

KEY TAKEAWAYS



GASSNOVA 



Foreword

The Knowledge Sharing 2026, CCS&CDR Summit was convened at a pivotal moment for carbon management. Across the CCS and CDR community, the focus is shifting from plans and ambition to projects in operation. For the first time, experiences from a fully operational value chain can be shared openly – from capture and transport to permanent geological storage beneath the seabed. This marks a significant milestone for the further development and scale-up of CCS and CDR in Norway and internationally.

The Longship project was established with a clear purpose: to pave the way for the projects that will follow. As a demonstration project, its responsibility goes beyond delivery. A significant value lies in what is shared – both successes and challenges alike – for the benefit of coming CCS and CDR projects. Open, systematic knowledge sharing is essential to reducing risk, costs and uncertainty, and to accelerating deployment across new projects. This principle lies at the heart of Gassnova's mandate and is the very rationale behind the Knowledge Sharing Summit.

The Summit brought together stakeholders from across the entire CCS and CDR value chain – industry, public authorities, technology providers, carbon market actors, financial institutions, research institutions, and project developers from around the world. Through plenary sessions, parallel tracks and in-depth technical discussions, participants exchanged concrete experiences and shared their knowledge in areas important for further deployment of CCS and CDR projects – insights that are often difficult to access beyond individual projects or organisations.

Knowledge sharing does not happen automatically. It requires trust, a willingness to collaborate, and arenas where different perspectives can meet and be challenged. The Knowledge Sharing Summit is intended to be such an arena – and a tangible expression of Gassnova's role in connecting projects, technologies and people, and in addressing information barriers that otherwise slow progress.

This report summarises the key insights from Knowledge Sharing 2026. Its ambition is to ensure that the knowledge shared contributes to learning, further innovation and the accelerated realisation of new CCS and CDR projects. If the insights captured here help make the path forward shorter and more predictable for those who follow, then the Summit will have fulfilled its most important purpose.

Porsgrunn, May 2026

Liv Lønne Dille
Project Manager

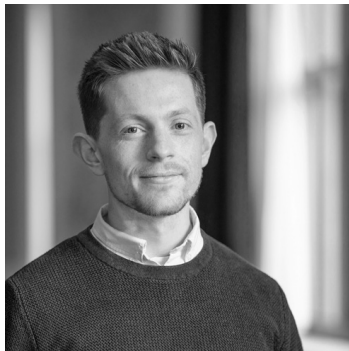
Programme committee



Jørild Svalestuen (Gassnova)



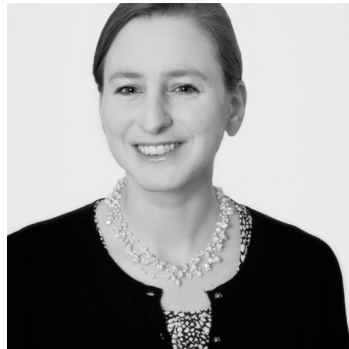
Liv Lønne Dille (Gassnova)



Eadbhard Pernot
(Carbon Management Europe)



Iria Vázquez Rodríguez
(Carbon Management Europe)



Jasmin Kemper (IEAGHG)



Juho Lipponen (CEM CCUS
INITIATIVE & MI CDR MISSION)



Samantha Neades (IEAGHG)



Stijn Santen (EBN /
Carbon Management Europe)

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Executive summary

Knowledge Sharing 2026 reinforced the importance of knowledge sharing and collaboration. The Summit gave a clear shift from “why CCS/CDR” to “how to deliver”. The lasting impression was that investment decisions now are less constrained by technology and more by issues like integration of value chains, bankability, fit-for-purpose standards, credible and aligned MRV. Going forward there is a need to reduce risks and costs. Operational learnings from early projects, like Longship, and of further innovations will reduce risk and cost for the needed next waves of projects that are needed to reach climate goals.

Key takeaways – what will move CCS and CDR forward

- 1. Treat CCS/CDR as a whole value chain, not separate assets**
Value chains fail at interfaces: misaligned assumptions across capture, conditioning, transport, storage and regulation propagate cost and delay. The strongest lesson was to assign clear interface ownership early and coordinate decisions across actors, not sequentially.
- 2. Secure the maturity needed before execution: FEED quality and change control decide project delivery outcomes**
CCS projects are often large and complex. Execution risk is strongly caused by lack of project maturity and late changes. The summit repeatedly highlighted minimum maturity requirements, early operational readiness, and disciplined change control as core levers to protect schedule, cost and commissioning performance.
- 3. Transport and storage access is a gating factor – design for hubs and optionality where this can contribute to cost reductions**
Across the European project pipeline, progress depends on access to transport and storage and the ability to connect to shared infrastructure. Flexible concepts (including shipping-based solutions) and hub approaches were repeatedly framed as practical enablers for scale and resilience.
- 4. Standardise where possible; tailor where necessary (CO₂ quality, interfaces, risk processes).** Cost and risk are amplified by fragmented specifications and bespoke requirements. A clear message was to converge on fit-for-purpose standards for CO₂ specifications and to align mitigation responsibilities across the chain—especially where mixed sources and hub solutions increase complexity.
- 5. MRV must be credible, interoperable, and workable across real value chains.** There is no single harmonised MRV framework today. The summit highlighted practical challenges that must be solved to scale: mixed CO₂ streams (incl. biogenic fractions), nonpipeline transport, and the need for MRV approaches that work across storage types and emerging “green product” value chains.

6. **Bankability is possible when conditions are right – revenue certainty and insurability unlock capital.** Projects become investable when downside risk is managed and cash flow is stable. Key enablers discussed long-term revenue structures, regulatory clarity, and insurance solutions that can price risk even with limited loss history. These are underpinned by better data, clearer regulatory definitions, and more standardised risk management practices.
7. **Real plant operation and open learning drive cost reduction faster than lab progress alone.** The summit emphasised that real plant operation reveals the constraints that matter (flue gas variability, integration, emissions control, energy use). Knowledge sharing and learnings from projects in operation matter for upcoming projects to reduce cost and risk. In addition are stepwise scale-up, demonstration and comparable test campaigns, plus nonproprietary knowledge sharing, still crucial for each project to succeed on the way towards full scale operation.
8. **Storage scale-up requires phased development, operational data, and monitoring optimisation.** Storage maturity grows through operations: models must be validated and updated with injection and monitoring data. Monitoring strategies should evolve from “learn fast” (early, high information) to “optimise cost” (later, fit-for-purpose). Scale will come from multiple reservoirs and hub-based systems, not one blueprint.
9. **CDR needs the same delivery discipline—plus demand and market architecture.** Technology-based removals remain a small share today, and meaningful scale requires rapid growth supported by infrastructure, standardisation, streamlined MRV/permitting and durable demand. Early markets are concentrated; scaling depends on predictable frameworks that broaden buyers and volumes. Government action (e.g. procurement) and policy drivers will play a larger role going forward.



We hope this report provides useful insights and supports continued progress on CCS and CDR. The organisers of Knowledge Sharing 2026 wish you an engaging and inspiring read.

Gassnova in cooperation with Carbon Management Europe, CEM CCUS Initiative, IEAGHG and Mission Innovation CDR Mission

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CCS & CDR Summit

MAIN PROGRAM

Status of CCS and CDR internationally

Moderator: Juho Lipponen (CEM CCUS / MI CDR)

Speakers: Chris Thackeray (Baringa),
Eve Tamme (Carbon Management Europe),
Jason Gadoury (Canada), Kristin Myskja (Norway),
Matthew Taylor (UK)

Five key takeaways from this workshop

- **Knowledge sharing is a core enabler for scale.** Scaling depends on systematically generating and openly sharing lessons from real projects, with Longship framed as a key European learning platform.
- **Longship shows end-to-end CCS is operational – and the next step should be more market-based.** Public risk-taking was necessary for the first chain; future expansion should rely on market-driven investment and stronger commercial incentives, based on a firmer /more reliable climate policy framework that can deliver the need investments for the climate neutrality goal.
- **Bankability – not technology – is the binding constraint for most projects.** Finance is increasingly comfortable with CCS as an asset class, but requires stable policy, bankable revenue stacks, and explicit downside-risk mitigation (value chain + infrastructure).
- **Different national policy models can deliver, but contexts differ.** Norway (state-backed demonstration + incentives), UK (detailed business models), Canada (progressive policy stack incl. investment tax credits) were presented as distinct pathways that produced projects.
- **CDR is increasingly intertwined with CCS infrastructure build-out.** The panel argued that CDR cashflows (voluntary markets + subsidies) can unlock storage infrastructure, and that scaling to 2030 requires demand liquidity, value on carbon, and mechanisms that manage “double burden” risks.

Main topics/discussions

1. Norway progress and milestones (policy + projects) last year.

- Waste-to-energy capture FID (Oslo) linked to voluntary carbon removal market backing.
- Northern Lights Phase 2 commercial and capacity step-up; shift toward market-based investment.
- Storage licensing approach and cross-border arrangements (London Protocol; bilateral cooperation and agreements).
- Over many years Norway has built an R&D foundation and a solid knowledge base (CLIMIT, TCM & Longship, together with extensive industrial experience (e.g. Sleipner CO₂ storage) and expertise).

