Greenhouse News

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GHGT-16 planning well underway, by Suzanne Killick, Events Manager, IEAGHG

As announced at the end of the GHGT-15 conference, we are delighted to confirm the upcoming GHGT-16 conference will take place in the city of Lyon in France from 23-27 October 2022.

Hosted by the French consortium of 'Club CO2' made up from – IFPEN, ADEME, BRGM and TotalEnergies, the conference is planned as an in-person event but will follow strict country guidelines to ensure all covid-19 regulations are met to mitigate any risk to those travelling and participating in the event. As a planned precaution some of the presentations will be recorded which can then be accessed post event for a fee if some delegates are still unable to travel.

The appetite for live events is now very strong especially in the CCUS industry. The benefits of being able to engage in person with colleagues and peers to share both knowledge and experiences is recognised as one of the biggest advantages when compared to trying to engage via a virtual platform.

With this in mind the plans and venues for the GHGT-16 conference are now well underway and will offer both spacious and well-equipped meeting space as well as diverse and interesting venues for the social activities included in the conference fees.

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GHGT-16 will be held at Congres de Lyon, Lyon, France.

Lyon Conference centre main plenary space

Designed by Renzo Piano, state-of-the-art facilities next to the Parc de la Tête d'Or, the Lyon Convention Centre can compete with all major international convention centres. Inspired by ancient Gallo-Roman constructions, the venue has an amphitheatre that is unrivalled in Europe, with a 180° semi-circular hall opening onto the stage area. This prestigious event complex in the heart of the city centre is equipped with state-of-the-art Internet connections with high-quality Wi-Fi and 4G access, thanks to fibre optics installed throughout the building. Situated in the Cité internationale complex, the Lyon Convention Centre has a host of on-site services and amenities: parking, hotels, restaurants, cinema, Casino, Museum, etc.

The call for abstracts to GHGT-16 opened in September 2021 and closed in January resulting in abstract submissions from over 800 authors from nearly 40 countries. These abstracts are now in the review process with authors expected to be offered either and oral or poster presentations before the end of April 2022.

As the CCUS industry evolves we see this in the main themes that authors are submitting their abstracts to. For 2022 we see a significant increase in abstracts relating to storage and respective sub-themes and a decrease in abstracts relating to capture and respective sub-themes. This of course reflects on the number of sessions we will have to cover the topics, which take place as a seven-stream programme across four days delivering 355 oral presentations, 6 panel discussions and 2 E-poster sessions.

For the social activities we will open the conference on the Sunday 23rd October with the much missed 'welcome reception' taking place in the older part of the city at the 'Palais de la Bourse' (the old stock exchange) here we can meet up with colleagues and welcome new faces in a relaxed atmosphere before the hard work of the conference begins the next day.

Also planned is the conference dinner on the evening of Wednesday 26th October in the unusual venue of the Sucriere buildings where we will provide transport to delegates attending to the venue for a gastronomic evening of the specialities of Lyon cuisine and again the chance to network with peers. Students and alumni are invited to their own reception on Tuesday 25th October straight after the conference day at a venue just outside of the conference building.

With a strong level of sponsorship verbally committed so far, we are planning to open the registration for the Early bird fees for both regular delegates and students by April. Prices will be payable in Euros and will include all local taxes, conference entrance to all areas, lunch and breaks during the conference, and invitation to social activities.Along with our hosts Club CO2 we very much look forward to attending the GHGT-16, enjoying the sites and gastronomy of Lyon and finally being with our colleagues and peers from across the industry at an in-person meeting!

Regional CO_2 Storage Hub Development for CCS Deployment in the Southeast United States, by Richard Esposito, Southern Company

The U.S. Department of Energy's Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative supports projects that focus on the development of geologic storage sites for more than 50 million metric tons (MMT) of CO_2 from a wide range of sources. The program allows industry partners to move through four separate phases of development with the goal of making an injection storage site ready for commercial operation with very low risk. The Project site, shown in Figure 1, is in proximity to Southern Company subsidiary Mississippi Power's Plant Ratcliffe, in Kemper County, Mississippi. The project is led by the Southern States Energy Board in coordination with Southern Company Research and Development and Mississippi Power.

