, as well as chemical looping modelling and testing. Afterwards, everyone assembled for the final session on the application of biomass to solid looping technologies, which was identified as one of the hot topics of the meeting, next to flexibility, as it could enable achieving net negative emissions. The meeting was concluded with another short panel discussion and a presentation by Eva Sundin, CEO of Swerea MEFOS, giving an overview about the company's activities and a safety briefing for the tour. Participants then boarded a bus bringing us to the site of SSAB's steel plant, where the STEPWISE demonstration plant is located. After a short reception with refreshments, the STEPWISE plant was officially opened, the ribbon cut and delegates

were given a tour around the facilities, including the control room, SEWGS column and compressor station.

Concluding from the panel discussions and technical sessions, it was noted that solid looping technologies now urgently need to move forward in term of scale. Especially since the progress appears to have stalled during the last 2 years with no new large pilot or demonstration plant having been announced. However, this development is not exclusively concerning solid looping technologies but rather all CCS technologies, as requests for technical details and costs have driven some researchers/engineer back to the lab. Negative emission through solid looping with biomass and flexible operation have been identified as the hot topics of this meeting. It is important that the HTSLCN community has started work on these topics. The forthcoming IPCC Special Report on 1.5°C will hopefully help to regain momentum for CCS technologies. Next to biomass, sorption enhanced reforming technologies appear as a promising near-term option to party replace conventional H2 production. Thus, opportunities for solid looping currently seem to be in the industrial sectors, rather than in the primarily targeted power sector.

Links to the Climate Change song from the 7th HTSLCN Dinner Entertainment:

- **With Lyrics:** https://youtu.be/jUHbwmtr7po
- **Without Lyrics:** https://youtu.be/MXL7FNYNYQQ
- **Anders' Acoustic Version:** http://youtu.be/6ymIvfyJ6rY

Anders Lyngfelt performing at the meeting dinner

IEAGHG 4th Post-Combustion Capture Conference (PCCC4), by Monica Garcia & Keith Burnard, IEAGHG

The fourth of IEAGHG's successful Post Combustion Conference (PCCC4) series was held at the Renaissance Ross Bridge Hotel, Birmingham, Alabama, from 5th – 8th September 2017. Through the week, 112 representatives from 16 nations active in the development of post-combustion capture technologies met to update each other on progress.

Apart from a strong contingent from North America and Europe, PCCC4 welcomed attendees from China, Democratic Republic of Congo, India, Japan, South Korea, and Taiwan. IEAGHG was particularly pleased to welcome the influential delegation from India, led by the Indian Secretary for Coal. India's commitment to a lower-carbon future was signalled by its contribution to the Paris Agreement and was reaffirmed by its participation in conferences such as PCCC4.

Keynote presentations at PCCC4 centred on learnings from some of the large CCS demonstration plants constructed, namely Canada's Boundary Dam Unit 3, China's Shanghai Shidongku and Chongqing Shuanghua, and the United States' Petra Nova and Kemper power plants. Presenters were generous in their sharing of information. They discussed and answered questions freely on, for example, the technology challenges they had encountered and ones they were still tackling and also,

Attendees of the PCCC4 Conference

Southern Company's Kemper Project

A Presentation during the Conference

importantly, on the costs of the plants and opportunities they had identified to reduce these for the next generation CCS facilities to be built.

Oral presentations given in the technical sessions covered research and development from bench-scale, through pilot-scale testing to demonstration at large scale, as well as addressing process modelling and environmental impacts.

Within the 50+ presentations made, recent progress on all the main capture technologies was addressed. For chemical absorption systems, a lot of R&D effort appeared to be focused on reducing the process energy consumption, particularly the solvent regeneration energy. The development of new materials was considered important to next generation membrane-based technologies, while the potential for additives to increase membrane separation efficiency was also being explored. And a session on environmental impacts looked closely at topics such as characterising and reducing the release of aerosols from solvents.

The technical sessions were sandwiched between two excellent and informative technical visits, first to the National Carbon Capture Centre (NCCC) and then to Kemper.

After testing in the laboratory and at bench-scale, and once some confidence has been gained in performance, the NCCC will provide a world-class test facility that, with support from its highly specialised staff, accelerates the commercialisation of promising capture technologies. While some satisfied technology developers described their experiences prior to the visit, others gave detailed descriptions during the tour itself. Facilities at NCCC allows testing to focus either on post-combustion capture for conventional pulverised coal-fired power plants or on pre-combustion capture for advanced integrated gasification combined cycle power plants.

The visit to the Kemper County IGCC Project on the final day, of course, topped off the conference in great fashion. While operation of the


Site Visit to the National Carbon Capture Centre

facility has been suspended since 28th June, apparently resulting from cost overruns for the first-of-a-kind plant, the opportunity to see the technology at first hand and to have it described by experts at the plant was appreciated by all. Sitting in the centre of a near unending supply of lignite, the 580 MW (net) IGCC plant was designed to capture 4 Mt/yr CO_2, with the option of either storing it in a saline aquifer or piping it away for enhanced oil recovery. Emissions from the plant were projected to be very low, lower even than for natural gas plant while, at the same time producing 135,000 t/yr sulphuric acid and 38,000 t/yr ammonia as by-products.

Following the closing of PCCC4, many came up to express their appreciation of the event to the IEAGHG team. In turn, of course, IEAGHG recognises that the quality of the conference was enhanced by our co-organiser and host, the NCCC, not least for the tour of their excellent facilities. IEAGHG was also greatly indebted to the conference sponsors, namely, the USDOE's Office of Fossil Energy, the Japan Coal Energy Centre (JCOAL) and Norway's Technology Centre Mongstad (TCM) that, through their generous donations, helped keep fees low, reduced barriers to access for all participants and, significantly, facilitated the sharing of information on such an important technology.

Given the widely-appreciated content of PCCC4, IEAGHG's 5th PCCC in 2019 is eagerly anticipated.

