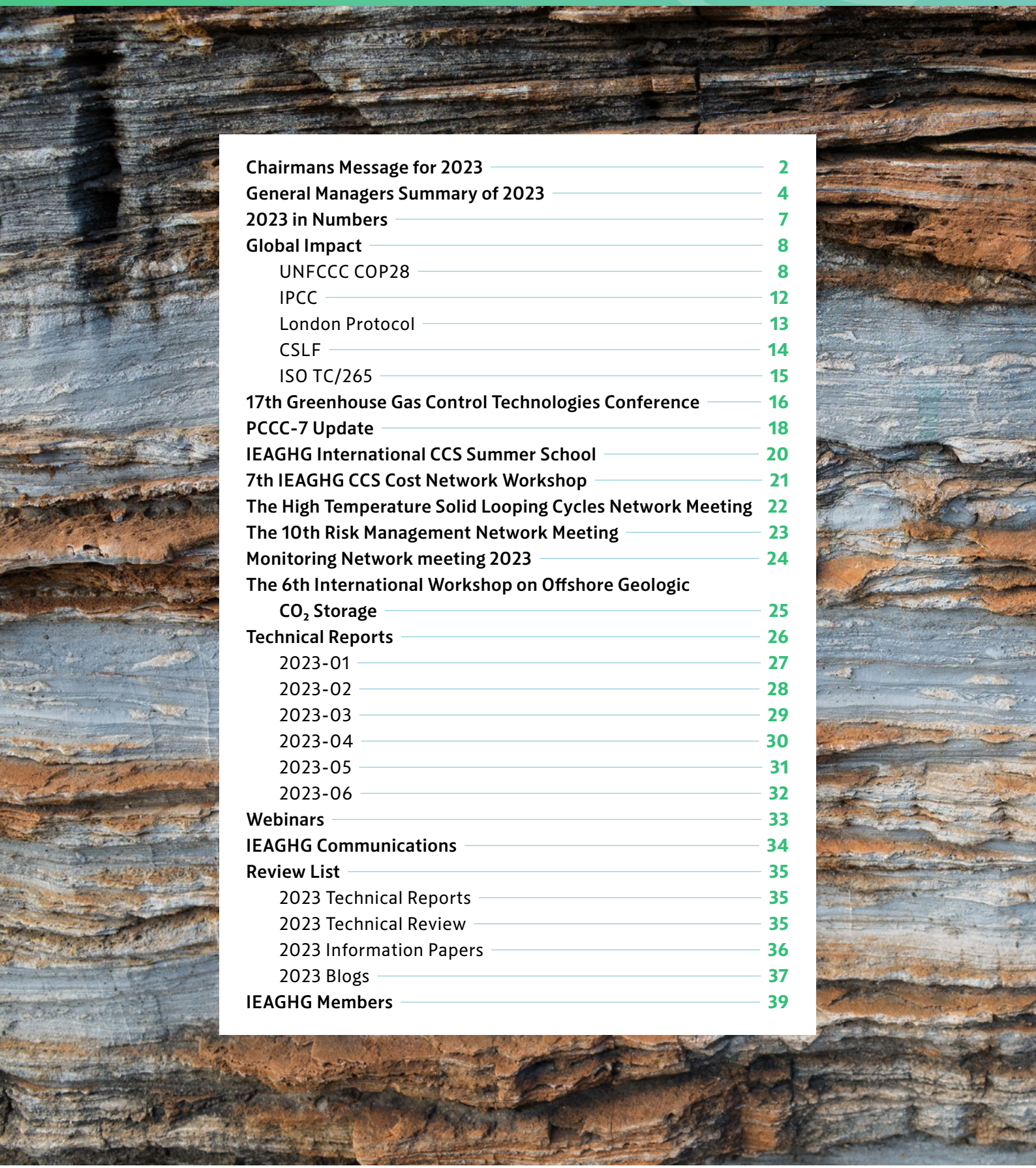
Annual Review 2023

IEAGHG

www.ieaghg.org

Contents



Chairman's Message for 2023

March 2023 saw the release of the IPCC[1] Synthesis Report (SYR) of its 6th Assessment Report (AR6). It integrates the main findings of three previously released AR6 Working Group reports and an additional three special assessment reports that included the assessment of the pathways to achieve the 1.5 C goal by 2100.

In the wrap-up of its findings, IPCC's SYR of AR6 acknowledges that:

1. CCS is an option to reduce emissions from large-scale fossil-based energy and industry sources;
2. CO_2 capture and subsurface injection are mature technologies;
3. geological storage capacity is ~1000 $GtCO_2$, which exceeds requirements through 2100 to limit global warming to 1.5°C;
4. geological storage can permanently isolate CO_2 from the atmosphere.

In April 2023, the IEA released its report on 'Credible Pathways to 1.5C – 4 Pillars of Action in the 2020s' to frame the near-term response to 2030. The pillars of action include:

1. Achieving the substantial near-term emissions reductions from the **energy sector** necessary to put it on a pathway to reach **net zero CO_2 emissions by mid-century**.
2. Reducing **deforestation to net zero by 2030** and taking additional mitigation actions in the land-use sector.
3. **Cutting non-CO_2 greenhouse gases** (GHGs), especially methane and other short-lived climate pollutants which have an outsized impact on lowering peak warming.
4. Scaling up the innovation and deployment of **carbon management technologies**.

Kelly Thambimuthu at GHGT-16, Lyon, France

5. Carbon management technologies – **CCS/ CCUS, BECCS and DACCS** – have an impact across 3 of the 4 pillars of action. Greater penetration of renewable and nuclear energy, switching to lower-emission fuels and greater use of electricity and hydrogen in end-use applications also being significantly important. An earlier IEA Net Zero Roadmap 2021 identifies targets for CO_2 removal by carbon management of 1 Gt per annum by 2030 and 10 Gt pa by 2050, the latter dominated by direct removal of CO_2 from the atmosphere.

As we navigate forward with carbon-managed energy technologies we must address:

- Achieving CO_2 capture rates at +99% efficiency that can significantly reduce at marginal cost, the quantum of atmospheric CO_2 removal required by mid-century.

[1] *IPCC – Intergovernmental Panel on Climate Change*

Chairman's Message for 2023

- Adjudicate the role and relative merits based on energy efficiency, cost, and environmental sustainability of DACCS and BECCS in removing atmospheric CO_2. The deployment of BECCS provides an additional source of energy as well as requiring very much lower energy use per mole of CO_2 removed.
- Adjudicate the relative role, scope, scale, and environmental impact of deployment of **all net zero energy technologies** based on the time-averaged primary energy conversion efficiency to electricity or hydrogen for end use as zero carbon vectors– carbon-managed energy technologies have amongst the highest net time-averaged primary energy conversion efficiencies to electricity/hydrogen. In the case of hydrogen, the net efficiency for hydrogen production is significantly higher by wide margins.

Addressing the above will keep us very busy as we navigate the very challenging journey ahead to a climatically constrained zero-carbon energy world that must also duly consider energy security and environmental justice for all.

K.V. Thambimuthu.

Prof. Kelly Thambimuthu,
FTSE Chairman.

Post-Combustion Carbon Capture Centre: Southern Company

General Manager's Summary of 2023

Monitoring Network Field Trip

This was a particularly busy year for IEAGHG, which is appropriate given the increase in CCS and CDR activities worldwide and the increased urgency of action on climate change. This message of urgency was summarised in IPCC's AR6 Synthesis Report and IEA's, 'Credible Pathways to 1.5C – 4 Pillars of Action in the 2020s' report which the Chairman will comment further on.

We started the year with our High-Temperature Solid Looping Network in Italy, followed by our Costs Network in the Netherlands, the Risk Network in Scotland, the Monitoring Network in the USA, the Offshore CCS Workshop in Scotland, and our Post-combustion Capture Conference (PCCC7) in the USA. There will be more on these later, but a pattern emerged of significant CCS/CDR announcements happening in the same country at the same time as our meetings. This made our meetings even more exciting.

We held our 15th International Summer School in Regina, hosted by the International CCS Knowledge Centre. Over 700 alumni from 60 countries are now out in the world, many becoming CCS leaders.

In the climate policy area, we were invited to the G20 special event on CCUS in India, and the G20 and CEM/Mission Innovation Ministerial meetings also in India. COP28 was particularly significant this year, with the conclusion of the first Global Stocktake. As usual, we coordinated two side events there with our partners, one being the only UNFCCC-hosted side event on CCS. A new global initiative was launched by

General Manager's Summary of 2023

> **"Over 700 Summer School alumni from 60 countries are now out in the world, many becoming CCS leaders."**


Tim Dixon

the USA, the Carbon Management Challenge, to accelerate CCS and CDR to gigaton scale by 2030. It was a pleasure to be invited at COP28 to preparatory meetings and to the formal launch with John Kerry and other dignitaries. We look forward to supporting this important initiative, which is supported by 20 countries, most of which are our members. As well as our regular participation in the London Convention meeting, this meant our technical work and evidence base was being input directly into these relevant policy and regulatory active areas.

We were very pleased to have our members' meetings hosted in Indonesia and the UK. Both provided rich environments for our members to hear new information and direct our technical programme, a UK-focussed workshop and a visit to Drax bioenergy power station (to become BECCS). We were pleased to have Denmark and PDO (Oman) join as new members. It was a particular pleasure to assist Denmark with its new CCS R&D programme, INNO-CCUS, and to support Colombia in its first national workshop on CCS (which was stimulated by discussions at GHGT-16).

It is always good to see the IEAGHG team giving presentations at other conferences and meetings around the world, this year including at the NETL meeting in Pittsburgh and at events in the UAE, Sweden, India, the UK, Norway, France, Denmark, and Poland. These were in-person, and in addition, given the ease of online meetings now, it is routine for the team to virtually attend meetings and present at events in several different countries on the same day.

The organisation of GHGT-17 was well underway with our Canadian hosts, Emissions Reduction Alberta. This will be held in Calgary in October 2024. As the abstract deadline approached at the end of the year, it became clear we were going to beat recent records, reflecting the increased activity in CCS and CDR.

Whilst we have been particularly busy in 2023, there is a lot more to do as CCS and CDR development and deployment ramp up. So, we look forward to working with you and seeing many of you in person in 2024, especially at GHGT-17 in Calgary.

Tim Dixon
General Manager

2023 in Numbers

1127
GHGT-17 Abstract Submissions (10 year high)

6
Technical Reports

6
Technical Reviews

336 Attendees to IEAGHG in-person events

652
Attendees to IEAGHG webinars

8
IEAGHG conferences, networks and workshops

17 IEAGHG presentations at external conferences

39
Blogs

15
Information Papers

IEAGHG Operations Report

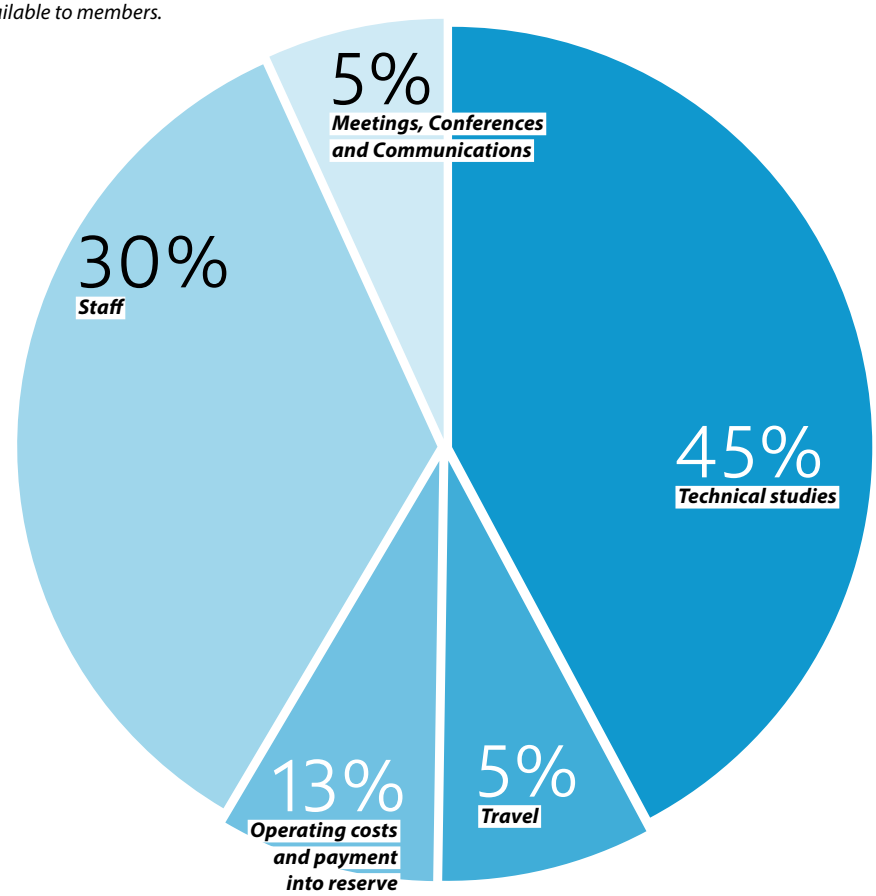
Membership grew to 38 members. We welcomed Denmark and PDO joining, and progressed many enquiries from other organisations as global interest in CCS development and deployment continues to grow. Our total annual income was approximately £2.0m, and the budget was allocated as illustrated below.