To date, a 30,000-acre area of interest (AOI) in eastern Mississippi has been identified and characterized. The AOI is underlain by more than 6,000 feet of sedimentary geologic formations. The target storage and confining formations are in the Cretaceous section of the AOI. In total, six wells have been drilled to characterize storage reservoirs and confining units. Open hole geophysical well log data indicates that the target storage horizon consists of a series of three stacked saline reservoirs separated by intervals of shale and mudstone. The target storage reservoirs are considerably thick, with net sand thickness commonly more than 100 feet. Similarly, the primary confining interval for the target horizon is frequently greater than 200 feet thick. More than 300 feet of whole core was collected from the characterization wells. Routine core analyses reveal the exceptional properties of the target saline reservoirs with porosity values commonly approaching 28% and 1 to 3 Darcy-class permeability. This allows for high volume injectivity and large long-term storage capacity. To further characterize the subsurface and identify subsurface risks, the project team acquired 92 linear miles of two-dimensional seismic data.

In addition to the subsurface characterization work, the project team is conducting a capture assessment to identify appropriate capture technologies for potential CO_2 sources in the region. Last, the project team is developing Underground Injection Control Class VI Permit application for review by EPA Region 4. The project represents a strategic initiative in the Southeast United States to advance the deployment of commercial-scale CCS.

Acknowledgements: The authors would like to acknowledge the financial support of the U.S. Department of Energy (DE-FE00031888) and the oversight provided by the National Energy Technology Laboratory.

Figure 1. Drone photo of Project E CO_2S field operations and the drilling of one of the six test wells. Photo: R.A. Esposito

Two eCCU pilot plants at one site

by Peter Moser, RWE

The Horizon 2020 projects LOTER.CO2M and OCEAN started commissioning at Niederaussem to demonstrate electrochemical CCU chains: Valorisation of captured CO_2 as feedstock for sustainable fuels and chemicals.

Without a strong contribution from all economic sectors the net-zero climate protection targets cannot be achieved. Fossil feedstock for the chemical industry and fossil fuels for long-distance transport must be substituted. Therefore, the reduction of CO_2 emissions by carbon capture and utilization (CCU) and an intersectoral carbon cycle economy will be crucial for the transformation of the supply systems in the future. Very promising are electrochemical synthesis technologies (eCCU) to produce fuels and base chemicals from renewable electricity and captured CO_2 as they can simplify process chains, reduce components and avoid high temperatures and pressures. In contradiction, the conventional thermo-chemical synthesis routes based on CO_2 and electrolytically produced H^2 typically require temperatures >300°C and pressures >20bar for the reverse water-gas-shift reaction and consecutive process steps. Additionally, eCCU reduces the need for a H2 infrastructure, lowers greenhouse gas emissions and offers security of supply and grid stability in an energy scenario relying heavily on renewable power generation.

For the economic viability it is a great advantage to couple the cathodic CO_2 reduction with a suitable oxidation reaction at the anode in order to avoid the formation of oxygen which normally cannot be utilized and would then be released to the atmosphere. Coupling of oxidative and reductive electrosynthesis processes is a key to improve efficiency while reducing costs, wastes and emissions. That is exactly what is now demonstrated as part of the European Horizon 2020-funded project OCEAN (No. 767798; www.spire2030.eu/ocean) at RWE's Innovation Center at Niederaussem, Germany. The process was engineered by Avantium, a leading technology company in renewable chemistry from the Netherlands, and the 6 kWel unit was constructed by the Italian engineering company Hysytech. Potassium formate is produced simultaneously at both electrodes of the electrochemical cell, cathode and anode. At the anode, glycerol – a by-product of the biodiesel production – is the feedstock and at the cathode CO_2 is converted. In consecutive processes oxalic acid can be produced from the formate as an intermediate for high-value specialty chemicals.

Two eCCU demonstrators are at the site in Niederaussem: this is the OCEAN unit.

E-fuels will be needed in applications where the poor energy density of batteries or hydrogen is prohibitive (e.g. aviation and long-haul transportation by truck and ship). E-fuels like alcohols and hydrocarbons offer a way to store and transport chemical energy effectively with a high density at a large scale and for long periods of time. E-fuels allow to use the existing supply system and infrastructure and could defossilize the existing vehicle fleet. The project LOTER.CO2M (No. 761093; www.loter CO_2m.eu) has developed advanced low-cost electro-catalysts for the direct electrochemical reduction of CO_2 to methanol and other important industrial feedstocks, like ethanol and ethylene. The developed electrochemical synthesis system works without the use of critical raw materials. The containerized 5 kWel demonstrator of the low-temperature and low-pressure CO_2-H2O co-electrolysis has been manufactured by the Belgian technology developer VITO. The LOTER.CO2M technology builds the basis for the follow-up project E CO_2Fuel (No. 101037389; https://e CO_2fuel-project.eu) which aims at the realization of the worldwide first low-temperature 1 MW direct, electrochemical CO_2 conversion system to produce sustainable liquid e-fuels (C1-C4 alcohols) under industrially relevant conditions. Like LOTER.CO2M, this ambitious project is coordinated by the German Aerospace Center (DLR) and started in October 2021.