New IEAGHG Report: 2017-07 CCS Deployment in the Context of Regional Developments in Meeting Long-Term Climate Change Objectives, by Jasmin Kemper, IEAGHG

CCS represents an important technology within a portfolio of abatement options available for achieving the 2°C goal. The technology is key to the International Energy Agency's (IEA) 2DS (which aims for an 80% probability of limiting the average global temperature increase to 2°C) under which CCS contributes 14% of the cumulative emissions reductions needed through 2050. Although the deployment rates vary over time and across sectors, the analysis shows a significant contribution from all world regions over the coming decades. Studies show that both the total investment cost and the cost of emissions reduction are much higher for various scenarios when CCS is excluded from the list of mitigation options. The Intergovernmental Panel on Climate Change (IPCC) estimates that without CCS the cost of climate mitigation by 2100 would increase by between 29% and 297%, while the IEA estimates that without investment in CCS, total mitigation costs in the power sector alone would increase by USD 2 trillion by 2050. For those countries that are heavily reliant upon continued use of fossil fuels for economic growth, CCS represents a means of ensuring continued growth and energy security whilst enabling deep cuts in domestic emissions. Furthermore, when combined with the use of enhanced hydrocarbon recovery (EHR), CCS technology offers those countries whose economies are based on oil and gas production a viable option for contributing to global mitigation efforts.

Despite its potential, the uptake of CCS remains significantly behind other low carbon technologies. There are currently 22 CCS projects worldwide (only 17 are operational). The total CO_2 capture capacity of these 17 projects combined is around 31 $MtCO_2$/yr. A number of jurisdictions worldwide have introduced wide-ranging R&D programmes, policy support and financial incentives for CCS and there is ongoing progress in the development of the legal and regulatory frameworks needed to ensure the safe and permanent storage of CO_2 in the sub-surface. At the United Nations Framework

Convention on Climate Change (UNFCCC) level, the role of CCS as a clean technology has been recognised under the clean development mechanism (CDM).

The aim of this study was to characterise key countries and regions worldwide where CCS could play an important role in mitigation efforts, based on national circumstances and priorities. An additional objective was to identify how international frameworks, such as the UNFCCC, can support CCS and what these new architectures would mean with respect to the development of nationally determined contributions (NDCs). IEAGHG commissioned this analysis to Carbon Counts.

Key Messages

- Meeting the long-term goal to limit global temperature rises to 2°C or below compared to pre-industrial levels requires large-scale deployment of low carbon technologies such as CCS.
- CCS presents an opportunity for many countries worldwide to reduce greenhouse gas (GHG) emissions. A portfolio of technologies is available for CCS deployment depending on GHG sources and the availability of suitable geological storage sites.
- CCS deployment faces a broad spectrum of barriers. Some are technical, some are economic, some are institutional and regulatory, and some concern the cost effectiveness of the technology compared to alternative mitigation options.
- Large-scale CCS deployment involves the development of a pathway establishing the necessary framework of actions and policies to incentivise projects and programmes. Countries and regions are at different stages along this pathway, which includes the following steps:
  - o Scoping and agenda setting
  - o Strengthening institutional arrangements and legal & regulatory frameworks
  - o Design and implementation of effective and multifaceted policy portfolios
- The new climate agreement adopted under the UNFCCC (Paris Agreement) could help facilitate deployment of CCS as a mitigation option. Mechanisms within the emerging framework could support technology development in both developing and developed countries and help mobilise climate finance into projects and programs. Into this 'top-down' framework, NDCs provide the 'bottom-up' opportunity for countries to establish CCS firmly within national GHG efforts that are aligned with the Paris Agreement. The UNFCCC can help support CCS through the following routes:
  - o Providing the overall mitigation policy framework for CCS
  - o Mobilising finance for CCS projects through both market and non-market based mechanisms
  - o Addressing technology needs and helping with capacity building.
- Recommendations for further work include more work on defining the exact modalities for facilitating CCS under the UNFCCC and addressing ongoing uncertainties and challenges regarding the future form and scale of market-based support for projects. As it crosses the line of policy recommendations, this is not something IEAGHG would undertake. However, IEAGHG encourages organisations such as the IEA to make use of the information provided in the report and develop such recommendations.

New IEAGHG Report: 2017-08 CO_2 Migration in the Overburden, by Lydia Rycroft & James Craig, IEAGHG

At CO_2 storage sites, large-scale overburden heterogeneities and introduced man-made pathways (e.g. wells) could potentially breach the sealing strata and promote the migration of injected CO_2 in the dense, gaseous or dissolved phase. The ability to fully characterise the overburden would therefore allow identification of the preferred CO_2 vertical migration pathways which will then encourage more complete risk assessments. Overall this will allow for more focussed monitoring efforts and will lead to the deselection of sites prone to vertical migration.

The overburden is very site-specific but at most CO_2 storage projects it consists of a thick sequence of sedimentary rocks and young, poorly consolidated sediments. Heterogeneities in overburden sequences may allow fluids to flow vertically across stratal boundaries and provide fluid flow pathways to shallower depths or laterally beyond the immediate vicinity of the fluid source. In most cases the overburden will inevitably include internal heterogeneities and features (e.g. gas chimneys, and glacial landform) and many of these structures could serve to either hinder or promote fluid migration.

Understanding and quantifying potential migration of fluids within the overburden is difficult because of limited in-situ data from common large-scale features over large areas. Incorporation of overburden heterogeneities into risk assessments, given large uncertainties associated with some structures, presents an additional challenge for site selection and characterisation. IEAGHG published a report in 2016 reviewing the permeability of faults and this report develops on this work to look specifically at the overburden and other associated structures.

Key Messages

- This study was conducted to assess the natural rates of CO_2 and fluid migration that occur in the overburden (defined as the entire geological succession above the target reservoir formation with the lowermost stratum forming the primary seal) and the potential rates that may arise in the unlikely event of unintended migration outside a designated storage complex. The aim was to better inform risk assessments for CO_2 storage sites by providing relevant information on the effect of large-scale features associated with natural fluid migration analogues in the overburden.
- With appropriate site selection and site characterisation risk-based process, CO_2 storage sites are selected to minimise the likelihood and impacts of fluid migration.
- The five case studies in this report highlight that storage sites are likely to have numerous secondary storage formations within the overburden with low permeability sequences (e.g. shale) providing secondary seals, in addition to the primary caprock seal, thereby hindering or preventing migration through the overburden.
- The natural migration of fluid in the overburden over geological timescales is evident from the presence of chimneys, gas hydrates and sediment injections (pockmarks, mud volcanoes and mounds are also present offshore). Generally their formation has been well researched although their current in-situ properties (and their impacts on fluid flow) require further analysis due to the lack of data.
- The principal potential geological pathways which may enable the migration of fluids within the overburden are fractures and faults (chimneys and large-scale geomorphological features such as tunnel valleys and mass-movement deposits may also enhance flow in the overburden).
- Ice-loading on bedrock and sediment deposits can cause rafting, fracturing and faulting. Potential fluid migration pathways are created along faulted surfaces and rafting disrupting lateral seals. Evidence of glacio-tectonic deformation is recorded in areas where CO_2 storage is operational or planned such as onshore in Canada and offshore in the North Sea.
- The large volume and complexity of the overburden makes modelling potential migration pathways difficult. The characterisation of overburden structures should focus on parameterising elements and quantifying potential fluid flow rates.
- From this report, it is recommended that further in-situ data is acquired during future work, directly sampling overburden features such as faults and chimneys. Direct sampling is required to further refine the potential fluid properties of these structure and their implications for fluid migration. Further research, for example the EU funded STEMM project, will investigate these features and is already underway.