The Executive Committee, which is comprised of our member representatives and acts as the governing body overseeing IEAGHG's activities, met twice in the year. Both meetings were held in a hybrid format with the majority of members attending in person. ExCo63 was hosted by our member ITB in Bali, Indonesia. ExCo64 was hosted by the UK government in London with the addition of a UK-IEAGHG workshop. Relevant site visits were provided with both, to an LNG facility in Bali and to the Drax bioenergy power station in the UK (to become a BECCS project).

We welcomed Tim Wilson to the IEAGHG team as Communications and Social Media Manager, replacing Tom Billcliff.

IEAGHG EXPENDITURE 2023

Note 1: *This spans over two financial years so the values given here are approximated. Audited accounts are available to members.*



Global Impact

IEAGHG Side Event, COP28 – 3 Dec 2023. Image courtesy of IISD

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

UNFCCC COP28

The UAE Consensus

UNFCCC's COP28 was held in Dubai. This was a very significant COP because it would represent the conclusion of the Paris Agreement's first Global Stocktake (GST) of progress against its goals. It drew from the IPCC's AR6 reports, and concluded with concern that there was a significant gap between the goals and reality, with 1.1C of global warming already, and that the opportunity to limit global warming to 1.5C is narrowing rapidly and requires deep, rapid and sustained reductions in global greenhouse gas emissions of 43 per cent by 2030 and 60 per cent by 2035 relative to the 2019 level and reaching net zero carbon dioxide emissions by 2050.

The role of the energy sector in reducing emissions is very important. This was a very contentious area in COP28, whether to phase down or phase out fossil fuels was a key debate. The COP28 Presidency worked hard with several evolutions of the overall agreement text and succeeded in getting Parties to adopt the *"Outcome of the first global stocktake"* as part of the collection of agreements named *"The UAE Consensus"*.

This final GST text *"calls upon Parties to contribute to the following"* which includes:

- tripling renewable energy and doubling energy efficiency by 2030.
- phase down of unabated coal power.
- accelerating efforts to net zero fuels.
- *"transitioning away from fossil fuels in energy systems in a just orderly and equitable manner so as to achieve net zero by 2050 in keeping with science".*
- *"accelerating zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production".*
- substantially reducing methane emissions by 2030.
- reducing emissions from road transport.
- phasing out inefficient fossil fuel subsidies as soon as possible.

The whole GST can be seen at cma2023_L17_adv.pdf with the energy section in paragraphs 28(a)-(h).

In a COP agreement, significantly for the first time fossil fuels are named and there is a call for a transition away from all fossil fuels with a target timescale for achieving emissions net-zero. It is noted that this call is just for energy systems, not industrial uses such as in steel and cement. We welcome the inclusion of CCUS in the list of low-carbon technologies.

Article 6

Within the many different UNFCCC negotiations, the main area we have been following has been Paris Agreement Article 6.4, the new mechanism for international cooperation and carbon credits, and how it treats "removals", particularly engineered removals which are based on CCS i.e. DACCS and BECCS. Article 6.4 will enable a new international carbon market for project-based activities, like a new Clean Development Mechanism. The work and governance are undertaken by the Article 6.4 Supervisory Body (SB). IEAGHG's role is to ensure

Tomakomai, Japan CCS Demonstration Center at night

"There is a call to transition away from all fossil fuels with a target timescale for achieving emissions net zero."

Global Impact

COP28: Image courtesy of TD

decisions are evidence-based and there is no non-evidenced-based bias against geological storage-based mitigation methods such as CCS and DACCS. This area was controversial with push and misinformation against "engineered removals" and required several inputs from IEAGHG since the SB started in 2022. In 2023, after a biased SB Information Paper and two more submissions by IEAGHG, their work became more balanced and resulted in a removals recommendations paper which was reasonable and neutral between engineered and nature-based removals, recognising that permanence is a crucial criterion. This was submitted to COP28 for approval in the Paris Agreement plenary. Unfortunately, the recommendations on both Article 6.4 and Article 6.2 were not adopted in the plenary, both being sent back to SBSTA for further work and reporting to COP29 next year. This creates uncertainty and a one-year delay in fully operationalising the international compliance carbon markets.

Also, in COP28 but separate from the UNFCCC negotiations there were other significant agreements on climate action. Of most relevance to IEAGHG was the launch of the Carbon Management Challenge by the US, UK, Brazil, Indonesia and Canada. This aims to accelerate CCS and CDR to gigaton scale by 2030. 19 countries plus the EC have now signed up. As IEAGHG, we support this and were honoured to be invited to be in the room and sit at the table with John Kerry, China's Minister Xie and other dignitaries for the formal launch on 5 December. See Biden announces new Carbon Management Challenge on CCUS and CDR for COP28 - BLOG (ieaghg.org) and Carbon Management Challenge (CMC).

Also agreed was an update to the Global Methane Pledge (GMP). This aims to cut methane emissions by at least 30 percent by 2030. This year, GMP partners announced $1 billion in new grant funding, new tools including the full launch of the Methane Alert and Response System, and new members. Canada, Micronesia, Germany, Japan, and Nigeria joined the United States and European Union as GMP Champions. Turkmenistan, Kazakhstan, Kenya, Romania, and Angola joined the Pledge, bringing total

Global Impact

Tim Dixon speaks at COP28

participation to 155 governments. Furthermore, it was that 50 companies have joined the Oil and Gas Industry Decarbonization Charter, to achieve net zero in their operations by 2050 and stop routine flaring by 2030.

IEAGHG at COP28

Our primary activity was to be co-organiser of the main official UNFCCC Side-event on CCS, with the University of Texas, CCSA, International CCS Knowledge Centre, and Bellona. This COP was exceptionally busy for IEAGHG. Not only did we organise two events, , but we also spoke at or participated in many others. There were more CCS-focussed events than ever before.

Our UNFCCC-hosted side event was on the 3rd December, and focussed on CCS in the cement sector and whether progress in developed countries could happen fast enough to help those in developing countries. There were talks and presentations from Brad Crabtree (US DOE), Tim Dixon (IEAGHG), Beth Hardy-Valiaho (International CCS Knowledge Centre), Ruth Herbert (CCSA), Professor Katherine Romanak (University of Texas), Jonas Helseth (Bellona), and Claude Lorea (Global Cement and Concrete Association (GCCA)). The event concluded that the answer was yes! One example is the GCCA's new work on CCS on cement in India. The audience also learnt that Climate Action Network Europe has supported the CCS content in the EU's Net Zero Industry Act. The room was almost completely full with about 100 attendees. Questions and discussion flowed over to outside the room afterwards. There was good coverage by the COP media IISD, see Can Carbon Capture and Storage Decarbonise the Cement Sector in Developed and Emerging Economies? | IISD Earth Negotiations Bulletin. In a COP where the media had much misinformation on CCS, this created a welcome island of positivity.

The IEAGHG's other side-event was on CCS In Small Island States, organised with the University of Texas and kindly hosted by the Clean Air Task Force (CATF). After a welcome from Brad Crabtree (US DOE) there were updates from Trinidad and Tobago's Ministry of Energy and Energy Industry's Deputy Permanent Secretary Karinsa Tulsie and Professors David Alexander and Raffie Hosein on CCS progress in Trinidad and Tobago. This was followed by an update from Adiola Walcott and Josephine Maximus from the University of Guyana. Then for the first time at a COP we had Timor Leste presenting; Nomesia dos Rais from ANPM provided an update on the work in Timor Leste supported by the World Bank. Professor Katherine Romanak of the University of Texas wrapped-up and highlighted that these talks and presentations demonstrated not just healthy ambition on CCS but also the South-South exchanges which have and are taking place, for example from South Africa to Trinidad and Tobago, from Trinidad and Tobago to Guyana, and hopefully onwards to Timor Leste and other small island states. This also linked nicely with the Carbon Management Challenge.

Global Impact

IEAGHG's Tim Dixon was honoured to be invited to take part in a Youth NGO event. In a "majlis" format, the Youth Ambition Majlis Raising Ambitions Towards Net Zero was organised by the COP Presidency, YOUNGO Energy Working Group, and Youth Climate Change Champion. It was an enjoyable exchange of perspectives on a just and balanced energy transition. It was in the same afternoon that he was sat at the table with John Kerry and China's Minister Xie, he found it hard to say which was most important!

IEAGHG also spoke in an event in the Oman pavilion on decarbonization in Oman, in a CATF/Atlantic Council event on the Carbon Management Challenge, a CATF roundtable on the Carbon Management Challenge, and a CEM-CCUS/GCCA event on Creating CCS Infrastructure.

IPCC

Since 2014 the IEAGHG has provided two Expert Reviewers to the Intergovernmental Panel on Climate Change (IPCC). IEAGHG applied to be Observers to the IPCC so that we can improve our opportunities for input, for example, earlier sight of documents and the option of attending meetings. The application was made on 22nd March 2017 and we were informed by IPCC on 20th March 2018 that we were accredited as Observers.

The IPCC has completed its Sixth Assessment cycle. The Synthesis Report (SYR) of AR6 brings together all three underlying reports from WGI, WGII and WGIII. IEAGHG had provided a total of 107 substantive comments to these reports. The final SYR report was approved and issued in March 2023, and IEAGHG produced an Information Paper to summarise the most relevant messages for CCUS (IEAGHG 2023-IP07) and presented this at ExCo63.

At its meeting in July, the IPCC appointed Dr Jim Skea (UK) as its new Chair. Jim is known to the IEAGHG and has a good awareness of CCS.

"The IEAGHG provided 107 substantive comments to the IPCC Synthesis Report of AR6."

The United Nations Office Geneva

In WGIII (Mitigation) he is replaced by co-chairs Katherine Calvin (USA) and Joy Jacqueline Pereira (Malaysia).

In terms of the timing for the seventh assessment cycle, we understand that IPCC countries want it to start from July 2023 and to take five to seven years, to feed into the second Global Stocktake in 2028. IEAGHG will input and review as for previous assessment cycles.

Container carriers offloading

LONDON PROTOCOL

The London Convention and the London Protocol are the global marine treaties that protect the marine environment. We previously reported on the CCS amendments and the 2019 Resolution to allow export of CO_2. In 2021 to provide easier access to and understanding of the London Protocol's detailed guidance and guidelines for export of CO_2 for offshore storage, IEAGHG produced a report, IEAGHG 2021-TR02.

For the annual meetings of the Parties, IEAGHG is the only CCS-related organisation attending.

Previously IEAGHG has attended these meetings on the OECD/OEA's delegation. In 2022 IEAGHG formally applied to be an accredited observer in its own right, and this was approved at the LC44 meeting in 2022.

In 2022, IMO marked fifty years since the adoption of the London Convention.. In the 2023 meeting (LC45/LP18) this was celebrated with a launch of the 2022 conference proceedings "Protecting the ocean - moving forward at 50: London Convention/Protocol and Stockholm Declaration, fiftieth anniversary proceedings". The proceedings highlighted the major achievements, which include responding to the threats of climate change by the consideration of CCS and adoption of the CCS amendments in 2006, 2009 and 2019 to allow CCS and the export of CO_2 for CCS. IEAGHG played a role in all of these.