2. “What worked” across national approaches (Norway/UK/Canada).

- Incentives as a design choice; role of stable regulatory environments.
- Progressive policy layering to meet industry maturity; tax-credit conditionality tied to public knowledge sharing.
- UK learning from renewables/network finance; collaboration; open question on long-term financing models (especially for CDR scale).

3. Financing and FID: what is needed to move projects forward.

- Bridge cost gap (carbon pricing + green premiums + subsidy).
- Mitigate downside risks (infrastructure + cross-chain risks).
- Solve coordination/chicken-and-egg via public-private partnerships.
- Development capital bottleneck; need line-of-sight to revenue and policy durability; potential European risk-pooling concept for CO₂ infrastructure.

4. CDR scale-up

- Put a value on carbon; build demand liquidity beyond voluntary markets (compliance role discussed).
- Push-pull: accelerate innovation + create offtake (incl. public procurement/tenders).
- BioCCS ramp-up as volume inflection; Buyers' Club concept as potential demand-pull; “CCS guarantee mechanism” to avoid double burden if transport/storage disruptions occur.

Outcome and action points

Overall topics:

- **Make lessons reusable:** Make learnings from operational CCS FOAK projects available and develop standards, guidance, and bankable templates.
- **Build bankable stacks:** combine carbon pricing + green premiums + subsidies/CFDs + creditworthy offtake; integrate low-cost public finance where relevant.
- **De-risk infrastructure:** implement mechanisms that reduce cross-chain and infrastructure downside risk; explore pooling/risk-sharing for cross-border CO₂ infrastructure.
- **Create demand liquidity for CDR:** complement voluntary demand with compliance-grade pathways and public procurement; scale BioCCS as early large-volume lever.

Conclusion

The session framed **scaling CCS/CDR as a bankability and market-design challenge**: stable policy, credible revenue stacks, and explicit risk-sharing are required to move the majority of projects from development to FID. Longship was positioned as a critical European reference for learning-by-doing and for accelerating the next wave of projects—while acknowledging that future scaling must be more market-based than the first demonstration model.

Longship and upcoming CCS/CDR Projects in Europe before 2030 – part I

Moderator: *Camilla Brox (Karbon Interim)*

Speakers: *Giv Brantenberg (Heidelberg Materials),
Martin S. Lundby (Hafslund Celsio), Tim Heijn (Northern Lights)*

Five key takeaways from this workshop

- 1. Longship is operational and has proven the end-to-end CCS.** Northern Lights entered operations in 2025, with CO₂ shipping, offloading and injection successfully demonstrated, validating the full end-to-end value chain from capture to permanent storage.
- 2. Transport and storage fundamentally derisk capture projects.** With Northern Lights in operation and Phase 2 under construction, the traditional chickenandegg problem between capture and storage has largely been resolved.
- 3. Public–private partnership is a key enabler for first-of-a-kind CCS.** Norwegian state support, combined with strong industrial ownership, has been a decisive enabler for CCS projects in cement and wastetoenergy.
- 4. Industrial CCS is feasible but demanding to execute.** Experience from Brevik CCS and Oslo CCS highlights the importance of early planning, strong governance, HSE focus and organisational readiness.
- 5. The main challenge ahead is scaling, not technology.** Predictable framework conditions (EU ETS), funding mechanisms and demand for lowcarbon products and carbon removals are essential to move from individual projects to large-scale deployment.

Main topics/discussions

The workshop covered operational experience from Longship, lessons learned from first-of-a-kind industrial CCS projects, status and scalability of CO₂ transport and storage, and business models for CCS and CDR in a European context.

Outcome and action points

Overall topics:

- **Key learnings for next generation of projects.** Experience from Longship, Brevik CCS and Oslo CCS shows the importance of early and dynamic risk management, robust FEED maturity, early regulatory engagement, early integration of operations competence, and aligned contract strategies across the CCS value chain.
- **Need for further R&D.** Further R&D is primarily required in cost reduction and standardisation, integration of CCS in brownfield industries, and optimisation of transport and storage interfaces.
- **Use Longship experience to derisk future projects.** Experience from Longship should be actively used to de-risk and accelerate development of nextgeneration CCS projects, particularly in concept and pre-FEED phases, with systematic application of lessons related to risk management, FEED maturity, regulatory processes and contract strategies.

Topics specific for each workshop:

- **Distribution of responsibilities and risk sharing between actors.** Clear allocation of responsibilities and risk sharing across capture, transport and storage is essential in multiactor CCS projects and must be addressed early.
- **Cross-value chain alignment needs.** Alignment across the CCS value chain – including technical interfaces, CO₂ specifications, logistics solutions and commercial structures – is necessary to move from first-of-a-kind projects to scalable and repeatable deployment.
- **From first-of-a-kind to scalable projects.** Lessons from Longship illustrate how first-of-a-kind experience can be translated into standardised, bankable project models with reduced cost and risk.

Recommendations and further work

- Maintain longterm predictability and credibility of the EU ETS
- Reinvest ETS revenues to help bridge the gap to market for CCS
- Continue coordinated development of CO₂ transport and storage as shared European infrastructure

Conclusion

The workshop confirms that CCS has moved from concept to reality. Longship demonstrates that full-scale CCS works technically and organisationally. The critical task going forward is to translate first-of-a-kind experience into faster, cheaper and more standardised projects through predictable policy frameworks, viable funding mechanisms and stronger demandside pull.

Links

- Northern Lights:
<https://norlights.com/>
- Gassnova / Longship:
<https://www.gassnova.no/>
- Hafslund Celsio – Oslo CCS:
<https://www.celsio.no/>
- Heidelberg Materials – Brevik CCS:
<https://www.heidelbergmaterials.com/>

Longship and upcoming CCS/CDR Projects in Europe before 2030 – part II

Moderator: *Camilla Brox (Karbon Interim)*

Speakers: *Anders Egelrud / Erik Rylander (Stockholm Exergi), Kathrine Høeg Johansen (Ørsted), Michael Schlaug (Yara Netherlands), Sidsel Lindsø (Ecteras)*

Five key takeaways from this workshop

- 1. Projects are moving into realization, but progress takes longer than expected.** Several of the projects presented have progressed from demonstration into delivery. Ørsted's Kalundborg project and Stockholm Exergi's BECCS project clearly illustrate how CCS and CDR initiatives are now reaching operation or FID ahead of 2030. At the same time, experience from these projects shows that permitting processes, an immature supplier market and complex value-chain integration still tend to slow overall progress.
- 2. Predictable policy frameworks are critical for investment decisions.** Both Yara and Stockholm Exergi emphasized that longterm, stable regulatory and policy conditions are essential to make CCS and CDR business cases viable over investment horizons of 20–25 years.
- 3. Transport and storage access is decisive for FID.** Experience from capture projects and storage developers shows that access to transport and storage infrastructure is a prerequisite for taking FID. Hub and clusterbased solutions, as highlighted by Ørsted, Hafslund Celsio and Northern Lights, reduce both cost and risk across the value chain.
- 4. Lack of standardization creates inefficiency and cost.** Several contributors, including Ecteras and panel participants, pointed to fragmented approaches to MRV, certification and due diligence. Repeated and projectspecific documentation requirements create unnecessary friction and increase costs, underscoring the need for harmonized frameworks to enable scale-up.
- 5. The main remaining risks are nontechnical.** Drawing on subsurface and operational experience from Ecteras and Northern Lights, storage-related risks were described as largely manageable. Policy uncertainty, immature markets and insufficient demand signals now represent the dominant sources of project risk.

Main topics/discussions

The session brought together experience from operational and forthcoming CCS and CDR projects across the Nordics and Europe, including industrial CCS, BECCS and biogenic CDR. Presentations and discussions covered project maturation, key cost drivers, supplier readiness and interface management across the value chain. Experiences shared by Ørsted, Yara and Stockholm Exergi highlighted the practical challenges of moving from concept to execution, while Ecteras provided a subsurface perspective on storage capacity, injectivity and the realism of storage estimates. The panel discussion, including representatives from Northern Lights, Hafslund Celsio and Heidelberg Materials, complemented these insights with reflections on policy design, public support mechanisms, market formation and the importance of collaboration across actors.

Outcome and action points

Overall topics:

- Experience from first-mover projects provides important learning for the next generation of CCS and CDR projects, particularly related to project integration and realistic planning assumptions.
- Contributions from both project developers and storage providers highlighted the importance of balanced risk allocation across the value chain.
- Several contributors pointed to a continued need for targeted R&D, especially related to cost reduction, supplier development, storage characterization and system-level integration

Topics specific for each workshop:

- Clearer allocation of roles and responsibilities between capture, transport and storage actors is needed to improve project execution.
- Stronger coordination and information sharing across the value chain can significantly reduce technical, commercial and organizational risk.
- Learning directly from ongoing Nordic and European projects was highlighted as an effective way to lower entry barriers for new CCS and CDR initiatives.