IEAGHG Welcomes New Staff Member: Suzanne Killick, Events Programme Manager

Suzanne has worked as an Event Manager for more than 20 years, creating and delivering high profile events for companies across the globe.

These companies include : Intel, Vodafone, Cable & Wireless, John Lewis Partnership and Chase de Vere Financial Services Whilst living in the Netherlands for 4 years she worked as the Senior Conference Manager for the European Association of Geoscientists & Engineers (EAGE) and was responsible for the creation and delivery of topical international conferences and workshops, as well as managing specific areas of the Annual Conferences and Exhibition. This Annual event for 6000 + fee paying delegates included a full technical programme of papers and posters, plus field trips and social activities.

She now lives in Cirencester, Gloucestershire with her husband Paul and has two grown up children, both now married, one living in Swindon and one in Seattle, USA.

Summary of GeoConvention 2017 and its Relevance to CO_2 Storage, by James Craig, IEAGHG

GeoConvention is an annual gathering of geoscientists which is designed to provide a showcase technical conference focussed on the petroleum geoscience of Canada. It is organised by the Canadian Well Log Society (CWLS), the Canadian Society of Exploration Geophysicists (CSEG) and the Canadian Society of Petroleum Geologists (CSPG). Although the three day conference held in the TELUS Convention Centre, Calgary, is heavily orientated to oil and gas exploration and production, it also includes dedicated sessions on CO_2 storage and hydrogeology. Other relevant topics include microseismicity, sedimentary processes, stratigraphic modelling and the development of polygonal faulting. These more fundamental processes help to improve our understanding of the overburden especially the occurrence of secondary traps or potentially conductive routes for fluids.

Some of the Hydrogeology sessions demonstrated the importance of baseline characterisation particularly the origin of groundwater. One example, conducted by the Canada's Oil Sands Innovation Alliance (COSIA), which is a collaborative industry partnership, pooled operator data from the Athabasca Oil sands for collective benefit. Groundwater geochemistry and isotopic tracers have shown evidence of some aquifer connectivity. Ratios of $\delta^{18}O$ and $\delta^{2}H$ isotopes can be used to trace the origin of ground water. The proportion of these isotopes and the total dissolved solids can also be used to differentiate original sources and evidence of mixing of water from different origins.

GeoConvention included a series of dedicated sessions to Global Carbon Capture, Storage, Utilization and Monitoring over one day. Large scale storage topics covered the global status of capture and storage, Norway's impressive track record in the development of CCS, an overview of Shell's achievements, and the injection of CO_2 from a biofuels source at the Decatur site in Illinois into a deep saline formation. The use of CO_2 in enhanced oil recovery (EOR) and its use in unconventional reservoirs were also covered. Don Lawton from the Containment and Monitoring Institute (CaMI) updated delegates with the current status of the controlled release experimental facility now referred to as the Advanced CO_2 injection Research facility. The site has just got its permit to inject and will be commission by May-June 2017[1]. Baseline borehole geophysical surveys had been completed by August 2017 . One of the planned experiments at this site will be the use of noble gases to test gas migration in the subsurface. Noble gases have been demonstrated as useful tracers in studying the origin of gas in the subsurface. Noble gases are conservative tracers that do not participate in chemical or biochemical reactions. Their concentrations in water are determined by their solubility during recharge and by

the production of some isotopes in the subsurface. Previous research has demonstrated the utility of these gases to identify mechanisms of fugitive gas contamination in drinking water wells overlying the Marcellus and Barnetts shales.

The final three presentations outlined the progress that has been achieved with CO_2 retention at the PCOR Partnership region, Aquistore, and an overview of the first year of monitoring, modelling and verification at the Quest site.

GeoConvention 2017 included a highly varied mix of topics either directly or related to the challenges of CO_2 storage. It clearly shows that an interdisciplinary geoscientific approach is required to successfully develop secure long-term geological storage on a large-scale.

[1] Containment and Monitoring Institute - Baseline Geophysics for CO_2 Monitoring with Crosswell Seismic and Electromagnetics. Article published 28th August 2017. www.earthdoc.org/publication/publicationdetails/?publication=89850 (website accessed 20/09/17)

TCCS-9: 9th Trondheim Conference on CO_2 Capture, Transport and Storage, by Monica Garcia, IEAGHG

The TCCS-9 conference took place in Trondheim between the 12th - 14th June. Organized by NCCS – International CCS Research Centre and under auspices of NTNU and SINTEF, this event included 115 presentations and 10 keynotes about the last advances on carbon capture, transport, storage, utilization and cross-cutting issues.

As a key message, the need of CCS as part of the energetic symbiosis is required as soon as possible, instead of waiting for further consequences. CCS projects at industrial scale have supported the viability of CCS technologies in an integrated system, and the future strategy must be the result of Research + Development + Demonstration. In addition, the application of CCS technologies to industrial sectors has been one of the objectives in the Norwegian plan, and we saw later in the 2017 NETL review meeting some advances on CO_2 utilization in the cement industry in USA.

This event covered advances on CO_2 capture solvents and tests at pilot and large scale. Additionally, the Boundary-Dam team showed problems during implementation, which gave a realistic view of issues we can find during the scale-up. The pilot plant demonstration on membranes was explained and the SINTEF-NTNU CCS Award was given to Emerita Professor May-Britt Hagg, recognising her role in business and the recent exclusive license agreement with Air Product.

In this event, the need for collaboration and the role of CCU were addressed, while negative emissions were mentioned as needing a pathway to achieve the 1.5°C scenario. Flexibility will be essential to reach long-term economic solutions on CCS and new configurations will be indispensable to get more efficient CCS systems.

More information about this conference can be found in: https://www.sintef.no/projectweb/tccs-9/

Innovate UK Feasibility Study "Corrosion Prediction in CO_2 Pipelines: Shifting the Paradigm", by Monica Garcia, IEAGHG

The Innovate UK feasibility study "Corrosion Prediction in CO_2 Pipelines: Shifting the Paradigm" organised one Experts Workshop as part of their planning tactic.