At LC45 in October 2023, the meeting asked for updates on the acceptance and ratification of the 2009 CO_2 Export Amendment and the use of the 2019 Provisional Application of the Export Amendment. The number of countries who have accepted the 2009 Amendment has not changed from last year, still ten, so it is a long way from coming into force. On the Provisional Application, in the last year, the UK has sent a declaration to IMO to bring the total to seven countries (Norway, Netherlands, Belgium, Denmark, Korea, Sweden and the UK) who can use this for exporting/importing CO_2 for CCS.

Norway provided an update on their CCS activities, including the work towards legally binding bilateral agreements for importing CO_2, and the commercial arrangements developing with Yara in the Netherlands and Oersted in Denmark to import their CO_2. Denmark provided an update on their CCS activities, including the bilateral arrangement with

Belgium for the import of CO_2. They consider that the EU ETS and CCS Directives provide sufficient legally binding agreement hence their "arrangement" with Belgium instead of a legally binding "agreement". They stated that they prefer an EU-wide consistent approach, as described by the European Commission at LC44 last year with their London Protocol analysis paper (EU - London Protocol Analysis paper final 0930 | Climate Action (europa.eu)). The Netherlands also supported this approach. The UK provided an update on their CCS project activities, including the issuing of 21 offshore storage licences recently (see the IEAGHG blog dated 19th September).

In terms of sharing experiences with offshore CO_2 storage, a correspondence group is underway, led by Japan and Australia, with seven other Parties and the IEAGHG involved, to investigate the experiences in the application of the CO_2 Specific Guidelines (2007 originally and 2012 version amended for export) for the issuing of permits. A total of ten Parties have responded. This will report to the London Convention Scientific Group meeting in 2024.

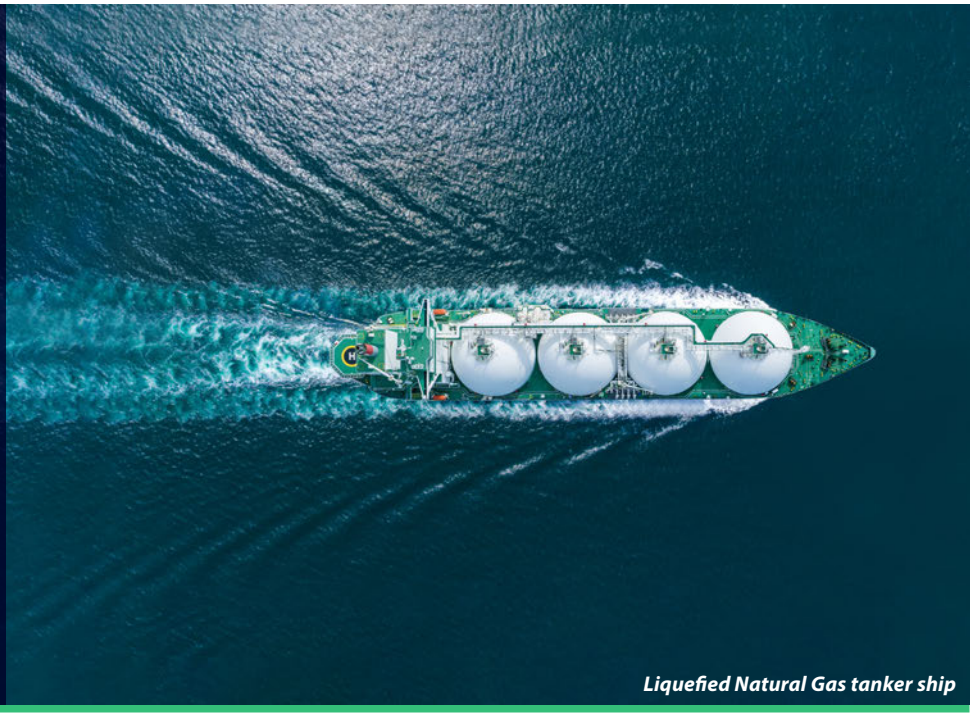
The IEAGHG provided an update on our activities relating to offshore CCS, covering the 6th Offshore CCS workshop (see IEAGHG blog 19 September), the IEAGHG Monitoring Network meeting (see IEAGHG blog from 14th August) and the GoMCarb final annual meeting (see IEAGHG blog of the 11th April). Greenpeace thanked us and Norway, and asked for more details to be provided.

Also, much work is underway on marine geoengineering, and the IEAGHG follows this. See IEAGHG blog from 9th October 2023.

CSLF

The Carbon Sequestration Leadership Forum (CSLF) was a government-to-government initiative to accelerate the development of CCUS technologies, with some 25 country members.

"The IEAGHG provided an update on our activities relating to offshore CCS, including the 6th Offshore CCS workshop and Monitoring Network meeting."



Liquefied Natural Gas tanker ship

The IEAGHG participated through an agreement from 2007.

This year's CSLF Technical Group meeting was held in Warsaw on 13th June. The CSLF secretariat proposed for the CSLF Technical Group to become dormant. The CSLF Policy Group had previously done similar and in effect migrated into the CEM-CCUS Initiative.

After twenty years of existence, the CSLF Technical Group and its task forces have produced many good reports such as on an early storage capacity estimation methodology, Technology Roadmaps, offshore storage, and learnings from regulations on projects. It is intended these useful resources will continue to be made available through the website Carbon Sequestration Leadership Forum (cslforum.org) or other means.

At this last meeting, two new projects were approved for CSLF recognition. One was in Brazil, Petrobras's Santos Basin project. Known for its deep water, this has been operational since 2013. The other project was in China, SINOPEC's Qilu-Shengli Oilfield CCUS project, which started full-scale operations in 2022.

As usual, the IEAGHG provided an update on our activities and moderated a discussion panel on clusters and infrastructure.

So, the CSLF has been around since the earlier days of CCS, a clue being in its name, when there was a debate about whether to use the term sequestration or storage. It is considered to have met its mission, which was to *"Facilitate the development and deployment of CCS technologies via collaborative efforts that address key technical, economic, and environmental obstacles"*, and other CCS initiatives have emerged such as CEM-CCUS and Mission Innovation. It also provided a meeting place for governments working on CCS or wanting to find out more about CCS. The IEAGHG has been pleased to have been part of CSLF since the outset. So, an acknowledgement should be made to all the good work produced and a thank you to all who have been involved in the CSLF over its twenty years.

ISO TC/265

This ISO committee was proposed by Canada and set up in 2012 with a Canadian Chair and Canadian and Chinese Secretariat. There are 19 participating countries, 13 observing members, and 7 Liaison organisations. It consists of seven working groups: WG 1 Capture; WG 2 Transport by Pipeline; WG 3 Storage; WG 4 Quantification and Verification; WG 5 Cross-cutting issues; WG 6 CO_2-EOR; WG 7 Transport by ship (new in 2022). The IEAGHG is a Liaison Organisation to TC265, and is a member of WG 3 and WG 5. The last plenary was held virtually on 23 June 2023. IEAGHG provided an update to input our technical reports. More information is available at ISO - ISO/TC 265 - Carbon dioxide capture, transportation, and geological storage.

Construction works at the Northern Lights onshore facilities

17th Greenhouse Gas Control Technologies Conference

GHGT-16 Opening Session

Throughout 2023 preparations have been underway for the 17th Greenhouse Gas Control Technologies Conference (GHGT-17) which will take place in October 2024 in Calgary, Canada. Already the conference is shaping up to be a record-breaker.

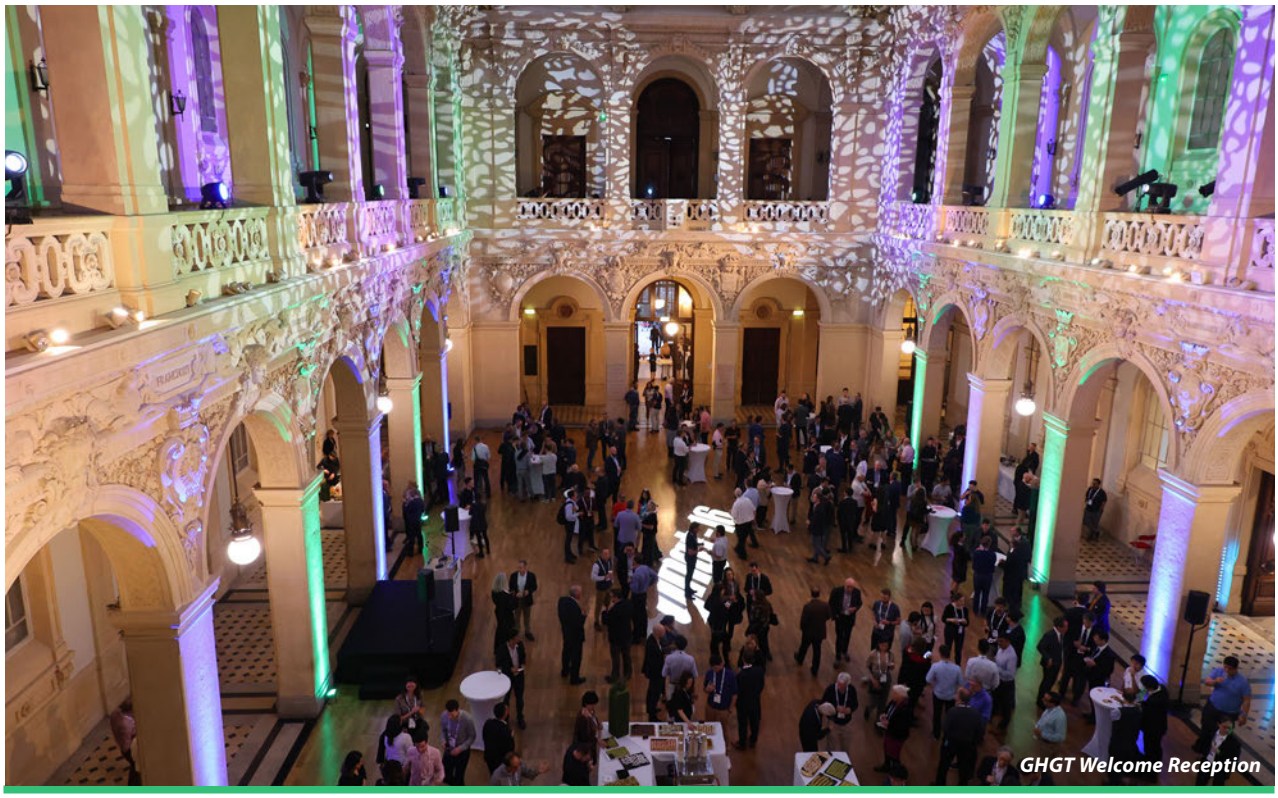
GHGT-16 Main Auditorium

2024 Greenhouse Gas Control Technology Conference

Following the call for abstracts opening on 16th September 2023 (which closed on 16th January 2024) we received a record number of submissions. 1127 abstracts were submitted from more than 50 countries including 128 from Canada, 230 from the USA, 113 from the UK and 90 from Norway. These have all been reviewed and the Technical Programme Committee will select work for the 71 sessions throughout the conference. In addition to the 7 technical streams, we have added an 8th stream dedicated to a business-to-business audience which will run for 3 days of the conference. Our poster sessions will be delivered by 'Kubify' who specialise in e-posters to give those presenting the best experience. There will be 6 e-poster stations to accommodate over 500 posters.

For conference delegates, we will be charging a nominal fee towards the costs of the gala dinner. There will also be four site visits to four CCS locations which are still being finalised. Again, there will be a fee to cover the costs and places are limited. All the visits will take place on the Friday after the conference.

Based on the exceptional numbers of abstracts submitted we are predicting a conference attendance between 1500-1700 delegates – a 25-40% increase on GHGT-16 in 2022. The high level of interest in the conference continues as we have confirmed platinum, gold, and silver level sponsors as well as sponsors for all social activities, e-posters, conference bags, lanyards, and keep cups. Overall, GHGT-17 is promising to be one of the biggest and best conferences in the series' history. Early bird reservations will open in March 2024 so don't forget to reserve your place. This conference will be one you don't want to miss.