Recommendations and further work

- Develop common European frameworks and programs that prioritize projects with high execution maturity and shared infrastructure.
- Advance standardized contractual and pricing models for transport and storage services, building on experience from projects such as Longship and Northern Lights.
- Strengthen Nordic and European cooperation to accelerate large-scale deployment of CCS and CDR towards 2030.

Conclusion

Overall, the session confirmed that CCS and CDR technologies are available and increasingly proven at full scale, as demonstrated by several of the projects presented. However, the pace of deployment and the potential for cost reductions depend on coordinated action between authorities, industry and financial actors. Projects are most robust where risks are shared, infrastructure is used efficiently and regulatory frameworks are credible and predictable over time. Experience from first-mover projects such as Longship, Kalundborg and Stockholm Exergi indicates that the next generation of CCS and CDR projects can be delivered faster and at lower cost if they build on existing infrastructure, standardized solutions and shared learning.

Links

- Ørsted: [Carbon Capture & Storage \(CCS\) | Ørsted](#)
- Hafslund Celsio: [Karbonfangst og -lagring - hafslund.no](#)
- Stockholm Exergi: [Beccs Stockholm – one of the world’s largest facilities - Stockholm Exergi](#)
- Yara International: [Carbon Capture and Storage in action: Yara’s project in Sluiskil | Yara International](#)

Pitch session – Upcoming CCS projects in Europe

Moderator: Iria Vázquez (Carbon Management Europe)

Speakers: James Cogan (Danube Carbon Storage),
Dr. Pantelis Vogiatzis (EnEarth), Flaviu Barsan (ONE-Dyas)

Five key takeaways from this workshop

- CCS projects can be delivered at significantly lower cost through simple, fit-for-purpose design, modular development, and reuse of existing oil and gas infrastructure.
- Technological maturity is not the main barrier to CCS deployment; instead, financing, revenue certainty, and market design remain the decisive challenges.
- Shipping-based CO₂ transport and flexible injection concepts enable access to storage for emitters without pipeline connectivity and increase overall system flexibility.
- A structural imbalance between industrial emissions and available storage capacity, particularly in Southern and South-East Europe, represents a major system bottleneck.
- Regulatory readiness and coherent EU market frameworks are critical enablers for investment confidence and project momentum.

Main topics and discussions

Discussions focused on how CCS projects are adapting to diverse regional conditions across Europe. Projects ranged from smaller onshore saline aquifer developments to large-scale offshore storage hubs, with strong emphasis on cost drivers, simplified value chains, and infrastructure reuse. Shipping-based CO₂ transport, compressed CO₂, and flexible injection concepts such as Direct Offshore Injection (DOI) were discussed as key enablers for access to storage and increased CO₂ specification flexibility. Financing models and EU market frameworks, including the Innovation Fund, ETS, and the Net Zero Industry Act (NZIA), were highlighted as decisive factors. The allocation of risk across the CCS value chain remains a challenge, with storage developers increasingly carrying subsurface and permitting risks.

Outcome and action points

- Strengthen structured knowledge sharing between advanced CCS regions and emerging European markets.
- Promote best practices for permitting and regulatory implementation to reduce project lead times.
- Support shipping-based and complementary CO₂ transport solutions alongside pipeline infrastructure.
- Increase transparency and coordination around planned storage capacity at the European level.
- Continue refining EU market and regulatory frameworks to underpin long-term investment confidence.

Conclusion

The pitch session demonstrated that Europe is not constrained by a lack of technically viable CCS solutions. The main limitation lies in market design, regulatory certainty, and access to stable revenue mechanisms. Continued progress will depend on coherent policy frameworks, cross-border coordination, and a portfolio of transport and storage solutions adapted to regional conditions.

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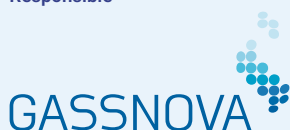
WORK- SHOPS

Longship experience sharing: Insights across the full project lifecycle

Moderator: *Eve Tamme (Carbon Management Europe)*

Speakers: *Aslak Viumdal (Gassnova),
Tor Gautestad (Heidelberg Materials),
Jannicke Gerner Bjerås (Hafslund Celsio),
Ove Dalland (Northern Lights), Knut Bakke (Equinor)*

Responsible



Five key takeaways from this workshop

- 1. Longship was established to demonstrate full-chain CCS and enable learning.** The objective is to show that large-scale CCS is technically feasible and safe, and to generate technical, regulatory and commercial learning that can reduce cost and risk in future projects.
- 2. Gassnovas role in Longship has been to be a project integrator and to follow up the industrial projects through state aid agreements.** In the development of Longship, Gassnova early identified the whole-chain risk as a major investment barrier. This led to splitting the CCS chain in two, capture and transport & storage. And, Gassnova taking on an integrator role, including facilitating for a common design basis, coordination of schedules and decision gates, and structuring requirements and cooperation on experience sharing. The industrial actors retained responsibility for their own project execution. Gassnova has been following up the industrial project development, and are now following up the state aid agreements for construction and operation.
- 3. Integration into existing industrial plants is technically demanding.** Experience from Brevik CCS and Oslo CCS shows that limited space, complex interfaces with existing processes, energy integration and continued operation significantly increase execution risk.
- 4. FEED maturity and scope discipline are decisive.** Experience from Brevik CCS and Oslo CCS shows that a mature FEED and strict control of scope changes are critical for contract negotiations, execution, cost control and schedule.
- 5. Interfaces dominate risk during commissioning and startup.** Northern Lights' experience shows that many technical and schedule challenges materialize late, when capture, transport and storage systems are tested together and handed over to operations.

Main topics/discussions

The workshop brought together experience from the full CCS value chain. Gassnova presented the background, mandate and lessons from establishing Longship, including the integrator role and the importance of systematic knowledge sharing through initiatives such as ccsnorway.com. Heidelberg Materials (Brevik CCS) shared detailed lessons from maturing and executing a first-of-a-kind capture project in an operating cement plant, focusing on FEED maturity, scope control, risk management and operational readiness. Hafslund Oslo Celsio presented experience from waste-to-energy capture and carbon removal, including energy integration and market aspects related to CDR. Northern Lights presented experience from CO₂ transport and storage as a service, with focus on interfaces, commissioning, start-up and handover to operations (please see [presentations](#) from the industrial actors for detailed learnings).

Outcome and action points

Overall topics:

- High FEED maturity before FID
- Clear scope definition and strict change control
- Interfaces as key drivers of cost, schedule and risk
- Early planning for commissioning and start up
- Continued cost reduction efforts across the CCS value chain
- Further standardization based on real project experience

Topics specific for each workshop:

- Clear allocation of responsibilities across capture, transport and storage
- Explicit and balanced risk sharing along the CCS value chain
- Focus on interfaces during commissioning and handover to operations
- Systematic documentation and reuse of lessons learned

Recommendations and further work

- Do not compromise on minimum FEED maturity requirements on CCS projects, as they often are large and complex projects, often at brown field sites and integrated on existing industrial plants, in operation
- Integrate operational readiness earlier in project development
- Strengthen experience sharing through common platforms
- Continue development of common standards and practices based on execution and startup experience

Conclusion

The presentations showed that successful CCS delivery depends on early technical maturity, disciplined scope and interface management, and deliberate integration across capture, transport and storage. Longship demonstrates that full-chain CCS can be realized at industrial scale, while experience from Brevik CCS, Oslo CCS and Northern Lights provides concrete and transferable lessons on how and where risks materialize during execution and start-up.

Links

- Gassnova's site for lessons learned in Longship – <https://ccsnorway.com/reports/>
- Northern Lights – [Northern Lights](#)
- Hafslund Celsio/Oslo CCS – <https://www.hafslund.no>
- Heidelberg Materials / Brevik CCS – <https://www.brevikccs.com/en>

CO₂ transport technologies, contractual frameworks, and systems

Moderator: Stijn Santen (EBN/Carbon Management Europe)

Speakers: Wouter Schiferli (EBN), Anil Erdogan (Aramis/EBN), Kleopatra Avraam (Desfa), Fred Lockwood (Oceos)

Responsible



Five key takeaways from this workshop

1. **CO₂ transport must be designed as an integrated system, not as separate assets.** Across the presentations, the recurring message was that pipeline design, pressure and temperature regime, reservoir behaviour, wells, liquefaction, shipping and terminal interfaces are tightly interdependent. Optimizing one segment of the value chain might not pay off for the whole.
2. **First-of-a-kind (FOAK) projects require substantial upfront de-risking which is not necessarily 'early' in the project cycle.** Aramis showed that dense-phase CO₂ transport cannot simply be treated like natural gas, and that dedicated validation such as full-scale Running Ductile Fracture testing was needed. This full-scale test provides robust validation of the Aramis pipeline specifications for safe CO₂ transport, supporting regulatory compliance, risk assessment, and future CCS infrastructure design.
3. **Open-access hubs can unlock scale, but they also multiply interface and alignment challenges.** Both Aramis and ApolloCO₂ highlighted the value of shared infrastructure and optionality across emitters and storage sites but also showed that this requires coordination across many partners, technical standards, and investment timelines.
4. **If you haven't negotiated a commercial contract, your life has been a lot easier.**
5. **Collaborate early and along the value chain.** This was one of the clearest cross-cutting messages of the workshop. Early collaboration is needed on all fronts as designs are continuously evolving. Not understanding the interfaces always comes with additional costs, complexities, and delays.