This workshop took place at the University of Leeds and was organised by Alex Hunt, from Woodview Technologies, counting with the presence of the rest of partners, University of Leeds and Wood Group Kenny UK Limited, and industries. The main goals of this study are to improve predictive tools for both physical properties and corrosion rates; and to validate predictions with laboratory and field data.

During the workshop, there were presentations given by the organisations involved and great open discussions with the rests of attendees. We wish for the best output from this collaborative initiative and we will keep in touch.

For more information about this feasibility study, please visit: http://gtr.rcuk.ac.uk/projects?ref=132712

Introduction to New US DOE CarbonSAFE Projects (Information Paper 2017-IP47), by Lydia Rycroft & Tim Dixon, IEAGHG

The US DOE's annual 'Carbon Storage and Oil & Natural Gas Technologies Review Meeting' was held in Pittsburgh 1st - 3rd August 2017. The program included 16 presentations from the new CarbonSAFE projects (see IEAGHG 2016-IP54).

In November 2016, the DOE announced that 16 carbon storage projects had been chosen to receive approximately $44 million for cost-shared research and development. This funding came under the DOE's Carbon Storage Assurance Enterprise initiative (CarbonSAFE) and will build on the previous work of the Regional Carbon Sequestration Partnerships (RCSPs) which are now reaching their final stages. The projects will provide information on the development of the next scale of geological storage sites (+50 million metric tons of CO_2) from a variety of industrial sources.

The CarbonSAFE FOAs aimed to develop CCS projects that assess the feasibility of constructing and permitting a commercial-scale storage complex and initiate characterization activities. The projects are currently within two phases of development as described below.

Phase 1: Integrated Pre-Feasibility

Thirteen projects have been selected for Phase 1 (representing 10 recipients and $15 million of federal funding). Full details of each project can be found on the US DOE website including the initial funding opportunity announcement outlining the full objectives for Phase 1 and 2. The Phase 1 projects include, amongst others, two offshore assessments (one into basalt formations), a site in California and a site developing stacked storage hubs in Nebraska and Kansas.

The aims of Phase 1 will be to develop a plan including technical requirements, economic feasibility and public acceptance and identify issues specific to commercial scale deployment of CCS projects. The following objectives must be met to be eligible to move on to Phase 2:

- Formation of capable team (to address technical and non-technical challenges to commercial-scale deployment of CO_2 storage);
- Development of plan (including public acceptance and economic feasibility) to encompass all technical requirements;
- High-level technical evaluations of the sub-basin and potential CO_2 source(s).

Currently the projects are at varying stages of development, having had a kick-off meeting towards the start of the year. Potential capture sources are being assessed as part of the pre-feasibility assessment with numerous sources being considered for each site. These include power plants, refineries, ethanol production plants and other industry sources. Potential pipeline utilisation has also been considered for some of the sites taking into account existing infrastructure. The sites vary in distance between the CO_2 source and storage complex with some being adjacent and some potentially requiring longer distance transportation (e.g. 300 miles for the ICKan project). The pre-feasibility will include an assessment of storage sites given potential sources and the relative benefits of the quality of the storage reservoir versus transportation distance. The projects will aim to make use of the National Risk Assessment Partnership (NRAP) tools.

Fieldwork and data collection has begun at numerous sites already, for example the Rock Springs Uplift site managed by the University of Wyoming has analysed data from a previous seismic survey and conducted fieldwork to start collecting samples. The ICKan project in Kansas, managed by the University of Kansas and Kansas Geological survey, has even completed initial porosity and permeability characterisation and technical analysis with the 3D static model completed and a dynamic model underway. Several projects are looking at sites with 'stacked storage' potential and which could include EOR, one benefit of which would be to reduce the 'Area of Review' for the same storage volume.

Phase 2: Storage Complex Feasibility

Three projects have been selected under Phase 2 funding to conduct an initial characterisation of a storage complex identified as having high potential. This work is to establish the feasibility for storage of 50+ million metric tons of CO_2 and will utilise over $29 million of federal funds. As part of the Phase 2 developments the projects will be required to use the NRAP tools to help in evaluating several elements of the subsurface which will help validate the tools and advance their development.

The storage complex characterisation will include data collection, geologic analysis, identifying regulatory requirements, subsurface monitoring and risk assessments. The three projects are:

- Southern States Energy Board – Geologic Storage adjacent to Mississippi

Power Company Kemper County Energy Facility (ECO2S). Two wells have already been drilled at the site (with core recovery for analysis) with 1 more currently being prepared. Initial indications are very positive on the storage geology.

- University of North Dakota – North Dakota Integrated Carbon Storage Complex. Two stratigraphic wells are planned to be drilled to allow for the collection of new data from the analysis of new core, subsurface fluid samples, and well logs. Reprocessing of existing 3D seismic data is planned as well as the acquisition of a new 2D survey. CO_2 sources under consideration include the Dakota Gasification Company's Synfuels Plant and coal power stations.
- University of Illinois, Illinois State Geological Survey – CarbonSAFE Illinois Macon County. This project is assessing geologic storage in the Mt. Simon sandstone in Macon County. It is still in the planning phase with the aim of drilling to 7500ft and into the basement rock, and to establish the variability in the lower Mt Simon sandstone depositional environment and therefore porosity variations, at the Forsyth Field (North-West of the existing project sites). Potential CO_2 sources include the ADM ethanol facility and coal power stations.

More details can be found on the US DOE's website:
https://energy.gov/under-secretary-science-and-energy/articles/energy-department-announces-more-44-million-co2-storage

And from the forthcoming presentation links on:
https://www.netl.doe.gov/File%20Library/Events/2017/tech%20review/2017-CS-and-O-and-G-Review-Meeting-Agenda-07312017-FINAL.PDF .

Overall, these projects appear to have made very quick progress in the short time so far, with a lot of new information being shared at the Carbon Storage Review meeting. We look forward to their results which will contribute towards the development of commercial-scale integrated CCS projects.

Petra Nova CCS Project – IEA hosted by NRG Energy, by Thomas Berly, IEA CCS Unit

NRG Energy invited the IEA to visit the operating Petra Nova CCS project, located southwest of Houston, Texas. Dr Thomas Berly, Energy Analyst at the IEA CCS unit, was given the opportunity to take a personal tour of the Petra Nova capture facilities at the WA Parish plant with Tony Armpriester, EPC Director for the project.