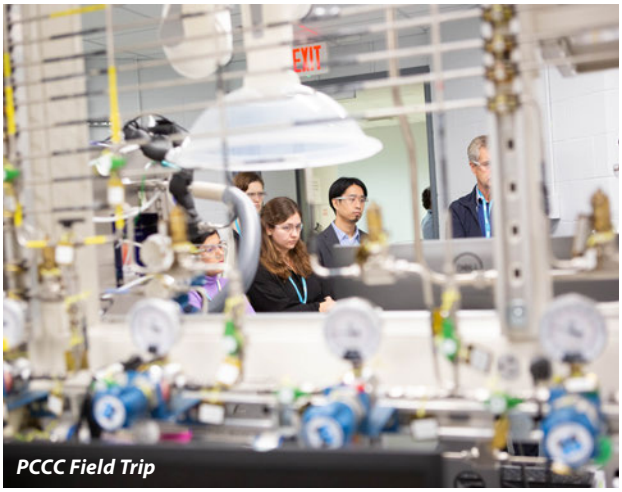
GHGT Welcome Reception

PCCC-7

The 7th Post Combustion Capture Conference (PCCC-7) was held on the 25th–27th September 2023 in Pittsburgh, United States, and was jointly hosted by IEAGHG, the U.S. Department of Energy and the National Energy Technology Laboratory (NETL). Sponsors of the conference were Worley, Shell, and Mitsubishi Heavy Industries (MHI).

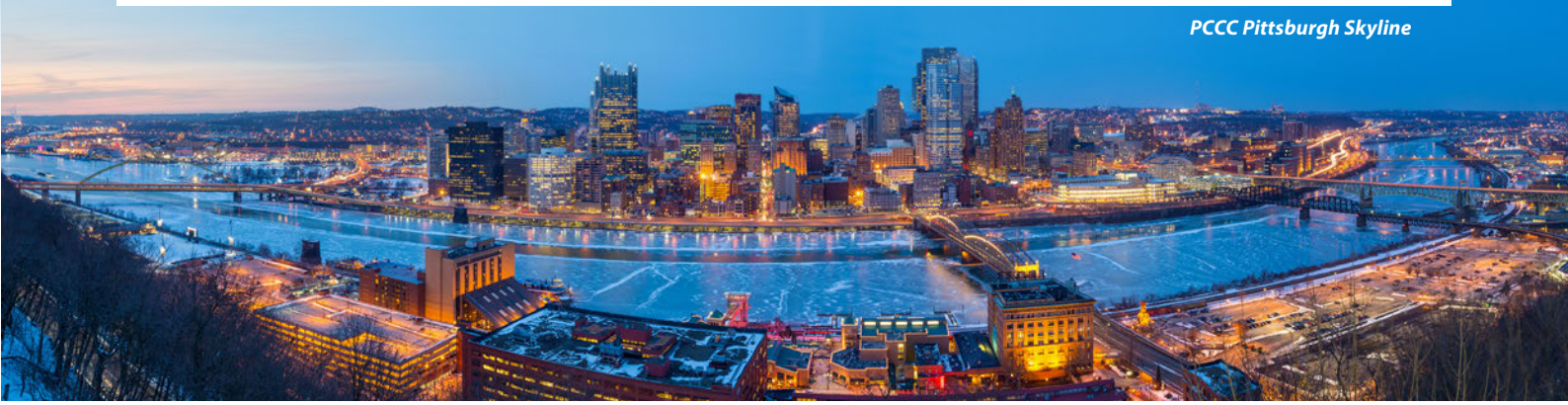
The PCC conference explores the latest progress in post-combustion capture (PCC) technologies. It is a platform for technology providers and developers to share experience and expertise across the CCUS value chain. The conference covers a wide spectrum of PCC technology with a particular focus on the results, challenges, and plans of pilot and large-scale capture plants.

The first morning of the conference was chaired by IEAGHG's Abdul'Aziz Aliyu, who was honoured to introduce welcome addresses from Kelly Thambimuthu (IEAGHG Chair), Dr. David Miller (NETL) and Jerad Bachar (VisitPITTSBURGH). On the second day, the keynote speakers were Sarah Forbes from the DOE's Office of Fossil Energy and Carbon Management (FECM), Ed Rubin of Carnegie Mellon University (and recipient of the IEAGHG Greenman Award in 2022), and Shell's Patricia Scozzafave. On the third and final day of the conference, the keynotes were given by Dan Hancu (FECM), Takashi Kamijo (MHI) and Rob Berra (Worley); with Gary Rochelle (University of Texas at Austin) and Jon Gibbins (UKCCSRC) finalising PCCC-7 with the concluding addresses.



PCCC Field Trip

Approximately 180 international delegates attended the conference, which featured 18 technical sessions organised into two parallel streams. The sessions covered a range of themes, including process configurations, process applications, process modelling, amine oxidation, amine degradation, demonstration activities, novel amines, modelling of novel amines, environmental impacts and alternative concepts.


PCCC Pittsburgh Skyline

PCCC-7 Update

“180 international delegates attended the conference, which featured 18 technical sessions organised into two parallel streams.”

From a technical perspective, the presentation covered a broad spectrum of strategies to reduce carbon emissions.

To achieve net zero emissions, Jon Gibbins pointed to two main strategies:

1. Reducing the fossil/energy ratio to zero, which means completely stopping the use of fossil fuels and conventional methods for producing cement, steel, etc., very rapidly.
2. Reducing the CO_2/fossil ratio to zero, which involves deploying CCS on all fossil fuels used, including direct air capture (DAC), capturing and storing CO_2 from the atmosphere.
3. Both strategies are supported by reducing the energy/GDP ratio. However, neither approach is easy to implement.

The significance of achieving CO_2 capture efficiency beyond 90% was a major focus at PCCC-7. This goal is particularly relevant in the context of net-zero emission targets, a point articulated strongly by the IEAGHG Chair in his welcoming remarks. The traditional 90% cap on capture rate, historically rooted in the economics of capture technology, is increasingly seen as an artificial limit. It does not reflect the full technical potential of current technologies.

On 28th September 2023, approximately 40 delegates were treated to a guided tour of NETL, offering them a first-hand glimpse into NETL's state-of-the-art facilities and R&D

PCCC-Session

initiatives that, over the last century, have pioneered breakthroughs in energy research and technology in response to the nation's evolving energy needs.

A highlight of the site visit was the NETL DAC Centre. The DAC Centre was gearing up to deploy a demonstration-scale DAC unit in the coming months. NETL aims for the facility to be a comprehensive, cutting-edge test platform that will facilitate collaborations with its top-tier expertise. It will offer both standardised and tailor-made solutions that meet the apex of performance standards. Furthermore, it will grant developers the flexibility to mimic a variety of conditions, thereby deepening the understanding of how DAC technologies perform across diverse climates, spanning from summer to winter conditions and from dry to humid atmospheres.

In conclusion, PCCC-7 transcended being merely a conference; it was a celebration of the collaborative spirit of the CCUS community, reuniting in person to advance a critical cause for our planet. The next installment of the conference, PCCC-8, is planned to take place in France in 2025.

IEAGHG International CCS Summer School

IEAGHG's 15th International CCS Summer School was held from the 9th to the 15th of July 2023 in Regina, Canada, and was another resounding success. Hosted by the International CCS Knowledge Centre, the event welcomed 32 students from 17 countries for a week of interactive learning from international experts on all aspects of carbon capture, utilisation, and storage.

Alongside the in-depth lecture programme on the CCUS value chain, students and mentors ventured 200km south of Regina to the world's first fully integrated and full-chain CCS facility on a coal-fired power plant – Saskpower's Boundary Dam 3 facility (BD3) and PTRC's Aquistore CO_2 storage site; a fantastic opportunity to see CCS at work in real-life. Not only did students have a jam-packed week of lectures and learnings on the field trip, but they were also tasked with group work throughout the week, culminating in a morning of presentations on the Friday.

IEAGHG would like to thank the hosts of the 2023 Summer School, the International CCS Knowledge Centre, for another fantastic event held at the University of Regina campus. In addition, we'd like to thank the IEAGHG Summer School Series Sponsors for their ongoing support of the Series – UK DESNZ, Shell, TotalEnergies, Swiss Federal Office of Energy, Gassnova, and ExxonMobil. Finally, thank you also to the 2023 local sponsors – the University of Regina, Emissions Reduction Alberta, Boilermakers, Heidelberg Material, Innovation Saskatchewan, Graham, MHI, Whitecap Resources Inc., PTRC, and SaskPower. Without this support, this event would not have been possible.

Last but not least, a big thank you to the speakers and expert mentors who committed their time for the week and also to all 32 students who attended for their enthusiasm, dedication, good humour and hard work throughout the week.

Summer School Field Trip

7th Edition of the IEAGHG CCS Cost Network Workshop

The 7th IEAGHG CCS Cost Network Workshop was hosted at the University of Groningen, Netherlands, on 12th-13th April 2023. The purpose of the workshop was to share and discuss the most recent information on the costs of CCS in various applications, as well as the outlook for future CCS costs and deployment.

The workshop was structured into five technical and three breakout sessions:

- The first session, chaired by NETL's Timothy Fout, addressed the cost of CCS industrial applications with a focus on cement production.
- In the second session, chaired by UKCCSRC's Jon Gibbins, the cost of CCS in power plant applications was addressed, with a focus on recent Front-End Engineering Design (FEED) studies.
- Howard Herzog (MIT) chaired the third session on direct air capture (DAC), which included discussions on the cost of DAC and DAC case studies focusing on sorbent and solvent systems.
- The fourth session on offshore CO_2 transport and storage was chaired by Sean McCoy (University of Calgary). In this session, the costs relating to offshore storage and lessons from the Aramis project were explored.
- Finally, the fifth session was chaired by Machteld van den Broek (University of Groningen), which addressed the outlook for CCS deployment and costs as reflected in large-scale energy-economic and integrated assessment models used for scenario and policy analysis.

During the breakout sessions, high capture efficiencies, blue/green hydrogen, and the outlook for onshore transport and storage costs were explored. The sessions were moderated by Jeffrey Hoffman (US DOE), Niall Mac Dowell (Imperial College London), and Candice Paton (Enhance Energy, Canada), respectively, providing in-depth discussions and insights into these critical topics.

The workshop underscored the complexity and variability of CCS costs across different sectors, highlighting the influence of geographical location, energy costs, and the critical need for funding and infrastructure development. The discussions, led by experts from various institutions, emphasised the necessity of developing CCS hubs to optimise costs related to transport and storage.

Cost studies are available in IEAGHG reports and previous workshop proceedings on IEAGHG's website.

Cost Network Group Photo

The High Temperature Solid Looping Cycles Network Meeting

The IEAGHG High Temperature Solid Looping Cycles Network (HTSLCN) brings together researchers and developers of technology to capture CO_2 at high temperatures in cyclical processes using either circulating or fixed beds of solids.

The technology has advanced considerably in past years and several large pilot plants have been constructed and brought into operation. This important step is expected to enable a convincing demonstration of the potential for the technology to work at an industrial scale to be done. The network is progressively expanding participation beyond the research community, businesses, plant designers and equipment suppliers as the technology moves rapidly through pilot and industrial demonstration towards full-scale commercial deployment.

The 9th HTSLCN Meeting took place from the 14th to the 15th of March 2023 at the Palazzo Farnese in Piacenza, Italy, hosted by the CLEANKER project and with support from the municipality of Piacenza. 82 attendees enjoyed a two-day programme with a total of 28 presentations and a site visit to Buzzi Unicem's demonstration plant in Vernasca.

After the technical sessions and discussions, it was concluded that Calcium looping technology is currently validated, also thanks to the promising results brought by the CLEANKER project, at technology readiness level (TRL) 7 for applications in the cement industry and in post-combustion applications and needs to move to TRL 8 with the erection of a bigger scale pilot plant. However, being this investment capital intensive, it is mandatory to find an industrial partner that is willing to invest in these advancements. This is the major challenge that the community faces in scaling up the technology. Negative emissions through solid looping with biomass and flexible operation was another hot topic of this meeting. It is important that the HTSLCN community has started work on these topics. Next to biomass, sorption-enhanced reforming technologies appear as a promising near-term option to partly 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. Calcium looping will be the protagonist technology in two Horizon projects started in the past six months and will be applied for the first time in the Iron & Steel and Waste-to-Energy sectors with the erection of pilot plants in industrially relevant environments.

Potential locations for the 10th HTSLCN Meeting, to be held in 2025 are Cranfield University (UK) or CSIC-Incar (Spain). A summary report of the 9th HTSLCN Meeting is available on the IEAGHG website (2023-TR02).