Main topics/discussions

1. Integrated modelling and transport strategy selection

Wouter Schiferli (EBN) showed why CCS in depleted gas fields is materially different from aquifer injection because of low initial reservoir pressure which results in extremely low injection temperature and well integrity challenges. In Porthos, this was overcome by starting injection in gas phase and switch to dense phase after certain pressure is reached. However, for the Aramis stores the arrival temperature at the sites will be lower and thus the operator must deal with cooling effects. EBN's Calysto tool was presented as an integrated thermal and transient modelling solution that links surface network, wells and reservoir, allowing operators to assess injection strategies and cold-front propagation more realistically than with separate tools.

2. Pipeline de-risking in Aramis

Anil Erdogdu (Aramis) explained how the Aramis project is developing open-access offshore CO₂ transport infrastructure linked to Porthos and CO₂next, and why dense-phase offshore transport required specific technical validation. As it became clear at FEED that they were dealing with immature technologies, proper derisking of the full project required TRL 6 across the board. A central example was the full-scale Running Ductile Fracture (RDF) test in Sardinia, used to demonstrate that the pipeline design could safely arrest fracture propagation and to validate design requirements before public tendering. She stressed that this example took a full year to derisk, flagging again that these FOAK projects are not to be taken lightly.

3. Development of integrated midstream hubs in Southern Europe

Kleopatra Avraam (Desfa) presented ApolloCO₂ as a midstream CCS hub that combines pipeline aggregation, liquefaction, temporary storage and shipping. CO₂ supply in Greece largely exceeds local storage capacity, so Desfa sees opportunity to aggregate volumes and reach economies of scale. These economies of scale might allow scalable shipping sizes that can cover longer distances across the Mediterranean. The project illustrated how policy, regulation and project development are progressing in parallel in Greece, and how integration with existing LNG infrastructure could improve project economics – potentially bringing down liquefaction costs by a factor 8.

4. Shipping, terminal interfaces and FOAK contracting

Fred Lockwood (OCEOS) introduced the company which is an Air Liquide and Sogestran JV. Air Liquide brings deep expertise in CO₂ handling and on-board boil-off gas management (from LNG). Shipping experience is provided by Sogestran and this JV reduces complexity for the customer, as the combined parties have experience in capture, liquefaction, and transport. He emphasized that CO₂ shipping projects succeed only if technical and commercial interfaces are addressed early by collaboration. In the process there will be a lot of design choices and risks, and the earlier they are handled the better. Fred concluded with the message that CCS is like a very big jigsaw puzzle, it is a lot easier if you start early, collaborate, and have an idea of the bigger picture in mind!

5. Broader enablers raised in the workshop format

The Mentimeter and short Q&A moments appeared to reinforce that stakeholders see financing and political/regulatory support as key barriers and enablers for scaling CCS. At the same time, the presentations collectively suggested that after the first projects, the real bottleneck becomes system integration and coordinated value-chain development rather than political ambition alone.

Conclusion

The workshop showed that CO₂ transport is fundamentally a **system-integration challenge**. Whether the mode is pipeline, shipping, or a hybrid hub solution, technical choices around pressure, temperature, purity, terminals and storage conditions are strongly interdependent.

The strongest common lesson across all speakers was therefore not about one preferred transport technology, but about the need to **de-risk early, validate assumptions physically where needed, and collaborate across the full value chain from the start**. Open-access infrastructure and hub concepts can accelerate scale-up, but only if technical, regulatory and commercial interfaces are managed as part of one system.

Insuring CCUS and CDR projects

Moderator: Lesley Harding (Liberty Mutual)

Speakers: Rafaella Rossi (Equinor), Michel Krenzer (SCOR), Hannah Jennings (Marsh)

Five key takeaways from this workshop

1. Insurance is necessary to make CCS projects bankable.
2. The more data the better – data sharing is key, and this helps insurers understand more and reduces the unknowns. This can then reduce the insurance premiums, offer more capacity and more tailored solutions to the actual problems.
3. Clear and more standardised regulations would be helpful for insurers, so they can more easily define the insurable risk. This will enable insurers to provide solutions and price appropriately. In addition, standardisation of risk management processes would be of benefit – this helps insurers assess risks and provide insurance that is also more standard and less bespoke for each project. Insurers recognise that each project WILL be different, but there are also overarching commonalities that can be recognised and used to provide a tailored package for projects.
4. High value-chain interdependence is a key challenge in ensuring CCS projects. Insurers always look at the worst-case scenarios. They also look at how such worst-case scenarios could be accumulated in the CCS chain.
5. Early engagement across the whole ecosystem with government entities, project developers and lenders will help to facilitate fit for purpose insurance solutions.

Responsible



Main topics/discussions

The discussion was moderated by Lesley Harding from Liberty Mutual. Lesley's introductory talk emphasised that insurance for CCS and CDR projects is no longer primarily focused on technical feasibility, but is instead also a regulatory necessity and a key mechanism for protecting revenue streams. Insurability is increasingly seen as a practical test of project maturity and viability.

Rafaella Rossi (Equinor) talked about risks in CCS projects, stakeholders and their liabilities and need for insurance. This scene-setting talk from the perspective of the operator highlighted that insurance plays an enabling role in CCS, but must operate within a highly interdependent value chain involving multiple actors. This interconnected structure creates a distinct and more complex risk landscape compared to traditional projects, with scalability identified as a key challenge.

Michel Krenzer from SCOR talked about the CCS insurance challenge: interdependencies. This talk looked at insurance from the underwriter's perspective, and drew on experience in underwriting energy risks to explain the specific challenges associated with CCS projects. CCS clusters involve significant interdependencies and risk accumulation across a wide value chain, including emitters, their customers, pipelines (onshore and offshore), shipping, terminals, and storage sites.

Hannah Jennings (Marsh) approached CCS and insurance from a broker's perspective. This talk covered the broker's role in working across the entire CCS value chain was emphasised, representing not only project participants but also a wider set of interested stakeholders. In doing so, they are increasingly observing a gap between how CCS risk allocation works in principle and how it is implemented in practice.

The discussion session was a dynamic conversation between audience members and panellists, and explored in depth how insurance frameworks apply in practice to CCS and CDR projects, highlighting uncertainties around risk definition, data availability, and market readiness.

Conclusions

The discussion underscored that while insurance can play a critical enabling role in CCS and CDR deployment, current frameworks are not yet fully equipped to address the sector's unique and interconnected risks. Key challenges include ambiguity in how losses are defined and triggered, particularly for events such as operational outages, geological leakage, and off-spec CO₂. These risks do not always align with conventional insurance models, which are typically based on discrete, observable events and annual policy structures. The complex, interdependent nature of the CCS value chain further complicates underwriting, as risks span capture, transport, and storage components that are not assessed holistically.

A major constraint is the lack of historical loss data, which limits insurers' ability to accurately price risk and build confidence in coverage. As a result, underwriting remains partly judgement-based, with reliance on analogue datasets and conservative approaches such as reduced risk participation. The availability of insurance capacity is therefore still limited, particularly for novel and performance-related risks, which can also be costly to insure. Early claims, when they occur, are expected to play a significant role in shaping market development, influencing both pricing and capacity over time.

To address these challenges, the session highlighted the need for greater data transparency, standardisation, and collaboration across stakeholders. Improved monitoring, reporting, and verification practices, clearer contractual arrangements, and more consistent regulatory frameworks would help reduce uncertainty and support insurability. There was also strong recognition of the potential role of governments and alternative risk-sharing mechanisms, such as public–private partnerships, in addressing systemic or long-term risks. Overall, advancing CCS insurance will require coordinated efforts to close data gaps, refine risk definitions, and develop innovative solutions tailored to the sector's specific characteristics.

Insurance is necessary for all the actors in the CCS chain. It is necessary to make CCS bankable. Identifying and managing risk is the core competence of the insurance industry. CCS is a new industry with many unknowns. The actors in the CCS chain are also interdependent of each other; this increases the risk. Sharing data, standardised contracts and standards in general, similar regulations across countries could reduce risk and insurance premiums.