Photo Courtesy of Petra Nova

The project consists of capturing up to 1.6 million tons of CO_2 per year from a 240MW slip stream of flue gas from WA Parish Unit 8, compressing the CO_2 on site before being transported via a 80 mile pipeline to the West Ranch Field where the CO_2 is injected to enhance oil production through the EOR operations. Despite the large scale and complexity of all integrated facilities, this billion-dollar CCS project was built on budget and on time. Since December 2016, plant performance is meeting expectations. This is credit to the project team, the project partners (NRG, JX Nippon and Hilcorp) and the funders (USDOE, JBIC and Mizuho Bank), who have made this commercial-scale integrated CCS project possible.

Petra Nova is a success story and needs to be replicated. It clearly demonstrates that CCS projects are happening now. Petra Nova's key success factors and lessons learned will certainly help develop other CCS projects around the world.

The IEA would like to thank NRG, JX Nippon and Hilcorp for providing access to the Petra Nova CCS project site. We particularly acknowledge David Greeson, Vice President for Development at NRG Energy, Tony Armpriester and the Hilcorp EOR team for their time and effort prior and during the IEA visit of the project.


Photo Courtesy of Petra Nova

KEPCO-Huaneng CERI: International Joint Research for Development of Advanced CO_2 Capture Technology, by Ji Hyun Lee, KEPRI & Gao Shiwang, CERI

On April 2017, the Korea Electric Power Corporation Research Institute (KEPRI), Korea Midland Power Co., Ltd., (KOMIPO) and the Huaneng Clean Energy Research Institute (Huaneng CERI) of China commenced a joint international research project for the development of post-combustion CO_2 capture technology of world-class standards.

KEPRI, the central research institute of KEPCO (the largest electric utility in South Korea), undertakes research and development of technology for various purposes, such as environment-friendly energy generation, reduction of greenhouse gases and renewable energy. KOMIPO, the main power generation subsidiary of KEPCO, currently operates six thermal power plants and various renewable energy facilities in south Korea. CERI is a clean energy R&D institution directly under China Huaneng Group (CHNG), the largest of the 5 major power generation companies in China. The institute is currently conducting research on clean energy, renewable energy and greenhouse gas reduction.

The joint international research launched in the current year follows the technical exchange MOU for the clean energy development signed between KEPCO and CHNG in 2014. The research is planned for a period of 27 months with total research funds of approximately 4 million USD.

The current status of CO_2 capture technology development in South Korea and China as well as the key points of the joint international research between KEPRI-KOMIPO-Huaneng CERI are as follows.

1. Status of Key CO_2 capture technology development in KEPRI and Huaneng CERI

South Korea and China invest greatly into various research and development to reduce greenhouse gas emissions resulting from the heavy reliance on fossil fuels for power generation in both nations. For example, KEPRI and KOMIPO in South Korea have independently developed the low-energy amine-based CO_2 solvents (KoSol series) through the research projects that began in the year 2000. Based on these development, a wet amine CO_2 capture pilot plant with an annual capture capacity of approximately 70,000 tons was constructed in 2013 and is currently in operation in 2017 (location: KOMIPO Boryeong power plant). Recently, the excellent CO_2 capture capabilities of the solvents were confirmed through 5,000 hours continuous operation. A separate compression process is applied for the captured CO_2, which is then stored to be sold for industrial and agricultural uses.

CHNG is also conducting substantial research in the development of CO_2 capture technology. Especially noteworthy is the construction and operation of a demo plant capable of approximately 120,000 tons of annual CO_2 capture in 2009, which is the largest in Asia in terms of CO_2 capture capacity (location: Shidongkou power plant in Shanghai). In particular, CO_2 capture technology developed by Huaneng CERI is considered to be highly economical in terms of cost of CO_2 avoided.

KEPRI/KOMIPO CO_2 Capture Pilot Plant
70,000 tCO_2/y (Boryeong, Korea)

Huaneng CO_2 Capture Demo Plant
120,000 tCO_2/y (Shanghai, China)

2. Research Content

The joint international research project plans to utilize the pilot post-combustion CO_2 capture plants developed and operated by KEPRI/KOMIPO and the Huaneng CERI to conduct cross-performance evaluation on the advanced CO_2 solvents and processes developed by each company, securing a track record for entry into the global CO_2 capture technology market and objectively demonstrating the technology reliability. [Refer to Figure]

For the first time in the field of international CO_2 capture technology research, cross-evaluation of solvent performances in different capture plants, with the CO_2 solvents developed by KEPRI (KoSol series) being tested in the Huaneng Shidongkou CO_2 capture plant, and the solvents developed by Huaneng CERI (HNC series) being tested in the Boryeong CO_2 capture plant, will be performed. In addition, development is underway to substantially improve the performance of specialised capture technology both institutes possess (KEPRI: development of an accelerator for faster CO_2 absorption & regeneration, Huaneng CERI: development of additives to improve long-term solvent durability). With the cross-performance evaluation and joint advancement research using the pilot-scale post-combustion CO_2 capture plants as a basis, KEPRI/KOMIPO and Huaneng CERI will conduct SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis on the CO_2 capture technology of both institute. Using the analysis results, optimum CO_2 capturing solvent & process development and joint intellectual property rights will be secured to establish a foundation for entry into the global CO_2 capture technology market in the future.

3. Future Prospects

As of 2017, wet amine-based post-combustion CO_2 capture technology has already been technically verified through the operation of commercial CO_2 capture technology plants with an annual capacity of over 1 million CO_2 tons in countries such as the United States and Canada. Therefore, the future research and development should be aimed at minimising the energy penalty in capture process operations, as well as reducing the capital and operating expenditure of the CO_2 capture technology.

The collaboration of China's great potential and economic competitiveness in the CO_2 capture technology market and Korea's advanced engineering technologies in the field of post-combustion CO_2 capture processes is expected to produce great synergy in the CO_2 capture technology field for the benefit of both nations, as well as generating a large ripple effect in related research globally.

The CO_2 capture technology field for the benefit of both nations, as well as generating a large ripple effect in related research globally.

Overview of the post-combustion wet amine CO_2 capture plants

- KEPRI & KOMIPO: Boryeong No. 8 power plant, South Korea, annual CO_2 capture capacity approximately 70,000 tons (Completed in 2013)
- Huaneng CERI: Shidongkou No.2 power plant in Shanghai, China, annual CO_2 capture capacity approximately 120,000 tons (Completed in 2009)

Mighty CCS Projects from little Acorns Grow

Acorn, a ground-breaking carbon capture and storage project, is moving forwards after several funding announcements this year. In May, Acorn was awarded funding from the EU funding round 'Accelerating CCS Technologies' (ACT), part of ERA-NET programme. This feasibility study work is now underway. On top of this, the Scottish Government has announced their support of Acorn and the provision of £100,000 to underpin the feasibility study and progress CCS in Scotland . Following several false starts in recent years, Acorn is an exciting step forwards for CCS in the UK.