High Temperature Solid Looping Cycles Network

The 10th Risk Management Network Meeting

The 10th Risk Management Network Meeting was hosted by Heriot-Watt University, Edinburgh from the 28th-30th June 2023 and was packed with 75 delegates from 15 countries. The two-day programme featured 26 presentations and lively panel discussions.

The theme for the meeting was the challenges posed by legacy wells and well integrity in a CCS project. A diverse steering committee drew from a wide cross-section of disciplines including material specialists, monitoring experts, legal professionals, academics and past risk steering committee members. Sessions covered identifying legacy well risks, looking at basin scale evaluations, best practice plugging and abandonment, well performance and containment in the long-term, well materials, monitoring, and communicating well-related risk to regulators and other stakeholders.

The concluding high-level messages noted that 'creaming curves' would no doubt apply to storage site availability based on the quantity and quality of legacy wells but that these areas might be unlocked as costs fall and technology to remediate improves. Cements were a key topic with encouraging laboratory testing on legacy wells and samples showing the effectiveness of Portland cement as a barrier over time. Monitoring plans were discussed as was how these can be streamlined with time. Insurers and financiers are starting to create products and a cross-cutting meeting would be beneficial as would be finding a common lexicon for communication of risk between industries. Standardising and streamlining the permitting process was a recurrent theme. The participants also recognised significant challenges remain which includes quantifying leakage rates and expected containment. Currently, well-behaved wells might prove problematic once commercial-scale CO_2 injection has commenced. And finally, remediating a leaking legacy well might create a higher environmental impact than the leak itself and might be better left undisturbed.

The meeting was followed by a geological tour of Arthurs Seat. A summary report has been published, the 'Risk Management Network Meeting Report' (report number 2023-TR03). Special thanks go to Heriot-Watt, OGCI and Shell for their support and sponsorship.

Risk Management Network Group Photo

The 14th Monitoring Network meeting

The 14th meeting of the IEAGHG Monitoring Network was held from the 8-10th August 2023 in Baton Rouge, Louisiana for another in-person event packed with news and developments in monitoring CO_2 storage projects.

Monitoring Network Session

Co-hosted by the Louisiana State University's Petroleum Engineering Department and the Gulf Coast Carbon Center, we were warmly welcomed at LSU's beautiful lakefront campus.

The theme of this two-day meeting was 'Monitoring, Commercialisation & Regulatory Developments', with the first day dedicated to a technical deep dive into recent developments in monitoring techniques, methods and processes aimed at monitoring experts. Day 2 was aimed more at regulators and detailed discussions on current regulatory issues in monitoring and was opened to online participants too. 56 attendees joined IEAGHG in person at the Lod Cook Alumni Center at LSU, with an additional 44 joining online for the second day of sessions.

Day 1 sessions included a delve into new learnings on fibre optics & low-cost monitoring technologies for subsurface seismic, along with a look into non-seismic methods. Offshore environmental monitoring and terrestrial monitoring were covered, as well as the important and timely topic of automation & integration of MMV. Day 2, the regulatory-focussed day, framed the issue / current challenges by summarising the key findings from day 1, along with a panel discussion looking at different approaches in the US, EU and Australia. International experts informed about developments in tools for monitoring, environmental aspects of importance and societal considerations of monitoring. To end day two, a panel discussion on 'getting to closure' stimulated in-depth discussions on the challenges faced in this realm, and to wrap up the meeting, the closing session looked at unmet needs and recommendations to move forward in this topic.

Following the meeting, in-person participants were treated to a field trip day and travelled northeast of Baton Rouge to a potential CO_2 storage site, followed by a visit to LSU's Petroleum Engineering Research, Training, & Testing (PERTT) Laboratory to see the training wells.

IEAGHG would like to thank our sponsors for this meeting, ExxonMobil and Air Products for their generosity in supporting this event, the hosts at LSU, and also our esteemed international network Steering Committee for their input and commitment over the past five months whilst we shaped both the technical and logistical programmes for this event.

The 6th International Workshop on Offshore Geologic CO_2 Storage

Offshore Workshop Group

The 6th international workshop on Offshore Geological CO_2 Storage was held in Aberdeen, on the 13th-14th September 2023, and organised with the University of Texas, co-hosted by the University of Aberdeen and sponsored by Storegga. This 6th workshop had 190 delegates (60 in-person and 130 virtual) from 35 countries, with a good mix of industry, researchers and regulators.

In a packed agenda of 44 presentations, the number and diversity of new projects with offshore storage being progressed was impressive. These covered many industry sectors, storage in depleted hydrocarbon fields and deep saline aquifers, and different transport means to storage. Following project updates, the workshop got into more technical details, such as impacts and screening of legacy wells, storage capacity, regulations, interaction with other seabed users, transport and infrastructure, stakeholder engagement, monitoring, and environmental aspects. Transport developments included ship CO_2 transport by Shell and the importance of pressure management in pipeline networks. The North Sea Transition Authority (NSTA) presented on the UK's first CO_2 storage licencing round and a day after the workshop the NSTA announced 21 new licences, mostly in the North Sea.

Conclusions and recommendations included the welcoming of "Just Transition" being incorporated in UK and US projects, the maturing of MMVs plans and their approval by regulators, the careful evaluation and allocation of storage resources contingent on the well density and pressure space, community benefits are just as critical in the offshore they just differ from the onshore, transparency and method of communicating risk is important. Recommendations include developing monitoring techniques for use around wind farms. Basin-wide management is an emerging topic with ways to manage the 'commons' or pressure space seen as a pressing need i.e. who is responsible for this and does the first mover win. There is a clear need to improve public knowledge, and positive engagement with the media is also imperative. Clarity is needed on the issuing licences to ensure that it is streamlined and future-proofed. Protocols for how to assess and monitor legacy wells was also a theme. Lastly, we were reminded that knowledge transfer in countries without a mature hydrocarbon industry was required, especially in the Global South.

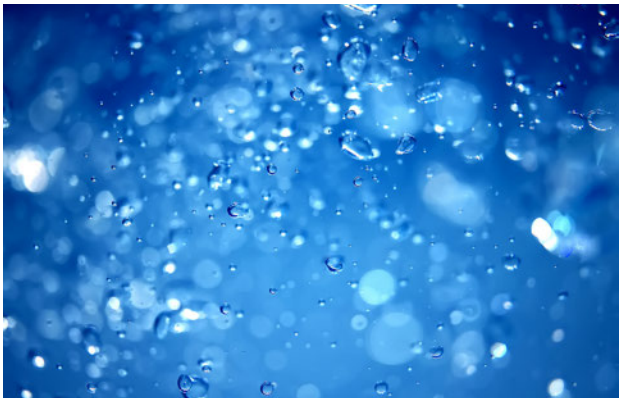
Overall, there is impressive progress in developing CCS projects offshore, and much knowledge was shared in this workshop. A report on the workshop has been published (2023-TR06 6th International Workshop on Offshore Geologic CO_2 Storage), and the presentations are available on the GCCC website at BEG (gccc.beg.utexas.edu).

Technical Reports

As a leader in Carbon Capture and Storage (CCS) research our technical reports are a cornerstone of what we do. Produced in collaboration with world-leading institutions these in-depth reports are accelerating the development and deployment of CCS projects across the globe.

1 ***Integrating CCS in International Cooperation and Carbon Markets under Article 6 of the Paris Agreement | 2023-01***

2 ***Prospective Integration of Geothermal Energy with Carbon Capture and Storage | 2023-02***



3 ***Techno-Economic Assessment of Electrochemical CO_2 Conversion Technologies | 2023-03***

4 ***Components of CCS Infrastructure Interim CO_2 Storage Options | 2023-04***

5 ***Classification of Total Storage Resources and Storage Coefficients | 2023-05***

6 ***International Standards and Testing for Novel CO_2-Containing Building Materials | 2023-06***

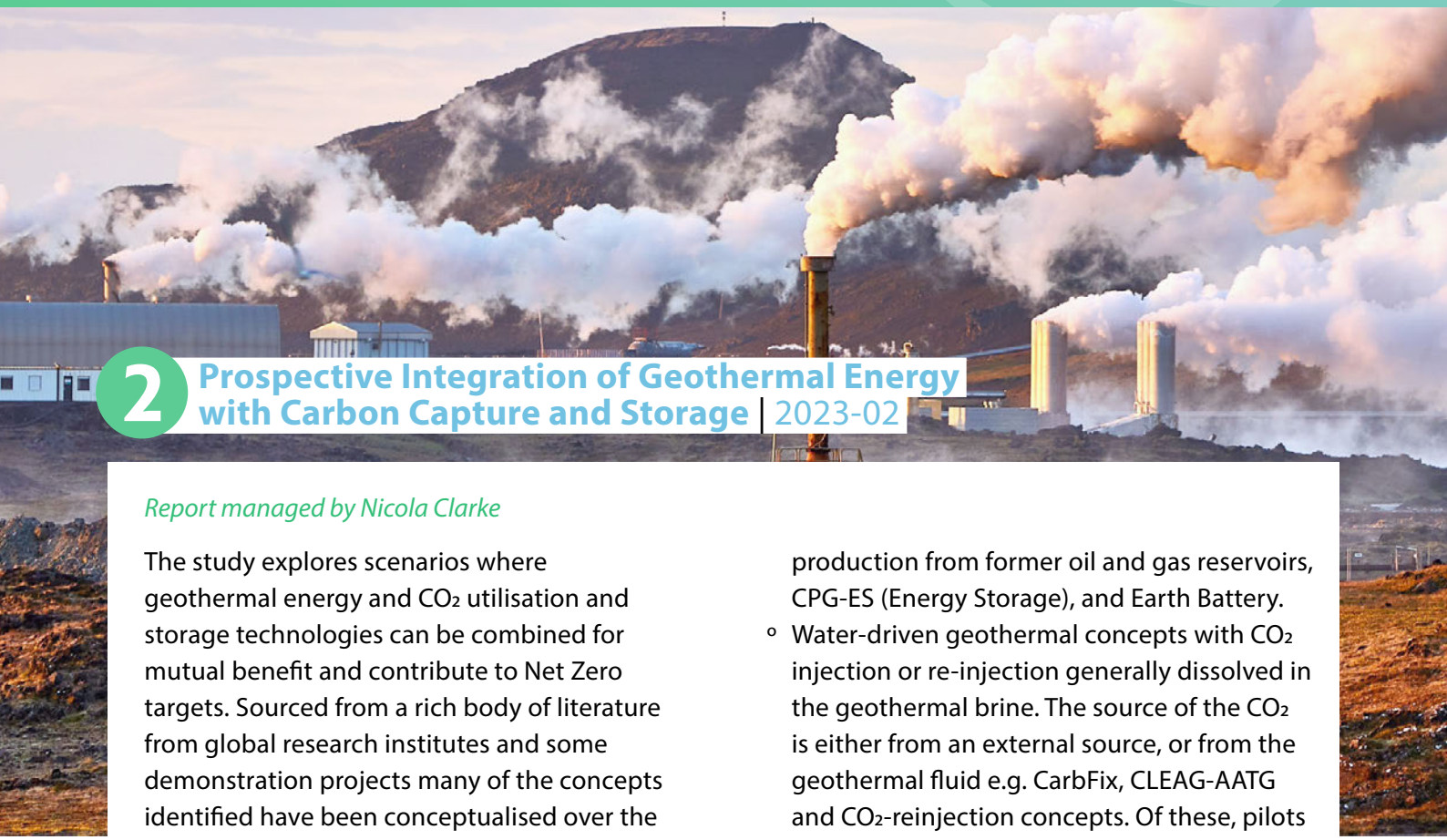
Technical Reports

1 Integrating CCS in International Cooperation and Carbon Markets under Article 6 of the Paris Agreement | 2023-01

Report managed by Samantha Neades

This work assesses the status of and outlooks for international cooperation under Article 6 of the Paris Agreement and considers how approaches could support the deployment of carbon capture and storage (CCS). It provides an up-to-date look at the Article 6 rules, the types of markets and mechanisms that could evolve, and the units that could be traded. It then considers how Article 6 could apply to CCS through linked emissions trading systems, crediting systems and alternative approaches.