Recommendations

- 1. Develop standardised risk frameworks and definitions across the CCS value chain.** A shared risk taxonomy, consistent definitions (e.g. leakage, loss events), and aligned regulatory frameworks are essential to reduce ambiguity and support insurability. Greater international standardisation would improve risk allocation, underwriting efficiency, and market confidence.
- 2. Improve data sharing and transparency to support underwriting and pricing.** The lack of historical loss data remains a critical barrier. Stakeholders should prioritise systematic data sharing from pilot and commercial projects, including performance data, monitoring results, and loss events. Enhanced transparency will enable better risk modelling, more accurate pricing, and increased insurance capacity over time.
- 3. Integrate insurance early within project design and risk allocation frameworks.** Insurance should be embedded from the outset of project development, rather than treated as an add-on. This includes designing contractual structures that fairly allocate risks across the value chain, ensuring all parties can access appropriate cover, and aligning mitigation strategies with insurability requirements. Early engagement with insurers and brokers will help address currently uninsurable risks and reduce later-stage uncertainty.
- 4. Develop blended risk-sharing solutions beyond traditional insurance.** Given the complexity, interdependence, and long-term nature of CCS risks, traditional insurance alone is insufficient. There is a need for complementary mechanisms such as public-private partnerships, risk pooling, and government-backed instruments to address systemic and hard-to-insure risks (e.g. long-term storage liability, cross-chain outages). These approaches can help unlock investment, support scalability, and maintain affordability in a low-margin sector.

Links

- Liberty Mutual: <https://www.libertyspecialtymarkets.com/gb-en>
- Equinor: <https://www.equinor.com/>
- SCOR: <https://www.scor.com/en>
- Marsh: <https://www.marsh.com/en-gb/home.html>
- IEAGHG work on insuring CO₂ projects: <https://ieaghg.org/publications/insurance-coverage-for-co2-storage-projects/>

Driving large scale carbon dioxide removals

Moderator:

Juho Lipponen (Coordinator & Acting Director, MI CDR Mission)

Speakers: *Nico Fairbairn/Morgan Edwards (State of CDR), Dr. Abbie Mabey (44.01), Hanna Ojanen (Carbo Culture), Danny Broberg (Stripe Climate and Frontier), Erik Rylander (Stockholm Exergi), Alexander Mäkelä (Carbon Gap), Jason Gadoury (CAN), Asser Rasmussen Berling (DEN), Eve Tamme (Carbon Management Europe)*

Responsible



Five key takeaways from this workshop

- Novel CDR¹ remains a very small share of total removals (<0.1%) but the sector is dynamic with an abundance of actors. Novel CDR is growing fast, but would need a sustained growth rate comparable to solar PV, to contribute meaningfully towards 2050 climate targets. The next 5–10 years represent a formative phase.
- Cost reductions across CDR pathways depend primarily on scale-up, supported by infrastructure development, standardization, modular approaches, heat integration and optimization through learning-by-doing, and streamlining of MRV and permitting processes.
- Demand is currently driven by voluntary markets and a concentrated buyer base, including so called advance market commitments (AMCs). Companies buying removal credits from the voluntary markets do so purely for climate reasons. To reach gigatonne-scale deployment, broader demand and the emergence of compliance-type markets will be required, mixing both public and private buyers. Demand must be built!
- Policy frameworks for CDR are being put in place in various parts of the world, with various push and pull policy levers being deployed. However policies often remain fragmented and insufficient. The role of removals will need to be defined by governments. Once net-zero is inscribed into law, it automatically speeds up CDR development.
- Global CDR governance is emerging as an issue: stronger international coordination and institutional capacity to facilitate CDR deployment (modelled e.g. from IRENA for renewables) might be able to give a stronger boost for removals in the coming years.

1 Novel CDR includes technology-based removals, e.g. direct air capture and storage, biomass carbon removal and storage, carbon mineralization etc. It excludes nature-based solutions.

Main topics/discussions

- Status of novel CDR and whether deployment is on track, based on insights from the State of Carbon Dioxide Removal.
- Governance gaps and the fragmented institutional landscape.
- The need for fit-for-purpose international coordination models, including coalitions of the willing (e.g. MI CDR, GONE).
- Cost reduction and scale-up pathways across biochar, BECCS, DACCS and mineralization.
- MRV development and standardisation challenges (e.g. growing documentation requirements).
- The need to mobilise new buyers to voluntary carbon markets, to create and foster long-term partnerships and to foster government procurement of removal credits.
- The need to set up a variety of government policy tools (tax credits, procurement programmes, loan guarantees etc.) that can facilitate investment, drive demand for removals and unlock scale.

Conclusion

Novel CDR has been largely driven by the private sector in the past five years and it now seems evident that more government action is needed going forward. Large-scale carbon dioxide removals must grow from a very small base, and decisions taken today and in the coming 3-5 years will shape markets, standards and institutional capacity for the long term. Progress depends on scaling projects to reduce costs, maturing MRV and permitting frameworks, broadening demand beyond the current group of early buyers, ensuring policy predictability, improving investor confidence and strengthening coordination so that public and private actions reinforce one another.

Links

- The State of Carbon Dioxide Removal – <https://www.stateofcdr.org/>
- IRENA – International Renewable Energy Agency – <https://www.irena.org/>
- Carbo Culture – <https://carboculture.com/>
- 44.01 – <https://www.4401.earth/>
- Stockholm Exergi – <https://www.stockholmexergi.se/en/beccs/>
- Frontier – <https://frontierclimate.com/>
- Carbon Gap – <https://carbongap.org/>
- Natural Resources Canada – <https://natural-resources.canada.ca/>
- Danish Ministry of Climate, Energy and Utilities – <https://www.en.kefm.dk/>
- Carbon Management Europe – <https://carbonmanagementeurope.org/>

Integrating technologies and processes for cost-effective CO₂ specifications over the CCS value chain

Moderator: *Stijn Santen (EBN / Carbon Management Europe)*

Speakers: *Michalis Agraniotis (Mitsubishi Heavy Industries), Manuel Herraiz (Siemens Energy), Marcel de Vries (Aramis/Gasunie), Chris Philips (Wood Group)*

Responsible



Five key takeaways from this workshop

- 1. Integration is key in designing CO₂ capture and transport systems.** Heat and process integration between compression and capture, assessment of optimum conditioning locations and pressure/temperature conditions can all strongly affect cost and energy use.
- 2. The advent of CO₂ hubs (mixing CO₂ sources) requires careful evaluation:** Formation of (sulfuric) acid from NO_x, H₂S, SO_x and water has been demonstrated in lab experiments even at very low ppm levels. It is crucial to develop a specification with safe limits for these components, but this is very challenging because many critical factors are currently uncertain (reaction kinetics, acid formation process, transport of acid droplets)
- 3. Knowledge from operational capture plants and CO₂ transport infrastructure is very important in designing future networks.** Operational plants and CO₂ transport infrastructure give extensive information about expected impurities and should be used. Even in post-combustion plants impurity levels are typically very low (single ppm level). Steady operation helps keep impurity levels low.
- 4. CO₂ conditioning (removing specific impurities and water) can have a large impact on system cost.** Careful assessment is required to decide which impurities need to be removed and where. Some impurities are much more costly to remove than others and centralized processing may be prohibitively expensive due to the expense of corrosion-resistant materials upstream of the centralized processing point.
- 5. There is large scope to reduce energy requirement of compression and capture.** Together form largest part of energy use in CCS. Newly solvents result in 40% lower energy for regeneration than MEA. Heat integration (using compression heat) can significantly reduce energy needed for regeneration.

Main topics/discussions

MHI presented lessons learnt from operating 18 CO₂ capture plants:

- Solvent development results in large energy gains (proprietary solvent up to 40% lower energy requirements than MEA)
- Extensive knowledge on impurity levels from capture plants. Impurities from amine degradation can be minimized by optimizing operation. Impurities in feed stream partially go into CO₂ stream (through amine regeneration). Level of impurities depends among others on operation mode.
- Even in post-combustion plant H₂S, NO_x, SO_x levels can be low (below 2–3 ppm detectability threshold). No sign of acid drop-out.
- Mixing several CO₂ streams is new. Critical to understand interdependencies across value chain to be able to mitigate resulting risks in most efficient location.

Siemens presented role of compression in CCS chain:

- Compression and gas treatment interrelated. Impurities need to be reduced prior to capture to prevent amine degradation. Important to consider pressure and temperature at which this can be most effectively done
- Impurities (non-condensable) can be important: 5% impurities can cause 10% higher compression power and 30% lower subsurface storage capacity.
- Heat integration between compression and capture is important. Heat of compression can be used in amine regeneration or to allow O₂ removal.
- Process integration also promising: intentionally creating dP to create low T to aid liquefaction, dehydration between compressor stages.

Gasunie presented the latest research by the Aramis partners on the effect of impurities in CO₂ transport systems:

- Clear risk of sulfuric acid formation identified in lab tests, as a result of reactions between NO_x, H₂S, SO_x and water
- Acid formation can be prevented by removing all NO_x or all sulphur. This is not feasible in practice.
- Cross-border networks require standard specification specifying maximum impurity levels. Extensive R&D efforts are ongoing to achieve this but many factors still unknown.
- Currently a tight spec is the only solution. Other potential solutions are being investigated (inhibitors, scavengers, coatings) but these are not yet available in the market.

Wood presented their cost assessment of CO₂ stream conditioning:

- Final report to be released by end 2026
- Full-chain analysis including all emitter process facilities is required to understand most cost-effective conditioning.
- Sulphur removal is generally expensive for flue gases: total sulphur removal not practical.
- Centralized treatment (e.g. dehydration) generally not economical due to the high cost of pipelines in corrosion-resistant materials.