Acorn is a small scale full chain project in North East Scotland. CO_2 is captured from existing emissions at the St Fergus gas terminal, which would otherwise enter the atmosphere. CO_2 is then transported offshore and injected deep underground for permanent sequestration in a saline formation. The Acorn CCS project will re-use existing oil and gas infrastructure which is now redundant, prior to it being decommissioned. Re-using existing infrastructure, reduces project costs and makes best use of old facilities. On its current timetable the project could be operational before 2022. The project is planning to capture about 200,000T/y of CO_2.

The project would demonstrate the commercial and regulatory aspects of CCS project development in the UK. This would include the commercial aspects of transferring oil and gas infrastructure for use in CCS, the implementation of CO_2 storage permits and development of funding and risk allocation aspects of CCS projects.

Acorn also acts as a seed from which CCS in the UK can grow. Additional CO_2 sources can be added, including Peterhead Power station, ship import via Peterhead Harbour and transport via existing pipeline from industrial and power sources in Central Scotland. Additional transport and storage infrastructure can easily be developed, re-using additional oil and gas pipelines and developing storage sites in the Central North Sea, where data exists from our oil and gas heritage and there are many large-scale storage reservoirs.

Despite considerable effort, the UK has struggled to get Carbon Capture and Storage (CCS) started. The UK government has run two competitions to select a project but none have made it to construction. The scale of the proposed projects, with capital costs over £1bn, in a new market have prevented public and private sector agreement being reached.

CCS remains vital for the UK, and many other countries, to meet climate change obligations. By capturing CO_2 from industrial sources and existing thermal power stations we can significantly and quickly reduce our emissions. In addition, CCS enables the generation of Hydrogen in bulk, which can also be used for low carbon heating and transport.

CCS also has significant potential to generate economic value and create jobs through the delivery of future projects in the UK internationally. The UK is well placed with CCS supply chain skills to address this emerging market.

The time has come for the UK to deliver its first CCS project. A project on a small scale, re-using existing oil and gas infrastructure and ideally placed for subsequent CCS growth. A project like Acorn.●

NETL CO_2 Capture Technology Review Meeting, 21st - 25th August 2017, by Monica Garcia & Keith Burnard

As it does annually at this time of year, NETL chose Pittsburgh to host the 2017 review of the results and future plans of CO_2 capture technology projects that currently receive funding from the US DOE's Office of Fossil Energy. With the DOE having some involvement in the vast majority of research and development on CO_2 capture in the United States, the event marks an excellent opportunity to catch up on progress.


Dr Keith Burnard, IEAGHG

Lynn Brickett, NETL's Carbon Capture Technology Manager, opened the meeting by welcoming the 160 or so attendees. While the attendance comprised largely of representatives from the DOE, NETL, the national laboratories, industry and various research organisations, there was also a strong international contingent present. During her welcome, Lynn advised that there would be a break in proceedings shortly after lunch on the first day to allow those that wished to go outside for the solar eclipse. As it turned out, Pittsburgh was an excellent location to experience this phenomenon; an added attraction that not all events can offer!

John Litynski, DOE's Acting CCS Division Director, delivered the opening presentation, where he spoke on the revised DOE strategy going forward. He said there would be a shift in approach from testing in pilot-scale and larger facilities to earlier stage R&D and lower TRLs. Interestingly, industry would be expected to take much more of a lead in progressing technologies post-TRL5 to commercial. And 90% capture would no longer be a technology target, with the new priority to focus rather on the economics of the process. Otherwise, current priorities on such things as materials, oxy-combustion and chemical looping, for example, would remain.

Following a series of opening keynotes from EPRI, IEAGHG, Gassnova, TCM, Gamma Energy Technology and Southern Company, the meeting continued with extensive coverage of the full portfolio of CO_2 capture-related technologies, systems studies, modelling and technologies for CO_2 re-use. Ongoing work on solvents, sorbents, membranes, hybrid approaches, oxy-combustion, chemical looping, post- and pre-combustion, and CO_2 compression technologies at various stages of development was described. Presentations covered work undertaken at lab/bench-scale, small pilot-scale and large pilot-scale.

Highlights over the week included presentations on advances in post-combustion, where topics such as the characterisation of new solvents, studies on improved materials for membrane separation and novel process configurations were covered, a good part at high TRLs. There was also significant coverage of CO_2 utilisation projects at lower TRLs and just beginning their funding cycle. Lines of research included the use of CO_2 in synthesising chemicals and fuels, plus other final products such as cement. CO_2 re-use involved new chemical routes, novel catalytic processes and the use of lower footprint materials such as algae. Presentations during the final session were focused on chemical looping and oxy-combustion. Results showing microscopic observations of haematite at high temperature in chemical looping opened an interesting discussion on the chemical reactions taking place.

There was also a feature during the meeting on NETL's Carbon Capture Simulation for Industry Impact (CCSI2), a computational tool arising from the premise that developing a capture technology from inception to commercial availability is a tremendously costly endeavour. If a single stage, or even more than one stage, of the development could be achieved less expensively and/or more quickly, it would be very attractive and would accelerate the commercialisation of carbon capture technologies. CCSI2 is a partnership among national laboratories, industry and academic institutions to apply cutting edge computational modelling and simulation tools to precisely this aim.

It was evident from the numbers in attendance and the breadth of information imparted that R&D on CO_2 capture in the United States is in a healthy state. Options at various stages of development bode well for the future. Efforts to drive down costs are progressing. With its new strategy and renewed funding commitments, the DOE's programme looks set to continue the good work for which it is internationally renowned. ●

Visiting the Osaki CoolGen Project and Some Odd Connections, by John Gale, IEAGHG

The OsakiCoolGen project is sited on the island of Osakikamijima in the Seto Island sea, an area famous for its mild climate and production of lemons. To be clear The OsakiCoolGen Project is not a CCS demonstration project but a project that is demonstrating Japanese oxygen blown IGCC technology. It will however add a slipstream physical absorption capture train in 2019/2020 and around 2021 test fuel cell technology on a slipstream from the capture facility around 2021.