- Article 6 of the Paris Agreement is an enabler that will help countries cooperate to meet global emissions reduction targets by using international carbon markets, allowing transfers of emission reductions between countries and providing a framework for greenhouse gas emissions to be balanced globally.
- CCS could be incorporated into Article 6 through emissions trading or crediting, within compliant or voluntary markets, through governmental transfers of mitigation outcomes, and CCS-specific approaches. These actions may be national conditional measures, or supplementary to national measures.
- This study looks at three core models for CCS cooperation under Article 6: 1. Linked carbon pricing policies between countries (a representation of the mainstream climate policy approach of today), 2. Voluntary (or partially regulated) system of storage targets for fossil fuel producers, 3. Multilateral "CCS club" of Parties to the Paris Agreement.
- It is uncertain if technology-neutral market-based mechanisms (such as in model 1) can deliver significant amounts of geological CO_2 storage. These mechanisms are poorly suited to support the deployment of higher cost mitigation techniques such as CCS without supplementary measures. Carbon markets could lead to some near-term deployment of low-cost CCS projects, even under low carbon prices.
- Carbon storage unit (CSU) based policies (such as in models 2 and 3) could provide a supplementary mechanism to ensure geological CO_2 storage is included in more mitigation options.
- A top-down, country-led approach (as in model 3) could be more effective in enhancing geological storage. However, gaining agreement to adopt storage targets across multiple countries could be challenging, Model 2 may be more practical for implementation when bolstered by a few pioneering countries, An approach based on CSUs could help to provide additional financing for CCS and enhance the progression in Nationally Determined Contributions (NDCs). All models described can be considered as actions to help utilise CCS.

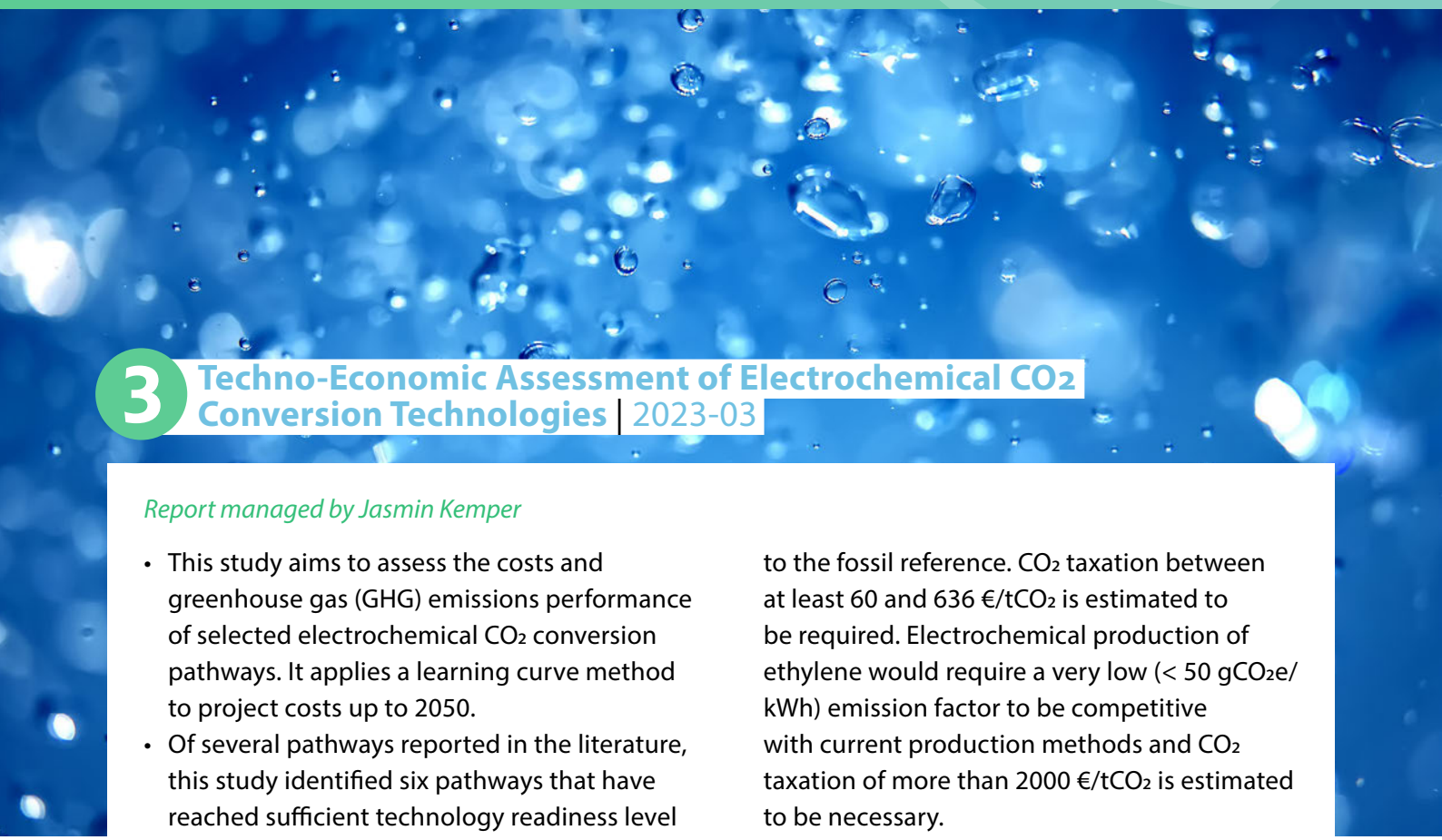


2 Prospective Integration of Geothermal Energy with Carbon Capture and Storage | 2023-02

Report managed by Nicola Clarke

The study explores scenarios where geothermal energy and CO_2 utilisation and storage technologies can be combined for mutual benefit and contribute to Net Zero targets. Sourced from a rich body of literature from global research institutes and some demonstration projects many of the concepts identified have been conceptualised over the past 20 years and are still in the early concept stage. These concepts have been categorised, described and evaluated.

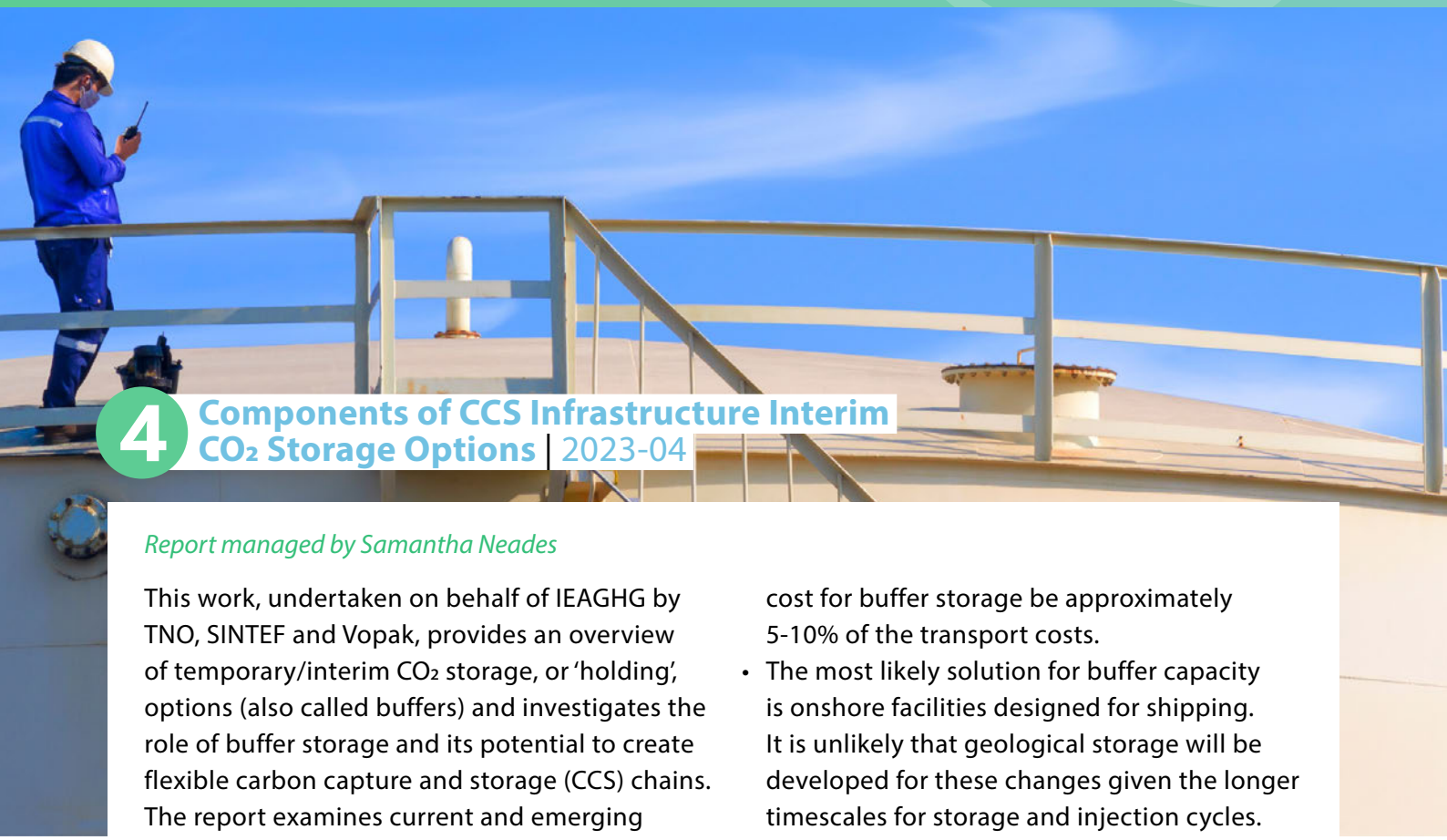
- The use of subsurface resources will play a central role among the many solutions necessary for climate change mitigation and to keep the Paris Agreements on track. These can comprise both shallow deep geological resources. The hybrid use of the subsurface to produce renewable heat or electricity that could largely be decarbonised and /or in conjunction with Carbon Capture and Storage (CCS) of an external industrial CO_2 source opens promising solutions.
- Most of the concepts described in this work need to be tested before demonstrating their potential for deployment.
- Concepts are grouped into main themes:
  - Use of supercritical CO_2 as a heat vector for geothermal energy production – this includes CPG (CO_2 Plume Geothermal), CO_2-EGS (Enhanced Geothermal Systems), Heat production from former oil and gas reservoirs, CPG-ES (Energy Storage), and Earth Battery.
  - Water-driven geothermal concepts with CO_2 injection or re-injection generally dissolved in the geothermal brine. The source of the CO_2 is either from an external source, or from the geothermal fluid e.g. CarbFix, CLEAG-AATG and CO_2-reinjection concepts. Of these, pilots are in preparation in France, operational in Iceland or about to start in Croatia, Italy, New Zealand and Turkey.
  - Other synergetic uses - CCS with improved efficiency in the capture process by using geothermal energy, synergy through dual non-competitive use in the same reservoir, and synergetic use through pressure management.
  - Borderline concepts were also discussed in brief but otherwise deemed out of scope for the study.
- Key criteria are identified and where possible used as comparisons between concepts made, for example, total CO_2 stored, the energy produced, an overview of research and a path to commerciality, and subsurface features.
- Future work on the economic evaluation will need to accompany pilot projects to assess the economic feasibility, a feature lacking in many desk-based studies to date, and engagement across multiple stakeholders is necessary to move concepts to development.



3 Techno-Economic Assessment of Electrochemical CO_2 Conversion Technologies | 2023-03

Report managed by Jasmin Kemper

- This study aims to assess the costs and greenhouse gas (GHG) emissions performance of selected electrochemical CO_2 conversion pathways. It applies a learning curve method to project costs up to 2050.
- Of several pathways reported in the literature, this study identified six pathways that have reached sufficient technology readiness level (TRL > 4) and sufficient data to allow for a first techno-economic assessment (TEA).
- The pathways include processes that produce carbon monoxide (CO), syngas (CO + H2), formic acid (HCOOH) and ethylene (C2H4), either by low-temperature (LT) electrolysis, high-temperature (HT) solid oxide electrolysis or a tandem LT/HT process.
- HT electrolysis to produce syngas is the closest to reaching break-even levelised production costs compared to the fossil reference. The economic performance of all routes is mainly determined by the CAPEX component and thanks to steep learning of the HT pathways, these routes are likely first to reach break-even. LT electrolysis processes still need a substantial reduction in investment costs to break even.
- The GHG performance of the pathways is highly dependent on the emission factor of the electricity used. Electrochemical production of formic acid, CO and syngas results or can soon result in substantial GHG savings compared to the fossil reference. CO_2 taxation between at least 60 and 636 €/tCO_2 is estimated to be required. Electrochemical production of ethylene would require a very low (< 50 gCO_2e/kWh) emission factor to be competitive with current production methods and CO_2 taxation of more than 2000 €/tCO_2 is estimated to be necessary.
- As the assessment in this study involves the assessment of relatively low TRL technologies, it is important to keep in mind that the related uncertainties can be high.
- The results of this study will be of interest to research organisations, industry, as well as financial RD&D sponsors.
- Recommendations:
  - This study identified several knowledge gaps and suggestions for future research direction, which can be picked up by research organisations. One overarching topic concerned information on the purity requirements of the CO_2 feed.
  - On a more general level, more development and investments are necessary to enhance TRL and decrease the costs of the investigated CO_2 electroconversion routes. Especially pilot projects which demonstrate the entire process chain will be necessary to validate the projected economic and environmental performance.