CCUS/CDR MRV in action: Challenges, opportunities, and implementation strategies

Moderator: Jasmin Kemper (IEAGHG)

Speakers: Thor Solnes (Northern Lights),
Gerard Ostheime (Clean Energy Ministerial Biofuture Industry Council),
Claude Lorea (CL4Change), Dr. Abbie Mabey (44.01)

Responsible



Five key takeaways from this workshop

1. MRV is critical for credibility, compliance, and market acceptance of CCS/CCUS
2. There is no single harmonized MRV framework, and integration across approaches is a key challenge
3. Handling mixed CO₂ streams, including biogenic fractions, is a major technical and accounting issue
4. Non-pipeline CO₂ transport systems introduce additional complexity for MRV
5. MRV frameworks must be flexible to accommodate both different storage mechanisms, including mineralization, and emerging value chains such as green products

Main topics/discussions

- Comparison of different MRV frameworks and methodologies
- Integration challenges across the capture–transport–storage value chain
- Measurement approaches for:
 - Mixed CO₂ streams (fossil and biogenic)
 - Industrial and waste-to-energy applications
- MRV challenges in non-pipeline CO₂ transport (including shipping and trucking)
- Accounting methodologies for low-carbon and green products
- Practical experiences from implementation of MRV systems
- Need for harmonization and interoperability of MRV approaches
- Emerging perspectives on CO₂ storage pathways, including mineralization, and implications for MRV design

Outcome and action points

Overall topics

- Develop harmonized MRV frameworks across regions and value chains
- Improve measurement technologies for complex CO₂ streams
- Enable robust accounting for biogenic CO₂ fractions
- Strengthen integration between MRV systems and regulatory frameworks
- Ensure MRV approaches are applicable across different storage typesupport standardization for emerging CCS business models

Topics specific for each workshop

- Address MRV challenges in non-pipeline CO₂ transport systems
- Define methodologies for mixed-stream CO₂ accounting (biogenic and fossil)
- Develop frameworks for certifying green products from CCUS value chains
- Improve data consistency across capture–transport–storage interfaces
- One presentation highlighted CO₂ storage through mineralization in onshore mafic and ultramafic formations, raising additional considerations for MRV design, verification methods, and accounting approaches ensure alignment between MRV requirements and market mechanisms

Recommendations and further work

- Establish common MRV standards at European and international level
- Advance measurement and monitoring technologies for complex CO₂ streams
- Develop robust certification systems for CCUS-derived products
- Improve digital data integration across the value chain
- Strengthen collaboration between industry, regulators, and standardization bodies to develop MRV approaches for emerging storage types, including mineralization-based storage

Conclusion

MRV is a foundational enabler for scaling CCS/CCUS, but current approaches remain fragmented. The key challenge is to connect and integrate MRV systems across the value chain, ensuring consistency, transparency, and trust in both regulatory and commercial contexts, while remaining adaptable to different storage mechanisms and applications.

Pushing projects forward: How government policy can help develop sound business models for carbon management

Responsible



Moderator: Eadbhard Pernot (Carbon Management Europe)

Speakers: Martin van de Sande (RVO), Alexander Engh (Norway), Matthew Taylor (UK), Jason Gadoury (Canada), Nathália Weber (Brazil)

Key takeaways

- **Policy mix is essential:** Combining carbon pricing (“sticks”) with subsidies and tax incentives (“carrots”) is critical to de-risk early CCS/CDR projects.
- **Public funding unlocks markets:** First-of-a-kind projects (e.g. Norway’s Longship) require significant public investment to catalyse private participation.
- **Cluster-based approaches work:** The UK model shows that integrating capture, transport, and storage with risk-sharing contracts accelerates deployment.
- **Layered policy frameworks scale faster:** Canada demonstrates how carbon pricing, tax credits, and tailored financing can jointly address CAPEX and first-mover risk.
- **Regulation is the starting point:** Brazil highlights that early regulatory clarity, and flexible frameworks are key to unlocking initial project pipelines.

Conclusion

CCS/CDR deployment is still in a **government-led phase**, requiring risk-sharing, infrastructure support, and financial incentives. Over time, systems should transition toward **market-based models**, driven by carbon pricing and demand for low-carbon products.

There is **no universal model** (policy design depends on national context) but **cross-border collaboration and value chain integration** are critical for scale.

Policy approaches

- Netherlands: Market-led approach with strong government enablement (SDE++, ETS, state-backed storage via Porthos/Aramis).
- Norway: Heavy upfront public investment; storage-driven strategy with international CO₂ imports and strong cross-border collaboration.
- UK: Cluster-based deployment targeting industrial emissions; government manages key risks (volume, transport, first-mover) via contracts.
- Canada: Hybrid model – carbon pricing + tax credits + project-specific financing; strong federal–provincial coordination required.
- Brazil: Early-stage framework; strong regulatory momentum but limited incentives; BECCS (ethanol) is the most viable near-term opportunity.

Action points

- Maintain **public support mechanisms** to enable first-of-a-kind projects
- Strengthen **cross-border coordination** (transport, storage, certification)
- Provide **long-term policy visibility** to investors
- Improve **data transparency** (costs, pricing, storage capacity)
- Expand **public–private collaboration** across the value chain
- Align **national and subnational policies**

Recommendations

- **Create demand:** Public procurement, product standards, and carbon removal markets
- **Standardise risk-sharing:** Develop models for liability, volume, and price risks
- **Innovate business models:** Integrate CCS with hydrogen, BECCS, and industrial hubs
- **Clarify regulation:** Accelerate MRV, liability, and cross-border frameworks
- **Scale CDR:** Integrate removals into compliance markets and pricing systems
- **Build capacity:** Support industry and buyers in understanding and adopting CCS/CDR

Scaling up storage: Insights on developing operational storage capacity in Europe

Moderator: Sarah Gasda (NORCE)

Speakers: Rachel Moore (CarbStrat), Kristoffer Engenes (NOD), Randy Locke (Illinois State Geological Survey), Caterina Topini (ENI – Ravenna Project)

Responsible



Key takeaways

- Scaling CCS storage requires a phased approach, from pilot to commercial scale, due to strong site-specific geological uncertainties.
- Operational data is critical, models must be continuously validated and updated with real injection and monitoring data.
- Europe's scale-up will rely on integrating multiple reservoirs and hub-based systems, not only large saline aquifers.
- Monitoring strategies evolve, early over-monitoring builds knowledge, later optimisation reduces costs.
- Storage development must be treated as a system-wide challenge involving regulation, stakeholders, and full value-chain alignment, including flexibility for emerging storage types (e.g. mafic/ultramafic).

Key topics discussed

- Potential of alternative storage formations (mafic and ultramafic rocks) was highlighted, along with key technical challenges (drilling, MMV, modelling), injection strategies, and the need for flexible, technology-agnostic regulations.
- Significant large-scale storage capacity exists in regions like the North Sea, supported by extensive subsurface data and established regulatory frameworks, though pressure interference and cross-border effects require further attention.
- Phased project development and pilot-scale learning play a crucial role in de-risking CCS, with emphasis on risk-based design, early intensive monitoring, and transitioning towards simplified, cost-effective commercial systems.
- Scaling strategies rely on integrating multiple reservoirs and reusing existing infrastructure, supported by strong coupling between modelling and real operational data to ensure safety and performance.
- Discussions emphasised the balance between pilots and commercial deployment, optimisation of monitoring, regulatory flexibility, common terminology (capacity vs resources), and the importance of stakeholder engagement and collaboration.

Outcome and action points

- Continue phased project development to reduce technical and operational risks
- Improve data sharing and transparency across projects and regions
- Optimise monitoring strategies for cost-effective deployment
- Strengthen collaboration between academia, industry, and regulators
- Enhance stakeholder engagement and public communication
- Accelerate integration of CCS hubs and infrastructure networks

Key learnings / R&D focus

- Need for improved understanding of pressure interference and basin-scale effects
- Development of cost-effective monitoring (MMV) technologies
- Further research on alternative storage formations (mafic/ultramafic rocks)
- Better integration of geomechanical and reactive transport models
- Continued work on regulatory frameworks and CO₂ stream definitions

Recommendations and further work

- Develop adaptive and experience-based regulatory frameworks while ensuring safety
- Reduce permitting timelines through knowledge reuse and standardisation
- Expand CO₂ transport and storage hubs to enable scale
- Encourage international collaboration and knowledge exchange
- Maintain strong focus on data-driven decision-making and operational learning
- Ensure policies remain technology-agnostic to accommodate emerging storage options.

Conclusion

The workshop concluded that while CCS storage is technically feasible, scaling to climate-relevant levels requires integrating geological understanding, operational experience, and system-level coordination. A phased, data-driven approach combined with regulatory evolution and collaboration is essential for successful deployment.