For me this was an intriguing project to visit because in my earlier life with British Coal I was involved in the development of the air blown pressurised gasification system. The company developed the gasifier as part its combined cycle power generation technology known as the "Topping Cycle " Then later as a consultant I was involved in an assessment of the potential for IGCC deployment in China at a power plant near Xiamen in Fujian province. As part of that project, I had the fortunate task of taking a party of Chinese engineers to visit the key IGCC demonstration projects at that time: Wabash River and Tampa Electric projects in the USA, Buggenheim in the Netherlands and, Puertollano (Spain). I also have had the opportunity to visit the Huaneng GreenGen IGCC project in China. Therefore, an opportunity to visit to the OsakICoolGen Project was one not to be missed as gasification is in my blood.

At the time of visiting the IGCC unit was operational and was firing on a sub bituminous coal imported from Indonesia. I note this is a new development since all the 1990's IGGC demonstration projects as I recall ran on bituminous coal. The IGGC plant had completed its first 500 hours of continuous operation and was producing an output of 134 MWe that was being fed to the grid. The maximum plant rating is 166MWe. The project team were setting up to start a continuous and/or endurance 5000 hour test, which they exuded confidence they would achieve.

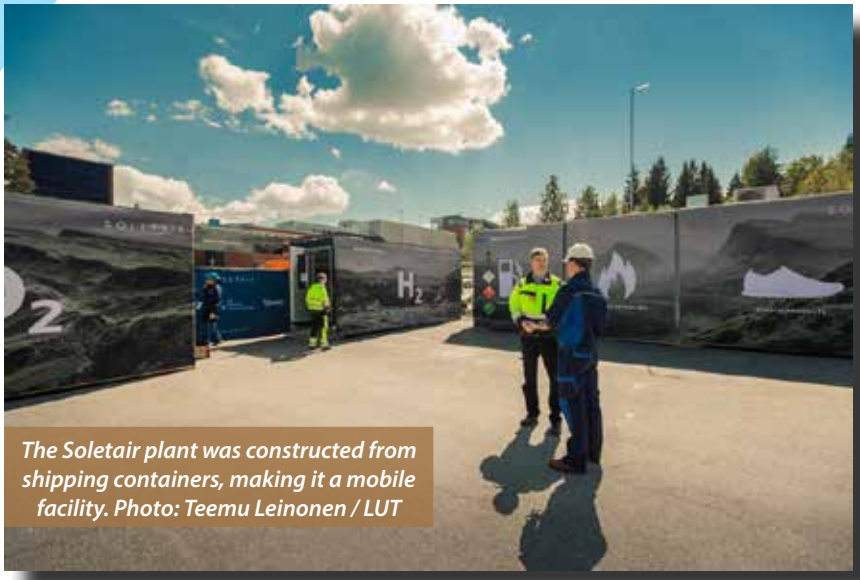
IGCC technology offers the potential for higher electrical generation efficiencies than pulverised coal plant, increased efficiency of course translates to reduced CO2 emissions. With advanced 1700 GT,'s the efficiency could reach 48%, comparable or just above that of Advanced Ultrasupercrticial plants. The OsakiGoolGen team and J-Power, suggest that IGGC technology could be more reliable and less costly than A-USC, more deployable in developing countries and may be more operational flexible. If they are right and the planned operations at CoolGen prove that then this is a big step forward in the cleaner use of coal. One other interesting twist to my visit. The Osaki Power Station until operated to 2011 a 250MW PFBC power plant. In my clean coal days at British Coal, I was also briefly attached to the PFBC demonstration project at Grimethorpe, UK. This was an IEA collaborative project, to my recollection the only one of its kind.

Finnish Researchers use Air, Solar Power to Create Renewable Hydrocarbon, by Kristin Onarheim, VTT

Researchers developed a new technology for producing a renewable hydrocarbon. The process has the potential to shakeup the global energy industry -- if it moves beyond the experimental stage. Piloted by a consortium of energy players working with the Lappeenranta University of Technology and the state research agency VTT, the Soletair project has generated a great deal of international interest.

Hydrocarbons are among the world's most important compounds, as they are refined into fuels for use in cars, ships and aircraft. They are also used in the production of plastics.

In Finland, a pilot plant known as Soletair – a joint venture between the Technology Research Centre of Finland VTT and the



The Soletair plant was constructed from shipping containers, making it a mobile facility. Photo: Teemu Leinonen / LUT

Soletair's end product is a potential replacement for fossil-based crude oil, a renewable hydrocarbon. Photo: Teemu Leinonen / LUT

Lappeenranta University of Technology LUT -- has been set up to use hydrogen extracted from water and carbon dioxide captured from air as raw materials to produce hydrocarbons.

The experimental facility was constructed using three shipping containers and is located on the campus of the Lappeenranta University of Technology in southeast Finland. The process requires a great deal of electricity, so the facility generates its own energy from an on-site solar power plant.

Essentially, the final product is a renewable carbon-neutral oil whose usage does not accelerate global warming.
"We can produce gasoline, diesel, kerosene and the raw material for plastics. In practice the product can replace the fossil fuel-based crude oil that is now used in refineries," explained VTT lead researcher Pasi Vainikka.

Existing technology with a new twist

To the layman's ear, extracting crude oil from air and water sounds revolutionary, but there is nothing especially new about Soletair's technology.

Hydrogen is separated from water using electrolysis. Carbon dioxide is recovered from air using a unit that resembles an air scrubber or purifier, which is used in craft such as space shuttles and submarines.

Carbon dioxide and hydrogen are combined using the Fischer-Tropsch synthesis method that has been known for nearly 100 years. What is new is the networking among the devices and the use of solar energy as a power source.

One of the main goals of the research project has been to validate the technical functionality of the process in one spot. Due to its chemical properties the product is suitable for refinement as is.

The plant also produces a solid, waxy substance that looks and feels like wax from an old-fashioned paraffin candle.

"Technologically, the ability to replace crude oil is in place. That's what we want to demonstrate," Vainikka said. After surmounting initial hurdles, researchers have been able to make the equipment work in sync.

Implications for the transport sector

As an experimental facility, Soletair will produced about 200 litres of renewable fuels and chemicals for research purposes during the summer. By contrast, global consumption of fossil fuels is roughly 100 million barrels per day.

Understandably, Soletair's end product will be more expensive than traditional crude oil. The research team has estimated that if the price of the solar power used in the process is 25 euros per megawatt hour, then Soletair oil would cost approximately 140 US dollars a barrel between 2030 and 2040. That is on par with the price of crude oil from back in January 2008, but today's prices are less than 50 dollars a barrel.

However project leaders point out that the production costs of solar energy are falling and the technology used by Soletair will become cheaper with mass production.