The OCEAN and LOTER.CO2M units are fed by CO_2 that is captured by RWE's amine-based post-combustion capture pilot plant and operated 24/7 by the team on site. In the ongoing test program the performance of the technology is assessed and the operational behavior during startup, ramp up/down cycles, operational parameter variations and continuous full-load operation are evaluated.

Both projects have received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreements No 767798 (OCEAN) and 761093 (LOTER.CO2M).

Two eCCU demonstrators are at the site in Niederaussem: this is the LOTER. CO2M unit.

IEAGHG Risk Management Network Webinar: 'The Road to CCS Project Permitting' by Samantha Neades, IEAGHG

On Tuesday 18th January 2022, the IEAGHG Risk Management Network held a webinar on CCS / CCUS project operator experience with risk management during the permitting process. This webinar heard from panellists on the Northern Lights project, the Porthos project, California experiences with permitting and Oxy's recent project experiences.

The webinar attracted an audience of 138 in addition to 8 panellists and 2 IEAGHG staff. The IEAGHG Risk Management Network aims to bring worldwide experts together to discuss topics pertinent to the risk management of CCS / CCUS projects including risk analysis, risk data management, regulatory engagement and impacts of activities. This webinar was an informal roundtable discussion to learn about the experiences that project operators have had relating to risk management during the permitting process, provide an understanding of the challenges faced and explore potential ways to overcome such issues for future permits. We welcomed speakers from CCS projects and industry to hear their views and learn more about the challenges they have faced, specifically when going through the permitting process.

The key messages from the webinar overall were:

- CO_2 storage monitoring is similar to conventional reservoir processes but involves additional methods and systems related to special elements for injection and long-term storage.
- The CO_2 MMV plan needs to address several issues: safe site operations; regulatory requirements; public concerns; and secure long-term storage.
- CO_2 storage is still a relatively new technology with immature business drivers.
- The CO_2 storage risk profile is important and shows that the highest risks occur during injection, then the risk rapidly decays as a function of time.
- Risk management in storage involves four key technical areas: containment; seismic; operational; and commercial.
- A key initial step in the risk management and permitting process is to start early and thoroughly understand the requirements.
- Dialogue and collaboration between operators and regulators can be beneficial.
- Operators should be prepared for surprises throughout development and breaking new ground.
- The bow-tie method can be a valuable approach for risk management.
- Leveraging subsurface and operational knowledge and experience is very valuable.
- Long-term liability is an important factor to consider early on in the permitting process.
- The key affecting components of long-term liability are the reservoir and legacy wells, so site selection and well location, assessment and remediation (if needed) are crucial.

IEAGHG would like to thank the following panellists for their involvement in this virtual event:

- Samantha Neades, IEAGHG (UK, webinar moderator)
- Philip Ringrose, Equinor (Norway)
- Per Gunnar Stavland, Equinor (Norway)
- Bram Herfkens, Porthos Project (The Netherlands)
- Preston Jordan, Lawrence Berkeley National Laboratory (USA)
- Caroline Huet, Occidental Petroleum Corporation (Oxy) (USA)
- Robert Barrow, Oxy (USA)
- Myles Culhane, Oxy (USA)

The post-webinar report is currently underway and will be published by IEAGHG soon. IEAGHG are planning to hold a virtual Risk Management Network event with TotalEnergies in the summer of 2022 and more information will be released soon when details have been confirmed.

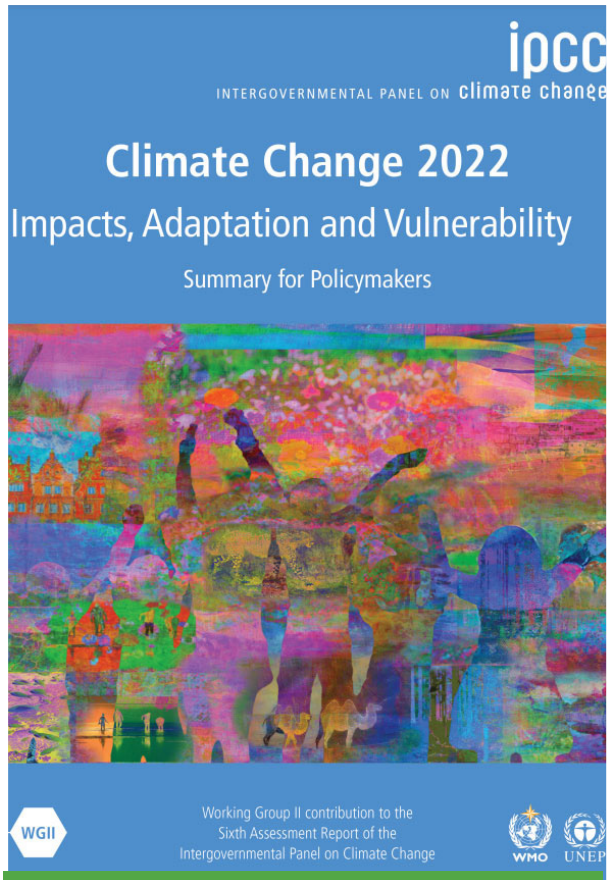
Please visit our website: https://ieaghg.org/networks/risk-management-network or contact sam.neades@ieaghg.org for more information on the IEAGHG Risk Management Network.

IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability, by Jasmin Kemper, IEAGHG

The IPCC has finalized the second part of the Sixth Assessment Report (AR6), 'Climate Change 2022: Impacts, Adaptation and Vulnerability', the Working Group II (WGII) contribution to the Sixth Assessment Report.

It was finalized on 27 February 2022 during the 12th Session of WGII and 55th Session of the IPCC. The WGII contribution to AR6 assesses the impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change. The report comprises a very comprehensive 3,675 pages and is structured into 18 chapters and in addition there are 7 cross-chapter papers. Overall, the authors have addressed more than 16k comments on the first order draft (FOD) and more than 40k comments on the second order draft (SOD).

The WGII contribution to AR6 shows unequivocally that climate change has already caused widespread adverse, and partly irreversible, impacts and related losses and damages to nature and people. It also warns that natural and human systems are being pushed beyond their ability to adapt. The window of opportunity for adaptation and mitigation, which need to go hand-in-hand, is narrowing quickly. The report contains some concerningly unbalanced statements with regards to CCS and DAC, none of which seem to have made it into the Summary for Policy Makers (SPM), although the issue of increased water use of CCS has made it onto the Technical Summary (TS).



The IPCC held a virtual press conference to present the Summary for Policymakers of the report on 28 February 2022.

However, these statements (which concern the negative impacts of mitigation approaches and thus would be expected in the WGIII report rather than in the WGII report) show that there is a potential need for IEAGHG to expand its reviewing activities of IPCC materials. We were also engaged in the review of the FOD of the Synthesis Report (SYR), which finished on 20 March. We reviewed with great care to check if concerning/unbalanced statements with regards to CCUS and CDR have made it into this report.

IEAGHG has produced two Information Papers that summarise the findings from the Working Group I & II reports.

They can be downloaded from our website:

2022-IP02: IPCC Climate Change 2022 Impacts, Adaptation and Vulnerability
2021-IP14: IPCC Working Group I report on the Physical Science Basis of Climate Change 2021

IEAGHG Information Papers Published since December 2021

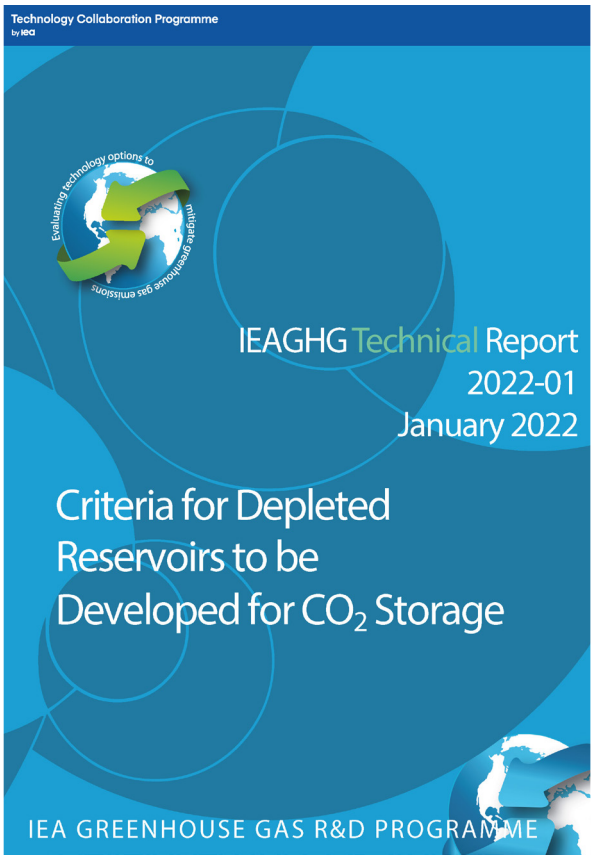
Information Paper Number and Title	Publication Date	Author
2021-IP29 CONFIDENTIAL	16/12/2021	Tim Dixon
2022-IP01 OGCI Gulf Countries CCUS White Paper External Stakeholder Workshop	31/01/2022	James Craig
2022-IP02 IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability	10/03/2022	Jasmin Kemper