Links

- [NORCE](#)
- [CarbStrat](#)
- [NOD](#)
- [Illinois State Geological Survey](#)
- [ENI – Ravenna Project](#)

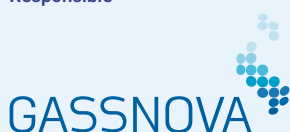
Reducing cost and risk in CO₂ capture through real plant operation and knowledge sharing

Moderator: Svein Ingar Semb (Gassnova)

Speakers:

Muhammad Ismail Shah (Technology Centre Mongstad – TCM),
Jim Stian Olsen (SLB Capturi), Marie Bysveen (SINTEF),
Tor Gautestad (Heidelberg Materials – Brevik CCS),
Cato Christiansen (Capsol Technologies),
Travis Brookson (Svante)

Responsible



Five key takeaways from this workshop

1. Stepwise scale-up, demonstration units and real plant testing reduce technical risk by exposing capture technologies to realistic fluegas and operational constraints before full-scale deployment.
2. Open, nonproprietary knowledge sharing (publications, open campaigns) accelerates information transfer between projects.
3. Successful capture plant operation depends on understanding the full system at the industrial site including upstream process providing flue gas.
4. Early, close collaboration between technology provider and customer/project owner is important.
5. Main goal of research is to reduce cost and risk. R&D priorities are developed by policy frameworks such as the European (e.g. EU Industrial Carbon Management Strategy, Net Zero Industry Act) and structured processes such as the SET Plan.

Main topics/discussions

- Collaborate with your customer
- Knowledge of the full system at the industrial site including plant operation, flue gas variations, actual production pattern etc.
- Considerable saving if carbon capture is included from start of a new plant.
- Minimise work at site – maximise prefabrication
- Execution & operability (interfaces, use of simulators for training etc.)
- R&D and innovation prioritisation: using structured processes (e.g., SET Plan inputs)
- Have common meeting places for knowledge sharing
- Having a key person who can maintain the project's ambitions over the long time needed for realisation has been shown to be important.

Overall topics – key learnings important for next generation of projects

- Capture systems must be designed for real industrial conditions, including flue gas variability, space constraints and interfaces with host plants.
- Modular and standardised solutions reduce execution risk and improve cost predictability.
- Structured prioritisation processes are needed to ensure research addresses barriers observed in industrial deployment.

Need for further R&D (with specification of field)

- Solvent stability, emissions control and degradation under real flue gas conditions.
- Energy optimisation and integration with industrial facilities and district heating systems.
- Digital monitoring, automation and system-level optimisation across the CCS value chain.

Topics specific for this workshop

- Knowledge sharing based on real plant operation and large-scale testing.
- Feedback loops between operators, technology developers and the R&I community.
- Alignment of industrial deployment needs with European R&I and policy frameworks.

Recommendations and further work

- Prioritise R&I activities directly informed by operational and industrial experience.
- Maintain and strengthen shared testing and knowledge-sharing infrastructure as strategic assets.
- Ensure funding and policy instruments support both capture innovation and full system integration across the CCS value chain.

Conclusion

The workshop confirmed that cost and risk reduction in CO₂ capture depends on learning from real plant operation. Validation of performance under realistic conditions, combined with open knowledge sharing and early collaboration across the value chain, is essential for effective system integration and successful large-scale deployment of CCS.

Links

- Technology Centre Mongstad: <https://tcmda.com/>
- SLB Capturi: <https://www.capturi.slb.com/>
- SINTEF: <https://www.sintef.no/>
- Capsol Technologies: <https://www.capsoltechnologies.com/>
- Heidelberg Materials: <https://www.heidelbergmaterials.com/en>
- Brevik CCS: <https://www.brevikccs.com/en>
- Svante: <https://www.svanteinc.com/>

Financing carbon management: Challenges and solutions

Moderator: *Stijn Santen (EBN / Carbon Management Europe)*

Speakers: *Stijn Santen (EBN), Jan-Erik Berre (DNB Norway), Dr. Pantelis Vogiatzis (EnEarth), Lesley Harding (Liberty Mutual)*

Key takeaways from this workshop

The challenge for CCS is increasingly not technical but rather the alignment of policy, market design and capital structures.

- 1. Stable and predictable cash flow is essential for bankability**
Long-term contracts and revenue stability (e.g. via contract for difference subsidies) are prerequisites for attracting debt and equity financing.
- 2. Private capital must be mobilised at scale**
Public subsidies alone are insufficient to finance the growing CCS project pipeline in Europe and globally. Private capital from both banks (debt funding) as institutional investors/pension funds (equity funding) will play an increasingly important role.
- 3. Regulatory clarity and stability are critical**
Clear, consistent, and durable regulatory frameworks can mobilise finance, reduce risk premiums and financing costs.
- 4. Insurance has the potential to be an enabler of CCS financing**
Insurance supports both risk transfer and capital provision and increases confidence for lenders and investors.
- 5. Scale and risk sharing reduce overall system costs**
Shared infrastructure, capacity-based models, and multiple users lower unit costs over the project lifetime.

Responsible



Stijn Santen (EBN):

- In order for CCS to be deployed in at a large scale in many countries much more co-financing by private capital is needed besides project developers investments and government funding
- Project finance versus balance-sheet financing and capital costs for CCS projects. Balance sheet financing has lower capital costs and is often chosen by experienced investment grade companies who see CCS as part of their value proposition. Project financing has higher capital costs and is often chosen by companies who prefer to set their CCS activities aside of their core business or do not have the financial strength for balance sheet financing.
- Contractual models: CfDs (Contracts for Difference) are widely recognised as a very cost-efficient subsidy that leads to stable cashflows that is essential for project financing. The Dutch SDE++ scheme has been an example for this subsidy structure which will be applied in many other European countries like France and Germany.

Jan-Erik Berre (DNB Norway):

- More than 20 banks provide financing to CO₂ storage projects. The bank market is open for well structured projects like the Track 1 in the UK
- long term cash flows with store or pay contracts with a CO₂ price risk is required to secure bank financing at this early stage of the CCS development
- Availability of storage is not the main challenge - they will come when contracts with emitters are secured, at least in the North Sea region
- Most projects are financed over corporate balance sheets but the majority of new projects is looking for bank financing.

Lesley Harding (Liberty Mutual):

- Dual role of insurance: providing capital and risk transfer
- Regulatory clarity is key e.g. long-term CO₂ storage liability
- Insurance is most effective for residual risk
- Mitigate risks first; transfer risks is second

Pantelis Vogiatzis (EnEarth):

- CCS deployment requires not only infrastructure but an integrated framework combining regulation, market design, contractual arrangements and financing mechanisms.
- Greece has established a comprehensive CCS framework through Law 5261/2025 and the corresponding secondary regulatory framework, creating a regulatory basis across the full CO₂ value chain and providing institutional clarity.
- Open-access rules, market tests and long-term access arrangements are essential tools to move from market interest to binding commitments.
- Bankability requires stable and predictable revenues. Capacity-based commercial models can reduce volume risk and create financeable cash-flow structures
- Long-term liability obligations remain a key challenge for CCS projects and require robust financial security frameworks extending beyond the commercial horizon.
- Public funding is necessary to de-risk first-of-a-kind projects but alone is insufficient; additional mechanisms such as CCfDs for emitters, long-term contracts and anchor investors are needed.

Main Topics / Discussions

- Role of governments, regulators, banks, investors, and industry in risk sharing
- Risk allocation across the CCS value chain
- Financial security, liability, and post-closure obligations
- Role of insurance and guarantees in enabling bankability
- Need for standardised contractual frameworks, particularly also between countries

Conclusion

The workshop demonstrated that CCS in Europe is transitioning from single projects to large-scale, capital-intensive infrastructure hub and cluster development. Success depends on combining public risk-sharing mechanisms with private capital, robust regulatory frameworks, long-term contracts, and early involvement of banks and equity investors.

Outcomes and Action Points

- Further development of standardised CO₂ transport and storage contracts at EU level
- Early and structured dialogue between regulators, banks, insurers, and project developers
- Continued work in financing and risk working groups to share experience and best practices across projects and countries
- Develop an EU-wide contractual and risk-sharing framework for CCS
- Align CCS policy more closely with industrial, financial, and capital market policy

Links

- [Financing CCUS at Scale – Analysis - IEA](#)
- [BRINGING CLIMATE TECH TO MARKET: The powerful role of insurance](#)
- [Insurance-for-CCS-Global-CCS-Institute-2.pdf](#)

Responsible



Summing up day 2

Moderator: *Ingvild Ombudstvedt (IOM Law)*

Speakers: *Jasmin Kemper (IEAGHG), Sam Neades (IEAGHG), Eadhard Pernot (Carbon Management Europe), Jørild Svalestuen (Gassnova), Juho Lipponen (CEM CCUS / MI CDR)*

Conclusion

Key takeaways included the importance of the learning effect for CCS from risk management methodology in insurance, the need for government involvement in CDR projects, the role of public procurement in driving market growth and digital solutions to make efficient CDR reporting.