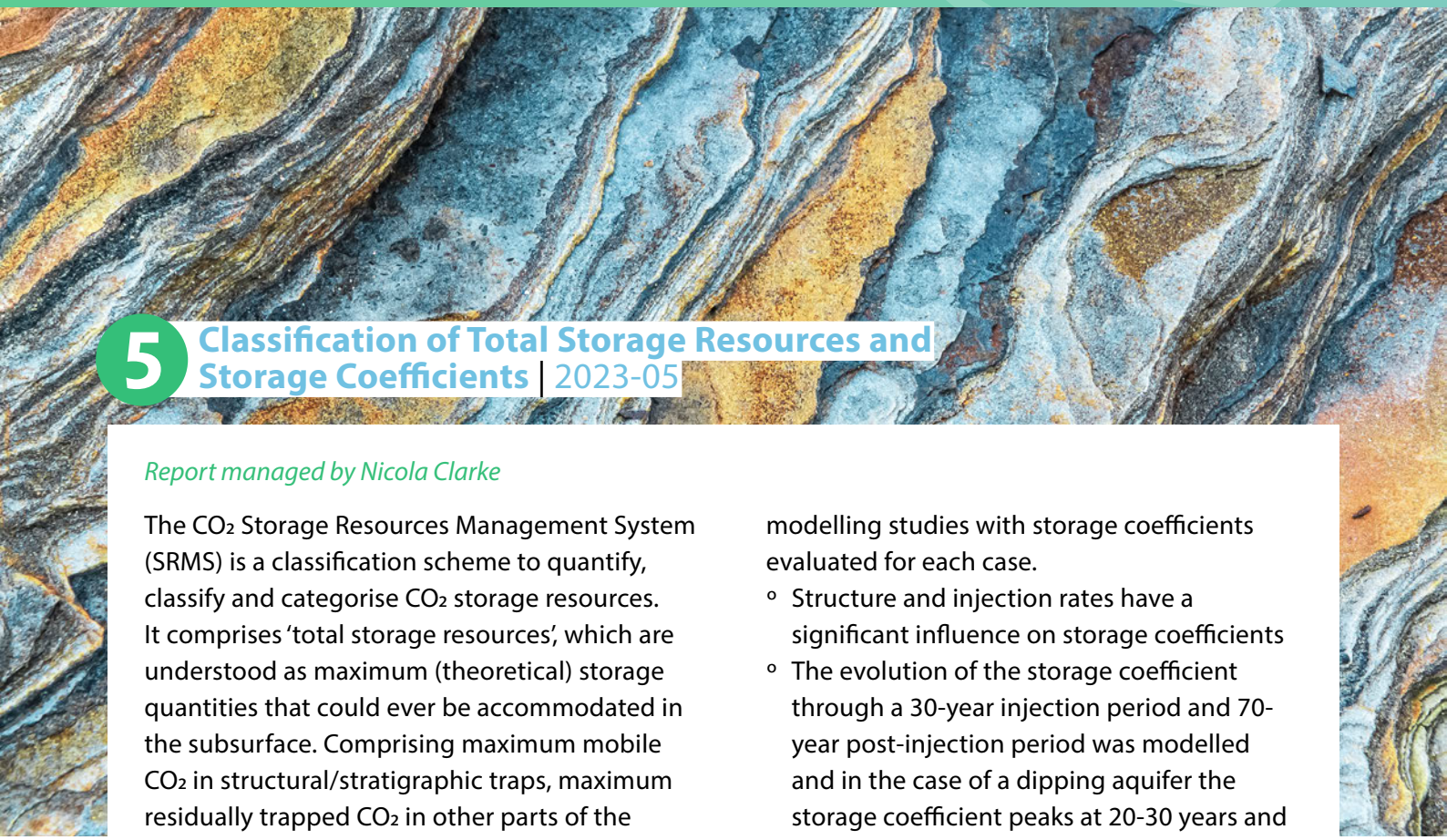
4 Components of CCS Infrastructure Interim CO_2 Storage Options | 2023-04

Report managed by Samantha Neades

This work, undertaken on behalf of IEAGHG by TNO, SINTEF and Vopak, provides an overview of temporary/interim CO_2 storage, or 'holding', options (also called buffers) and investigates the role of buffer storage and its potential to create flexible carbon capture and storage (CCS) chains. The report examines current and emerging buffer technologies, conducts simulations to demonstrate the temporary storage required for given flow-rate scenarios and discusses the impact of buffer capacity on transport costs.

- The transport of CO_2 needs to be flexible due to variations in the production of CO_2 and availability in the storage part of the chain; a buffer may be needed to make up for the batch-like nature of a ship-based transport chain as well as to assist with varying transport and storage (T&S) availability and to absorb variations in CO_2 supply and/or demand.
- Current technology options for buffering include quayside facilities and on-site tanks, geological gas storage, and pipeline line-packing.
- Emerging technology options may include offshore storage in salt and other caverns, and floating storage and injection units.
- Costs will be incurred when designing extra/interim CO_2 storage capacity into a CCS chain and as an estimate for cases in Europe, the cost for buffer storage be approximately 5-10% of the transport costs.
- The most likely solution for buffer capacity is onshore facilities designed for shipping. It is unlikely that geological storage will be developed for these changes given the longer timescales for storage and injection cycles. Man-made underground storage tanks are likely to become more common as energy storage becomes more widely used.
- In the scenarios investigated in this study, the cost is between 1 to 2.7 € per tonne of CO_2 buffer storage provided. These buffer storages should be located close to the capture site to minimise costs.
- It will be more cost-effective to design some level of flexibility into a T&S system through spare capacity in pipelines and wells, allowing some freedom to redirect CO_2 flows in cases of T&S downtime and an ability to handle flowrate variations.
- It will be more cost-effective to group CO_2 sources because when sources are connected in a T&S network.
- To assess whether a project should incorporate buffer storage, a full understanding is needed of the likelihood of having to close down specific wells due to the lack of CO_2.

Technical Reports



5 Classification of Total Storage Resources and Storage Coefficients | 2023-05

Report managed by Nicola Clarke

The CO_2 Storage Resources Management System (SRMS) is a classification scheme to quantify, classify and categorise CO_2 storage resources. It comprises 'total storage resources', which are understood as maximum (theoretical) storage quantities that could ever be accommodated in the subsurface. Comprising maximum mobile CO_2 in structural/stratigraphic traps, maximum residually trapped CO_2 in other parts of the formation, and maximum dissolution potential in remaining formation water. This study explores storage resource classification schemes and their evolution in understanding, the calculation of storage resources and the storage coefficient.

- The classification of storage resources and associated schemes have become more complex over time and more aligned to the requirements of operational storage with the SRMS becoming the industry standard.
- Storage coefficients are vital for quantifying accessible storage resources, standard methodologies have been presented and examples of usage within national and international databases. 97% of global storage is of a prospective nature and having quick screening criteria are useful in initial basin screening.
- Data from CO_2 storage sites can be used to calculate storage efficiency through time by measuring plume area on time-lapse seismic data.
- Numerical simulations were run with key parameters identified through publicly available modelling studies with storage coefficients evaluated for each case.
  - Structure and injection rates have a significant influence on storage coefficients
  - The evolution of the storage coefficient through a 30-year injection period and 70-year post-injection period was modelled and in the case of a dipping aquifer the storage coefficient peaks at 20-30 years and then gradually reduces whereas a structural closure sees a more stable post-injection storage coefficient.
  - Water production did not impact the storage coefficient, but modelling an open system may have impacted the results.
  - Hysteresis may not impact the storage coefficient significantly, but it does cause the distribution of CO_2 with more trapped in deeper layers of the reservoir increasing storage security.
- Analytical models from the literature have been modified to estimate storage coefficients and compared to modelled data from the storage sites. At first pass, they give a quick and easy estimate for lower stages of development but results slightly underperform. Another approach using dimensionless variables to emulate or build upon some of the numerical modelling work may provide a way to estimate storage coefficients for a cheaper cost than using full dynamic simulations.

Technical Reports

6 International Standards and Testing for Novel CO_2-Containing Building Materials | 2023-06

Report managed by Nicola Clarke

- Over 4 billion tonnes of cement are produced annually, ~ 8% of global anthropogenic CO_2 emissions, with industry growth expected with the expansion of the built environment just when emissions need to be reduced. The utilisation or reduction of CO_2 within cement could be a valuable way to contribute to emissions reductions in the sector, but there are several barriers, including the current state of standards, regulations and policies.
- Climate change is an important priority in the building materials industry, with CO_2 intensity or other measures being part of tendering processes and shareholder pressure to decarbonise an important factor. An increasing number of companies have emerged that are developing innovative materials that utilise CO_2 to lower the carbon emissions intensity of construction products. However, safety and testing are seen as vital to maintaining high standards and knowledge sharing across industries and countries is important.
- Performance-based standards are preferable but take effort, time, and funding to develop. It's a challenge to include every possible combination of materials in a performance-based standard. A transition to performance-based specifications will require the development of rapid and reliable performance test methods. Some test methods need to be altered for new materials.
- Comparing specifications for cements or concrete between international standards is difficult because cement types are defined using different criteria either using end-use requirements or composition. Within the same overarching standard, there are large differences in values between countries because they can set limits on specific properties when specifying the same material property for a material exposed to a particular set of conditions.
- Material such as carbonated concrete slurry waste can act in a complex manner within the cement, allowing a reduction of the total amount of cement clinker. There is a large potential resource of concrete slurry waste, and it could be profitably used.
- There's a significant potential market for carbonatable materials, but lifecycle emissions and commercial factors could reduce CO_2 savings and the total market available. Support through legislation and tax credits can help deploy new materials.
- An analysis of the CO_2 capture potential of industrial by-products from five sectors found that ~0.56 Gt of CO_2 emissions could be captured by 3.6Gt of carbonatable materials each year using CO_2 mineralisation. Emissions reductions for the substitution of other materials could save 0.01 to 0.49 kg CO_2eq per kg substituted.

Webinars

Webinars are an essential part of our knowledge sharing activity. Each event is recorded and publicly available on the IEAGHG YouTube channel. For details of our upcoming webinars you can subscribe to our email list at ieaghg.org/ccs-resources/weekly-news.

WEBINAR: 2023-01 Integrating CCS in international cooperation and carbon markets under Article 6

WED, MAR 22, 2023

75 ATTENDANCE | 219 YOUTUBE VIEWS SO FAR

A webinar to discuss the recent IEAGHG Technical Report, 2023-01 Integrating CCS in international cooperation and carbon markets under Article 6 of the Paris Agreement.

WEBINAR: 2022-11, Applying ISO Standards to Geologic Storage and EOR Projects

WED, APR 19, 2023

104 ATTENDANCE | 178 YOUTUBE VIEWS SO FAR

This study, undertaken by DNV on behalf of IEAGHG, aimed to summarise and synthesise the two ISO Standards relevant to the geological storage of CO_2: – ISO 27914:2017 ('Carbon dioxide capture, transportation and geological storage - Geological storage') and ISO 27916:2019 ('Carbon dioxide capture, transportation and geological storage - Carbon dioxide storage using enhanced oil recovery (CO_2-EOR)') – to provide a high-level understanding of the content into an easily digestible format.