IEAGHG Blogs Published since December 2021

Blog Title	Publication Date	Author
New IEAGHG Technical Report: Criteria for Depleted Reservoirs to be Developed for CO_2 Storage	17/01/2022	Samantha Neades
New IEAGHG report: Global Assessment of DACCS Costs, Scale and Potential	28/01/2022	Jasmin Kemper
UTCCS-6 – Texas hotspot for CCUS	31/01/2022	Tim Dixon
New IEAGHG Report: Current State of Knowledge Regarding the Risk of Induced Seismicity at CO_2 Storage Projects	01/02/2022	James Craig
New IEAGHG report: Assessing the Techno-Economic Performance, Opportunities and Challenges of Mature and Nearly-mature Negative Emissions Technologies (NETs)	02/02/2022	Jasmin Kemper
New IEAGHG Technical Report: Prime Solvent candidates for next generation of post-combustion CO_2 capture plants	28/02/2022	Abdul'Aziz Aliyu
New IEAGHG report: From CO_2 to Building Materials – Improving Process Efficiency	02/03/2022	Samantha Neades
IEA flagship report "Global Energy Review: CO_2 Emissions in 2021"	11/03/2022	Jasmin Kemper
Energy emission challenges from COVID and conflict - Do not forget CCS works on coal power also	16/03/2022	Tim Dixon

IEAGHG Technical Report overviews

2022-01 Criteria for Depleted Reservoirs to be Developed for CO_2 Storage



The long-term, secure storage of CO_2 depends on injection and retention within well characterised geological reservoirs, such as saline aquifers or depleted oil and gas fields (DO&GFs). The potential CO_2 storage capacity in saline formations is well understood, and the objective of this IEAGHG study was to specifically focus on a set of storage conditions that apply to depleted hydrocarbon fields. This work was contracted out by IEAGHG to the Bureau of Economic Geology at the University of Texas, Austin and was published in January 2022.

The study is split into three main sections: a review of case studies for CO_2 storage in depleted hydrocarbon fields; original research looking into reservoir pressure depletion, boundary conditions, the effect of residual hydrocarbons on injectivity and capacity; and the economics of infrastructure reuse for CO_2 storage sites. The third section discusses and integrates the lessons learned to facilitate evaluation of future depleted field storage opportunities.

This study offers a valuable record of the key criteria that operators should consider when looking into depleted hydrocarbon fields for potential CO_2 storage and the key messages learned are:

- DO&GFs are valuable and advantageous sites for the storage of CO_2.
- Site evaluation when considering depleted fields for storage should be project-specific and should consider the storage requirements and the operators' metrics for success and views of acceptable risk.
- Sub-hydrostatic reservoir pressure is a sign of closed or semi-closed reservoir boundaries and such reservoirs may offer greater storage security but also place limits on capacity.
- The presence of remaining hydrocarbon gas in place does not necessarily affect the CO_2 storage capacity of the depleted dry gas reservoirs, other than occupying pore space.
- Much of a CO_2 plume in a depleted dry gas reservoir remains mobile, while capillary and dissolution trapping mechanisms play minor roles in trapping.
- Other than occupying pore space, the amount of remaining gas in place does not significantly affect the capillary and dissolution trapping efficiency of CO_2 plume in a depleted dry gas reservoir.
- Infrastructure reuse, based on a comparison of modelled examples, will not always result in lower costs for CCS projects.
- In all projects, outreach and public relations are crucial for reassurance.
- The best scenarios for CO_2 storage in depleted fields may be 'hybrid' situations, such as CO_2-EOR or injection into the water leg down-dip of a depleted reservoir.
- The report includes key guidance on Site Evaluation and Desirable Characteristics.