Soletair production would be cheapest in areas such as North Africa, where solar energy is almost limitless. In Finland, the technology could run on alternative energy sources such as wind, nuclear or hydro power.

Oil is still the most important primary energy source in the world and it is widely believed that replacing it is the most difficult aspect of combating climate

change. We could probably use electric cars, but heavy mass transit such as cargo shipping, air transportation and the chemical industry will need hydrocarbons for some time.

A crucial question facing the expansion of technology like Soletair's would therefore be extending strict emission reduction targets from electricity and heat production to transportation.

"If the air transport industry has to significantly reduce emissions, then something like this might become indispensable," Vainikka observed.

The sample bottle contains renewable hydrocarbons. Photo: Teemu Leinonen / LUT

Electricity from storage to business activity

The Soletair project also involves another debate flashpoint in energy technology – electricity storage. The proliferation of solar and wind energy means that sunny and windy days may create more energy than is needed for consumption.

"Battery technologies are becoming common but creating large-scale energy storage also requires chemical processes. This is an example of that," said LUT professor Olli Pyrhönen.

At the Soletair plant, extra electricity is stored as hydrocarbons. It can be deployed as a mobile plant that can be taken wherever decentralised power generation is located.

Similar projects are also in the works in the United States and the global oil giant Shell is using a similar kind of synthesis at a project in Qatar -- however that project uses fossil-based natural gas as a raw material. ●

IEAGHG Information Papers and Blogs Published Since June 2017

IP Number	IP Title	Publication Date	Author
2017-IP30	Soil organic carbon sequestration	20/06/2017	Jasmin Kemper
2017-IP31	ZEP Press Release on Launch of Fast Track TS report	23/06/2017	N/A
2017-IP32	Mission 2020 – A New Global Strategy to "Rapidly" Reduce Carbon Emissions	29/06/2017	John Gale
2017-IP33	CEMCAP	30/06/2017	Monica Garcia
2017-IP34	New Threat to Ozone Layer Could Undermine Gains made by Montreal Protocol to date	05/07/2017	John Gale
2017-IP35	New Analysis Suggests Warming Has Been Much Faster Than Previously Predicted	05/07/2017	John Gale
2017-IP36	CONFIDENTIAL	07/07/2017	John Gale
2017-IP37	Water-Lean Solvents for Post-Combustion CO_2 Capture: Fundamentals, Uncertainties, Opportunities and Outlook	12/07/2017	Monica Garcia
2017-IP38	Volatility of Amines for CO_2 Capture	12/07/2017	Monica Garcia
2017-IP39	Fusion Power now not Ready Before 2050 at Earliest	12/07/2017	John Gale
2017-IP40	Climate & Clean Air Coalition (CCAC) Annual Science Update 2016	12/07/2017	N/A
2017-IP41	Renewable Deployment not all Plain Sailing	12/07/2017	John Gale
2017-IP42	Electric Cars Lead the Transport Charge	14/07/2017	John Gale
2017-IP43	Hat trick of Hottest Years on the Way	20/07/2017	John Gale
2017-IP44	Climate Change is the Defining Drivers for the Global Economy its Investors Cannot Avoid its Impacts	20/07/2017	John Gale
2017-IP45	Three Revised Best Practice Manuals have been Released by NETL	25/07/2017	James Craig
2017-IP46	The Greenland Ice Sheet is Melting Faster than Before	26/07/2017	John Gale
2017-IP47	Introduction to New US DOE CarbonSAFE Projects	21/08/2017	Traci Rodosta
2017-IP48	Weather Extremes Caused by Global Warming is Biggest Risk to Humans	23/08/2017	John Gale
2017-IP49	Biofuels – Transport Sector Saviours or Villains	24/08/2017	John Gale & Jasmin Kemper
2017-IP50	CO_2 Use and Reuse Research - 2017 NETL CO_2 Capture Technologies Review Meeting	29/08/2017	Monica Garcia
2017-IP51	Membrane based technologies - 2017 NETL CO_2 Capture Technologies Review Meeting	29/08/2017	Monica Garcia
2017-IP52	Developments on Carbon Pricing	04/09/2017	John Gale

Blog Title	Publication Date	Author
CTCN Workshop	30/05/17	Tim Dixon
TCCS-9	15/06/17	Monica Garcia
Monitoring Network Meeting in Traverse City	19/06/17	Tim Dixon
2nd Offshore Workshop	22/06/17	Tim Dixon
End of the ROAD	29/06/17	John Gale
MIssion 2020 - 3 Years to Save the Planet	29/06/17	John Gale
New IEAGHG Report: CCS Industry Build Out Rates - Comparison with Industry Analogues	04/07/17	Keith Burnard
Latest news on Kemper Disappointing	06/07/17	John Gale
G20 on Climate, Clean Energy and CCS	13/07/17	Tim Dixon
RIP the ICE, "A Big Plus for Transport Emissions"	26/07/17	John Gale
IEAGHG Welcomes New Staff Member: Suzanne Killick, Events Programme Manager	26/07/17	N/A
Boundary Dam Visit during IEAGHG's Summer School	27/07/17	Lydia Rycroft
CCS Measuring, Monitoring & Verification (MMV) – Engagement Day, NOC, Southampton 17th July 2017	28/07/17	James Craig
Offshore Storage Potential Presented at US DOE Carbon Storage Meeting	03/08/17	Tim Dixon
CO_2 Storage and Geothermal Energy Benefit from Mutual Technology Applications	08/08/17	James Craig
Technology innovation that can Enhance the Monitoring of CO_2 in the Subsurface Explained at the US DOE Carbon Storage Meeting	08/08/17	James Craig
NETL CO_2 Capture Technology Review Meeting, 21th - 25th August 2017	03/08/17	Monica Garcia & Keith Burnard
PCCC4: 4th Post-Combustion-Capture-Conference, Organised by IEAGHG	11/09/17	Monia Garcia
IPIECA Workshop – "Making CCS Fly"	13/09/17	Tim Dixon
7th High Temperature Sold Looping Cycles Networl (HTSLCN) Meeting	13/09/17	Jasmin Kemper
5th CCS Cost Network Workshop (13th - 14th September 2017)	19/09/17	Monica Garcia

Conferences & Meetings

This is a list of the key meetings IEAGHG are holding or contributing to throughout 2017/2018. Full details will be posted on the networks and meetings pages of our website at www.ieaghg.org.

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

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

GHGT-14

21st - 26th October 2018, Melbourne, Australia

Greenhouse News
ISSN 2047-2218 (Online)

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

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