WEBINAR: The Value of Research, Development & Demonstration in the Commercial Deployment of CCS

WED, JUN 7, 2023

79 ATTENDANCE | 108 YOUTUBE VIEWS SO FAR

The aim of the webinar is to describe some of the R&D conducted and its value to the commercial deployment of CCS. SINTEFF, TERC and TNO will inform the wider CCS community on how their CCS research activities give value to large-scale trials and ultimately translates to commercial deployment of CCS projects around the world. Practical examples of some of the studies conducted and their impact on large scale CCS projects will be descried. This webinar is targeted at raising awareness within the CCS community of the value of CCS R&D, pilot and demonstration studies.

WEBINAR: Prospective integration of Geothermal Energy with Carbon Capture and Storage (CCS)

WED, SEP 27, 2023

116 ATTENDANCE | 737 YOUTUBE VIEWS SO FAR

This webinar presents the key results of a study carried out by BRGM for IEAGHG in 2022-2023 reviewing the current state-of-the-art of technologies combining geothermal energy production and Carbon Capture and Storage (CCS).

IEAGHG Communications

IEAGHG is growing, with increasing demand for our technical reports and events we are seeing more traffic and engagement through our digital channels than ever before.

134k
Website Page Views
***16% Growth** from last year*

198k
LinkedIn Impressions*

2.4k
LinkedIn Followers
***107% Growth** from last year*

76k
Website Sessions
***25% Growth** from last year*

1.6k
Facebook Followers
***2% Growth** from last year*

40k
Twitter Impressions*

1k
Facebook Impressions
***58% Growth** from last year*

2.4k
Twitter Followers*
***1% Growth** from last year*

1.8k
Email List Subscribers*
***16% Growth** from last year*

***Footnotes:** *In some cases a full year of historical data is not available. In this instance, an approximation is made based on the monthly average. In some cases, it is not possible to calculate the year on year change so that has been omitted. | Percentage increases represent the year-on-year change from 2022 to 2023*

Review List

2023 TECHNICAL REPORTS

Report Title	Contractor/Colleague	Report No.	.pdf Creation Date
Integrating CCS in international cooperation and carbon markets under Article 6 of the Paris Agreement	Sam Neades	2023-01	18/01/2023
Geothermal energy with CCS	Nikki Clarke	2023-02	17/08/2023
Techno-Economic Assessment of Electrochemical CO_2 Conversion Technologies	Jasmin Kemper	2023-03	10/10/2023
Components of CCS Infrastructure - Interim CO_2 Holding Options	Sam Neades	2023-04	27/11/2023
Classification of Total Storage Resources and Storage Coefficients	Nicola Clarke	2023-05	05/12/2023
International Standards and Testing for Novel Carbonaceous Building Materials	Nicola Clarke	2023-06	05/12/2023

2023 TECHNICAL REVIEWS

Review Title	Report Manager	Report No.	Publication Date
A bibliometric analysis of GHGT abstract submissions	Jasmin Kemper	2023-TR01	14/06/2023
9th HTSLCN Meeting Report	Jasmin Kemper	2023-TR02	21/09/2023
Risk Management Network Meeting Report	Nicola Clarke	2023-Tr03	29/09/2023
Cost Network Proceedings	Abdul'Aziz Aliyu	2023-TR04	01/11/2023
Monitoring Network Meeting Report	Samantha Neades	2023-TR05	18/12/2023
International Workshop on Offshore Geologic CO_2 Storage	Nicola Clarke	2023-TR06	01/12/2023

Review List

2023 INFORMATION PAPERS

Information Paper Title	IP No.	Publication Date	Author
Coal in Net-Zero Transitions	2023-IP01	05/01/2023	Keith Burnard
Energy Technology Perspectives 2023	2023-IP02	24/01/2023	Keith Burnard
Low-Carbon Ammonia Roadmap	2023-IP03	13/02/2023	Abdul'Aziz Aliyu
NETL updated baseline study	2023-IP04	16/02/2023	Keith Burnard
IEA Global Methane Tracker 2022	2023-IP05	06/03/2023	Jasmin Kemper
IEA CO_2 Emissions in 2022	2023-IP06	07/03/2023	Jasmin Kemper
IPCC Synthesis Report of the 6th Assessment Cycle	2023-IP07	20/04/2023	Jasmin Kemper
World Bank report: Decarbonising natural gas through carbon capture, utilisation and storage	2023-IP08	26/04/2023	Jasmin Kemper
Credible Pathways to 1.5°C	2023-IP09	02/05/2023	Keith Burnard
U.S. National Clean Hydrogen Strategy and Roadmap	2023-IP10	26/06/2023	Abdul'Aziz Aliyu
86th Meeting of the IEA Working Party on Fossil Energy (members only)	2023-IP11	27/07/2023	Tim Dixon
Building blocks for e-fuel production	2023-IP12	14/09/2023	Abdul'Aziz Aliyu
IEA Net Zero Roadmap 2023 Update	2023-IP13	02/11/2023	Jasmin Kemper
2023-IP14 TCP Universal Meeting	2023-IP14	06/11/2023	Keith Burnard
87th Meeting of the IEA Working Party on Fossil Energy (members only)	2023-IP15	05/12/2023	Keith Burnard

Review List

2023 BLOGS

2023 Blogs	Author	Publication Date
The first Global Stocktake was concluded at COP28, and some reflections	Tim Dixon	14/12/2023
Update on COP28 at almost the end	Tim Dixon	12/12/2023
Update on COP28 at halfway	Tim Dixon	08/12/2023
Managing the Offshore Energy Transition (MOET) Stakeholder Meeting	Nicola Clarke	08/12/2023
The 2023 CCUS Forum – Aalborg, Denmark	Nicola Clarke	01/12/2023
New IEAGHG Report: 2023-04, Components of CCS Infrastructure – Interim CO_2 Holding Options	Samantha Neades	30/11/2023
Prospective integration of Geothermal Energy with Carbon Capture and Storage (CCS)	Nicola Clarke	29/11/2023
CCSA conference – Springboard to Net Zero, Central Hall, Westminster London, October 17-18 2023	Nicola Clarke	31/10/2023
IFC Nigeria Dissemination Workshop on Industrial CCUS and a new Centre of Excellence!	Tim Dixon	23/10/2023
First national workshop on CCUS for Colombia: Opportunities and Challenges	Tim Dixon	16/10/2023
50 Years of the London Convention	Tim Dixon	09/10/2023
The 7th Post Combustion Capture Conference, Pittsburgh	Abdul'Aziz Aliyu	05/10/2023
6th International Workshop on Offshore Geologic CO_2 Storage	Nicola Clarke	20/09/2023
SPE International Executive Symposium: Accelerating Decarbonisation Deployment through Innovation and Collaboration	Keith Burnard	19/09/2023
Blog on FECM NETL Carbon Management Meeting, Pittsburgh. 28th August – 1st September.	Nicola Clarke/ Samantha Neades	11/09/2023
2023 FECM / NETL Carbon Management Research Project Review Meeting	Samantha Neades/ Nicola Clarke	07/09/2023
IEAGHG Monitoring Network Meeting 2023	Samantha Neades	14/08/2023
Birds and CCS compared to other Low-Carbon Energy Technologies	Tim Dixon	27/07/2023
IEAGHG International CCS Summer School	Samantha Neades	26/07/2023

Review List

2023 BLOGS

2023 Blogs	Author	Publication Date
CCUS at CEM14, MI-8 and G20 Energy meetings in Goa	Tim Dixon	25/07/2023
SINTEF's Tiller CO_2 Capture Pilot Plant	Keith Burnard	27/06/2023
CSLF Technical Group meeting in Warsaw– will this be the last CSLF meeting?	Tim Dixon	16/06/2023
A Brief Bibliometric Analysis of GHGT Abstract Submissions	Jasmin Kemper	14/06/2023
First Danish CCUS Summit	Tim Dixon	13/06/2023
CCUS featured in the first Global Dialogue under the Paris Agreement's Mitigation Work Programme.	Tim Dixon	05/06/2023
IEA Discussion Meeting on DAC and Carbon Markets	Tim Dixon	05/06/2023
ExCo 63, Bali, Indonesia	Tim Dixon	26/05/2023
IETS Conference	Abdul'Aziz Aliyu	23/05/2023
Low-carbon technology 'single-mindedness' reminds me of Monty Python's Life of Brian.	Tim Dixon	17/05/2023
Biden announces new Carbon Management Challenge on CCUS and CDR for COP28	Tim Dixon	24/04/2023
7th IEAGHG CCS Cost Network Workshop	Abdul'Aziz Aliyu	20/04/2023
G7 Climate, Energy and Environment Communique encourages CCS and CDR	Tim Dixon	19/04/2023
GoMCarb Project Final meeting – CCS in Offshore Gulf of Mexico	Tim Dixon	11/04/2023
UK government announcement on CO_2 sources to connect to the Track 1 Cluster projects	Tim Dixon	30/03/2023
UK Government's Announcement of up to £20bn for CCS	Tim Dixon	15/03/2023
Sharing CO_2 data with the world	Nicola Clarke	11/03/2023
Gulf Coast Carbon Center's Sponsors Meeting, February 2023	Tim Dixon	27/02/2023
G20 International Seminar on CCUS, Bengaluru	Tim Dixon	06/02/2023
New IEAGHG Technical Report: 2023-01 Integrating CCS in international cooperation and carbon markets under Article 6 of the Paris Agreement	Samantha Neades	18/01/2023

IEAGHG Members

Chair	Vice Chair	Vice Chair
Kelly Thambimuthu	Mark Ackiewicz	Åse Slagtern

MEMBERS LIST AND REPRESENTATIVES

Australia
Paul Feron

Austria
Theodore Zillner
Gunter Simader

Canada
Eddy Chui

Denmark
Karina M. Søgaard

European Commission
Vassilios Kougionas
Jeroen Schuppers

Finland
Jussi Mäkelä | Elke Schnabel
Francesco Reda

France
Rowena Stead
Florence Delprat

India
Atul Kumar

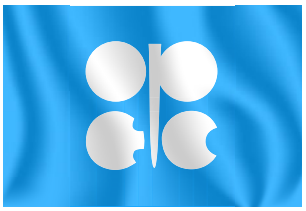
Japan
Ziqiu Xue | Tomonari Minezaki | Ken Asajima

IEAGHG Members

Korea
Jeom–In Baek

The Netherlands
Gerdi Breembroek
Martijn van de Sande

Norway
Åse Slagtern
Svein Ingar Semb



OPEC
Abderrezak Benyoucef
Elena Kaditi | Angelika Hauser

South Africa
Thulani Maupa

Sweden
Svante Soderholm
Isabella Gustafsson Ismodes

Switzerland
Stefano Benato
Sophie Wenger | Martin Jiskra
Nicole Lupi (observer)

United States of America
Mark Ackiewicz
Jeff Hoffman

United Kingdom
Will Lochhead | Carly Leighton
Treasure Udabor | Dominique Ritchie
Laura Kennedy | Amoah Christeller

Baker Hughes
Alexander John Cruz
Allyson Book

BP
Martin Towns
Simon Shoulders

Chevron
Arthur Lee

IEAGHG Members

CIAB
Peter Morris | Mark McCallum
Karl Bindemann

Drax
Catriona Reynolds
Gareth Johnson

ENI
Guido D'Alfonso | Sonia Caprara | Salvatore Gimmetti

EPRI
Rob Trautz

Equinor
Jamie Stuart Andrews
Peter Zweigel

ExxonMobil
Matthias Imhof

Juelich
Heiko Gerhauser
Eric Busche

IEA
Sara Budinis
Carl Greenfield

INEEL
Antonia Diego Marin

ITB
Warwan Gunawan A Kidir
Mohammad Rachmat Sule

JGC
Atsushi Matsumoto
Tsukasa Kumagai

J Power
Seiji Hongo
Shinichi Sakuno

IEAGHG Members

Petroleum Development Oman
Nabil Al Bulushi
Khalil Al Hanashi

RWE
Tilman Bechthold
Karl-Josef Wolf

Shell
Owain Tucker
Arpit Khandelwa

Sotacarbo
Gianni Serra

Southern Company
Richard Esposito

TotalEnergies
Philip Llewellyn

IEA Greenhouse Gas R&D Programme
Pure Offices, Cheltenham Office Park,
Hatherley Lane
Cheltenham, Glos. GL51 6SH, UK

Tel: +44 1242 802911
mail@ieaghg.org
www.ieaghg.org