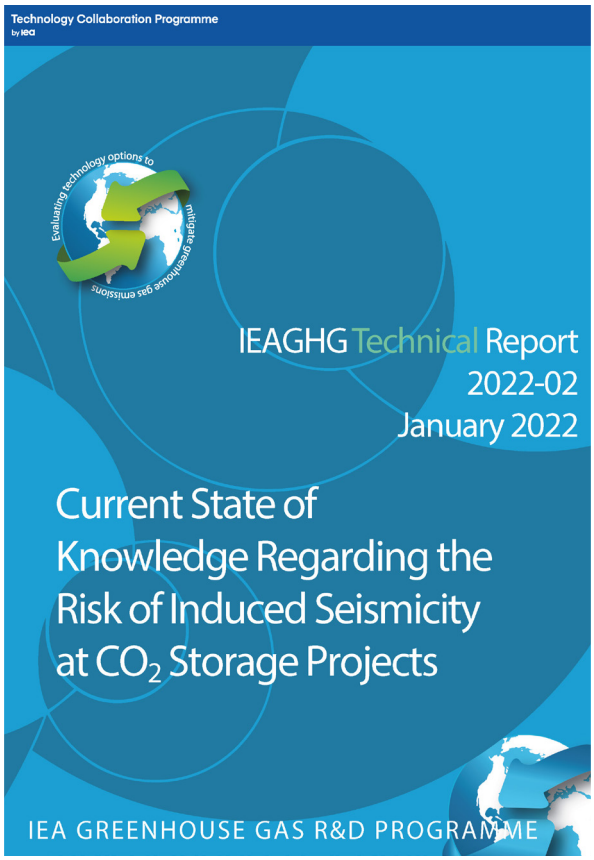
The report leads to several recommendations, including:

- More case studies of DO&GFs should be investigated, particularly projects that have reached the permitting phase for CO_2 storage.
- Further work should investigate the monitoring of CO_2 in a depleted field.
- It would be useful to consider more information on the cost-benefit analysis of storage in depleted hydrocarbon fields.
- Pipelines and platforms are the largest costs and this study suggests focusing potential further guidance in assessing these two cost elements in the case of reuse.
- Details could be taken from this work and used to create a comprehensive step-by-step guidance document for operators when selecting and evaluating a potential depleted field for CO_2 storage.

To request a copy of this report, please email tom.billcliff@ieaghg.org with the report reference number (2022-01).

2022-02 Current State of Knowledge Regarding the Risk of Induced Seismicity at CO_2 Storage Projects

This study reviewed the risk of induced seismicity at CO_2 storage sites. The phenomenon has multiple causes including waste water disposal, geothermal energy and mining. Natural seismicity is also a widespread occurrence and can detected in the same regions as industrial activities associated with induced seismicity. Consequently the detection of any seismicity has to be clearly distinguished. This study has compiled evidence from microseismic detection techniques used at demonstration CO_2 storage sites and what can be interpreted from them.



It has also examined other causes of induced seismicity notably the widespread practice of waste water disposal. The management and control measures that have been employed are discusse. Examples of outreach measures used to explain and reassure local communities that are affected by seismicity are included.

To request a copy of this report, please email tom.billcliff@ieaghg.org with the report reference number (2022-02).

2022-03 CO_2 as a Feedstock Comparison of CCU Pathways

Research, development, demonstration, and deployment of advanced solvents is at the forefront of decarbonising the fossil fuel combustion sectors with the aim of making solvent-based CO_2 capture more competitive in a net zero economy. Considering the extensive research in solvent design and development, a rapid and reliable screening protocol is imperative for new solvents and process configurations to be ranked against existing systems.

In light of the importance of vetting promising solvents for PCC, IEAGHG commissioned this study: ''prime solvent candidates for the next generation of post-combustion carbon capture (PCC) technology 2022-03, March 2022". The main objective of the study is to conduct a comprehensive assessment of the promising PCC solvents and process designs to accelerate the deployment of CO_2 capture technologies. This study further provides an analysis of the enhancement of PCC solvents and their potential functionality under standardized metrics to measure the solvents performance and their impact on capture costs including both capital expenditure (CAPEX) and operational expenditure (OPEX).

An exhaustive literature survey of solvents for PCC led to the creation of a solvent database named CO_2SOLV which comprises of 842 entries of various type of solvents that include aqueous amine solvents, solvent blends, water-free/water-lean solvent and biphasic solvents. It contains detailed properties of >107 solvents plus several process co nfiguration and modification schemes. This database includes publicly available information on installations testing solvents (at large, pilot and lab scale) for PCC, in addition to solvents reported in scientific publications and patents. This study developed a decision-matrix-tool to enable the comparison of the different solvents and processes based on Key Performance Indicators (KPIs). This performance indicators include monetised and non-monetised parameters/variables such as cyclic absorption capacity, heat of regeneration, solvent viscosity, enhancement indexing, heat capacity, degradability, surface tension, solvent cost, absorber sizing, reboiler temperature, among others.

This key messages from this study are as follows:

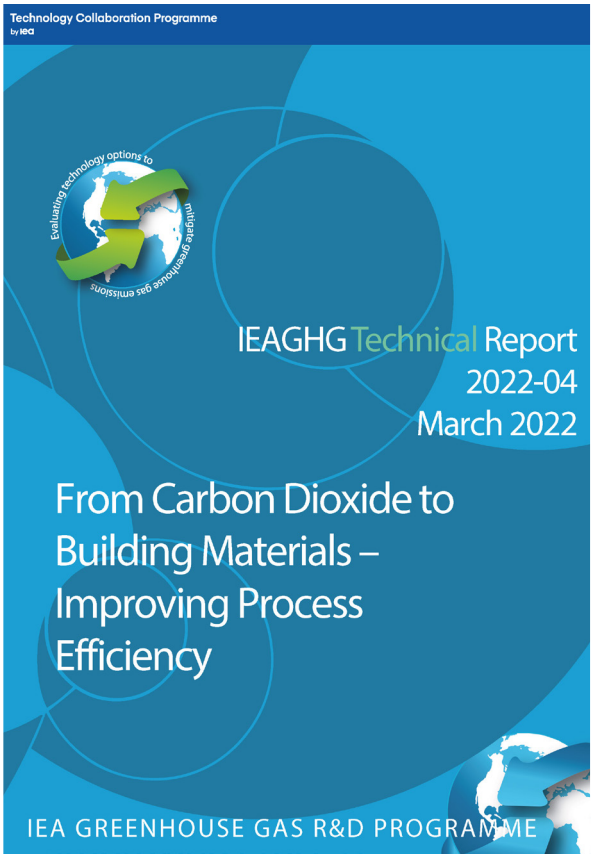
- Based on the collected data and their detailed analysis, no single amine was identified to have an overriding superior performance in terms of capital and operating costs. Most of the amines spanned between slightly better and poorer performance compared with MEA in terms of both capital and operating expenditures. The most promising amines were found to be 2-(isopropylamino) ethanol (IPAE), aminoethylethanolamine (AEEA), 2-methyl piperazine (2-MPZ), 2-(ethylamino) ethanol (2EAE), 2-amino-1,3-propandiol (2APD), 3-(methylamino) propylamine (MAPA), piperazine/2-amino-2-methyl-1-propanol (PZ/AMP) and monoethanolamine/ethylene glycol (MEA/EG).
- The solvent properties that have the most influence on the capital cost are the absorption capacity, reaction rate, absorption enthalpy (heat of absorption) and the liquid viscosity.
- In terms of process configurations, the most promising modifications include absorber inter-cooling, rich solvent split, stripper overhead compression, split flow, and lean vapour compression as per the reduction in the specific reboiler duty.
- In terms of process configurations, the most promising modifications was found to be absorber inter-cooling, rich solvent split, stripper overhead compression, split flow, and lean vapour compression as per the reduction in the specific reboiler duty. However, a techno-economic analysis is needed to account for the possible trade-off in the capital costs.

- Integration of two or more process modifications can potentially induce positive interactions and synergy in maximizing effects and mitigate offsets. Dual process integration showed various impacts on the overall process with a reported reduction of the specific reboiler duty (SRD) ranging from 11% to 39% when simulating MEA. Further study to evaluate the behaviour of other emerging solvents under the influence of multiple process modifications is expected to yield lower SRD. However, new research is expected to reveal the extent of savings in terms of the relevant indicators like SRD.

To request a copy of this report, please email tom.billcliff@ieaghg.org with the report reference number (2022-03).

2022-04 From CO_2 to Building Materials – Improving Process Efficiency

Decarbonising the economy through CCUS relies not only on viable methods to capture CO_2 but also efficient usage and/or storage of that CO_2. In some instances, e.g. where large transport distances are required, or for countries which do not have large geological storage resources, utilising the captured CO_2, or carbon capture and utilisation (CCU), may be the most effective way to decarbonise rather than transporting to a storage site.



This new study investigates how captured CO_2 may be used in building materials and explores the processes used to capture the CO_2. The study looked into the effects of carbonation on material utilisation, the design of a potential typical carbonation plant, and undertook a market analysis of carbonated building products.

This study offers a valuable insight into how capture CO_2 can be used in building material, with several key messages including:

- Accelerated carbonation products have the potential to be used as aggregates, fillers, reactive fillers, and supplementary cementitious materials (SCM).
- Carbonation is a relatively expensive method of CO_2 utilisation unless there is substantial avoided cost associated with raw material disposal.
- There is a degree of discrepancy between theoretical and experimental uptake rates for different materials. The measured CO_2 uptake is significantly lower than an estimation based solely on composition.
- It is important to consider the inherent trade-offs between each potential use – carbonating materials or use as an SCM.

- In many cases, carbonated materials should be preferentially used as a supplementary cementitious material or otherwise blended in to cement where possible.
- Non-Portland cementitious materials are frequently carbonated and can be used as an additive to cement and contribute to strength development in the final product. Note that the total amount of CO_2 present in the cement should generally not be too high as it can reduce the pH of the cement binder and dilute its cementitious properties.
- Natural carbonation processes will occur which will reduce the additionality of accelerated carbonation.
- Carbonation can act as a waste treatment process, stabilising heavy metals.
- The main driver for carbonation processes is the avoidance of landfill costs where applicable.
- Current market prices suggest that the market for carbonated products is limited and will be closely linked to robust CO_2 pricing mechanisms that recognise and value the mitigation service of carbonation.
- Further research is needed both to understand the potentials of more novel carbonated materials to store CO_2, and their production processes, as well as to understand their material properties.
- There is currently insufficient pull from the construction industry for carbonated or low carbon emission produced products.

To request a copy of the report, please email tom.billcliff@ieaghg.org with the report reference number (2022-04).

2022-05 Feasibility Study on Achieving Deep Decarbonization in Worldwide Fertilizer Production

Food production is expected to increase due to global population growth and, consequently, fertilizer production will be essential for global food security. Currently, the carbon dioxide (CO_2) emissions linked to fertilizer production are approximately 400 Mt/year (over 1% of global energy-related CO_2 emissions) with a predicted growth to 550 Mt/year by 2050. Fertilizers are basically produced from ammonia. It then follows that the feedstock used in ammonia production will play a significant role in the amount of energy consumption and CO_2 emissions produced during food production.

To limit the impact on the environment caused by the current ammonia production routes, which rely significantly on fossil fuels both as an energy source and as feedstock, sustainable production pathways need to be implemented. Since only nitrogen and hydrogen are required for ammonia synthesis, there are few variables for process optimization. The conventional steam methane reforming (SMR) hydrogen production route is one of the primary variables in the environmental impact of the ammonia process. The application of carbon capture on the production of fertilizer is recognized as one of the least-cost methods of capturing CO_2 from a thermodynamic and process perspective; and is equally attractive as it also has one of the lowest cost impacts on the price of the commodity.

IEAGHG commissioned a study on the 'Feasibility Study on Achieving Deep Decarbonization in Worldwide Fertilizer Production 2022-05, March 2022" to provide an overview of fertilizer production processes with and without CO_2 capture. Assessment of the identified fertilizer production processes from a broader environmental perspective was also included. Further, this study analysed the results and has provided recommendations on how deep decarbonization of fertilizer production can be achieved for regions such as Europe, North America, and the Middle East.

Three ammonia production routes for fertilizers are analysed and compared as follows:

Case 1: Production of ammonia from natural gas without CO_2 capture from SMR flue gases (base case)
Case 2: Production of ammonia from natural gas with CO_2 capture from SMR flue gases
Case 3: "Hybrid" production of ammonia from water electrolysis (partial) and natural gas, with CO_2 capture from SMR flue gases.

This study has highlighted the decrease of direct CO_2 emissions from the ammonia process derived from CO_2 capture. Specifically, the highest environmental benefit was gained from where an impact reduction of up to 70% was observed. In UK, USA and Saudi Arabia the impacts decreased by 53%, 40%, 33% respectively. In general, the results of this study implied that the environmental impacts of the fertilizer production routes investigated are mainly affected by energy (natural gas and electricity) demand and the related supply chain. The Norwegian case study was found to be the most sustainable option for fertilizer synthesis due to its significant environmental savings compared to other three cases in this study.

To request a copy of the report, please email tom.billcliff@ieaghg.org with the report reference number (2022-05).

Conferences & Meetings

This is a list of the key meetings IEAGHG are holding or contributing to throughout 2022. 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: tom.billcliff@ieaghg.org.

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

IEAGHG Webinar: Current State of Knowledge Regarding the Risk of Induced Seismicity at CO_2 Storage Projects
13th April 2022, Virtual, Online

IEAGHG Webinar: Feasibility Study on Achieving Deep Decarbonization in Worldwide Fertilizer Productions
24th May 2022, Virtual, Online

CSLF Workshop on CDR
28th June 2022, Bergen, Norway - more details to follow

UKCCSRC Spring 2022 Conference – Building capacity for CCS deployment
20-21st April 2022, Sheffield, UK/Online

5th Offshore CCS Workshop
19th May 2022, New Orleans, USA - more details to follow

2nd International Conference on Negative CO_2 Emissions
14th - 17th June 2022, Chalmers University, Gothenburg, Sweden

14th International CCS Summer School
Summer 2022 (TBC)

GHGT-16
23rd - 27th October 2022, Lyon, France

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