Specific insights highlighted the challenges of MRV (Monitoring, Reporting, and Verification) for CO₂ storage, the necessity of early data sharing for insurers, and the critical role of dedicated personnel in CCS (Carbon Capture and Storage) projects. The summit also emphasized the importance of collaboration between suppliers and customers, and the potential for government procurement to drive demand for green products such as cement and steel.

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SIDE EVENTS

Value chain reality check: Is CO₂ storage truly the real bottleneck for scaling up CCS in Europe?

Moderator: Iria Vázquez Rodríguez (Carbon Management Europe)

Speakers: Salman Muhammad (Carbon Management Europe),
Ziřan Özdemir (Carbon Management Europe),
Eric Rambech (CaptureMap/Endrava), Codie Rossi (Carbon Capture),
Kleopatra Avraam (Desfa), Ørjan Jentoft (Aker BP),
Trude Sundset (Norsk Hydro)

Key points

- **Costs and incentives** were highlighted as the most significant challenges in the CCS value chain. Participants discussed how economic frameworks and policy instruments can strengthen project realisation.
- **There are considerable differences in CO₂ storage capacity between Southern (i.e. Greece) and Northern Europe.** Northern Europe generally has more advanced storage opportunities, while Southern Europe lags behind, which affects the pace and possibilities for scaling up.
- **Successful CCS deployment requires thorough cooperation and coordination across all parts of the value chain,** from capture to storage. Lack of alignment can delay progress and reduce the impact of individual actors' efforts.

Main topics and discussions

Several participants highlighted the importance of developing shared strategies and solutions to accelerate and better coordinate the scaling-up process.

Highlights from Carbon Management Europe (formerly Zero Emissions Platform/ZEP)'s presentation:

Salman Muhammad, Policy and Technology Analyst at Carbon Management Europe, presented the *Innovation Fund ICM Projects Database*, an interactive mapping tool developed by Carbon Management Europe, analysing Innovation Fund (IF) projects.

It indicates capture volumes coming from IF projects could accelerate across Europe, reaching approximately ~25 Mtpa by 2035, if projects are realised.

Zisan Ozdemir, Policy and Technology Analyst at Carbon Management Europe, presented on the EU CDR Buyer's Club, a mechanism to unlock private capital for CDR. She highlighted that bridging government funding with buyer demand will be key to de-risking projects and enabling them to reach FID.

Eric Rambech presented insights on planned European CCS projects using data from CaptureMap, showing that constraints may relate not only to planned storage capacity, but also to timing, coordination between stakeholders, available funding, and geographic alignment.

Codie Rossi, from Clean Air Task Force, outlined the impact of the Net Zero Industry Act, which aims to advance CO₂ storage capacity in the EU. Codie presented analysis from Article 23 Watch, and insights on storage project timelines, showing that up to 40 Mtpa of storage capacity could be commercially available by 2030 based on planned projects.

The session ended with a panel discussion between DESFA, Aker BP and Norsk Hydro, sharing real-world perspectives on enabling large-scale deployment, highlighting financing constraints and the need for stronger coordination across the value chain.

Recommendations and further work

- It was emphasised that CCS still requires support and funding to become fully realised.
- Although CCS is reported to be the most cost-effective climate solution for many industries, it is essential to incentivise all value chain actors to invest and participate actively.
- Participants agreed that incentives are necessary both for technology development and for establishing long-term, sustainable solutions.

Conclusion

Key takeaways included the importance of the learning effect for CCS from risk management methodology in insurance, the need for government involvement in CDR projects, the role of public procurement in driving market growth and digital solutions to make efficient CDR reporting. Specific insights highlighted the challenges of MRV (Monitoring, Reporting, and Verification) for CO₂ storage, the necessity of early data sharing for insurers, and the critical role of dedicated personnel in CCS (Carbon Capture and Storage) projects. The summit also emphasized the importance of collaboration between suppliers and customers, and the potential for government procurement to drive demand for green products such as cement and steel.



International carbon management developments

Moderator: Juho Lipponen (CEM CCUS / MI CDR)

Speakers: Nathália Weber (CCS Brasil),
Eunsoo Jung (Korea CCUS Association),
Xueting Peng (ACCA21, Ministry of Science and Technology),
Rizky Muhammad Kahfie (Indonesia CCS Center)

Five key takeaways from this workshop

- At this workshop, coordinated by CEM CCUS Initiative, we heard presentations on latest developments in carbon management from Brazil, Indonesia, South Korea and China. The presentations showed how these countries are advancing, at varying speeds, with both strategy, technologies, projects and enabling frameworks.
- **Brazil** has identified a significant scale for CO₂ capture: ca. 200Mtpa. Out of this, 40 Mtpa would be from bio-based carbon, allowing for very low or zero-carbon products and even negative emissions. In addition to the world's largest single CO₂ injection project, the Petrobras Santos Basin project, several CCUS projects associated with biofuel production have been identified. Some projects are in advanced planning stages. The 2024 "Fuel of the Future" law provides a legal basis for CCUS; at this stage several more detailed regulations are in the making. Going forward, providing technical and institutional capacity for regulators, as well as strengthening public awareness will be key areas of focus.
- **South Korea** has a 2050 net-zero target from 2021, as well as a CCUS Act in place since February 2025. In South Korea's NDC, depending on scenarios, CCUS could play a role of roughly between 10–20 Mtpa by 2035. The Donghae project is the country's first large-scale demonstration project, largely driven by the government. The intention is that CO₂ is captured from local H₂ producers and power plants, transported via subsea pipelines and stored in the depleted Donghae-1 gas field. Also a "CCUS Mega Project" is being planned, targeting high-emitting industries in two regions. Transboundary aspects are critical, and South Korea has MoUs in place with Australia, Malaysia and Indonesia.

- **Indonesia** is profiling itself as a regional CCUS hub, with significant CO₂ storage potential in the hundreds of gigatonnes. Indonesia could thus import CO₂ for storage from various countries in the region. Altogether 19 CCUS projects have been identified to date, in refining, petrochemicals and the power sector, with first large-scale project expected operational in the early 2030s. Work now focuses on identifying and filling regulatory gaps, providing incentives, facilitating regional ecosystems and providing capacity building and knowledge transfer.
- **China** sees CCUS as a strategic technology option and a crucial component for carbon neutrality. CCUS is explicitly included in both the 14th and the current 15th Five Year Plan. China boasts 100+ projects of different sizes and in different stages, including several operational large-scale CO₂ capture projects in various industries. As a flagship, China Huaneng's 1.5Mtpa full-chain CCS project at the Zhengning 1GW coal-fired power unit commenced operation in September 2025. Future challenges and focus areas include technical improvements, the development of commercial and financing models and the development of incentive policies and risk sharing practices.

Overall, knowledge-sharing is vital: getting vital know-how on technical and non-technical areas to all countries intending to deploy carbon management can greatly accelerate progress.

Exploiting regional synergies can bring significant advantages. Particularly in the Asia-Pacific region, joint solutions on cross-border transport of CO₂, often by ship, and storage solutions for imported CO₂ will play a critical role. Countries in the panel stressed the importance of regional collaboration.

We thank the representatives from Brazil, Indonesia, South Korea and China for their excellent presentations and willingness to share their experience at the event!

Open access to state-of-the-art research infrastructure to generate industrial impact in CCUS and CDR

– Status and outlook of ECCSEL ERIC, Norwegian Infrastructure project ECCSEL Enhance and Cluster CCUS Innovation

Responsible



Moderators: Klaus Tobias Mosbacher (ECCSEL ERIC),
Francesco Finotti (CCUS Innovation)

Speakers: Volker Röhling (ECCSEL ERIC), Yessica Arellano (SINTEF),
Francesco Finotti (CCUS Innovation)

10 key takeaways from this workshop

1. Open access to state-of-the-art research infrastructure is a key enabler for accelerating CCUS and CDR development and deployment in Europe.
2. ECCSEL ERIC provides a coordinated European framework connecting distributed facilities, with ongoing efforts to expand membership and strengthen European coverage.
3. Industrial Membership expansion facilitated through cooperation with industrial clusters such as CCUS Innovation
4. The research infrastructure actively engages with pertinent industry, academia, and research communities to address identified research needs across the TRL1 to TRL7 spectrum and Knowledge-Sharing.
5. Enhances the participation and success of ECCSEL Partner Research Institutes in EU Horizon calls through strategic coordination, facilitation, and promotion
6. Strengthening national nodes, such as ECCSEL-ENC in Norway, is essential to enhance capabilities across the full CCS value chain and ensure Norwegian value creation in green technologies
7. Reliable CO₂ measurement, traceability and fiscal metering are critical for enabling trust, regulatory compliance and commercial CO₂ transactions.
8. The main barriers to scaling CCUS are now related to coordination, financing and policy alignment rather than maturity of technology.

9. Success factor to enhancing research, development, eventually innovation deployment within the whole TRL level needs close collaboration and dialogue between RI's, Industries and public funding bodies (e.g. Gassnova and Research Council Norway)
10. There is a need for stronger pathways from research to industrial implementation in order to create more industrial success stories and large industrial base.

Main topics/discussions

- Role of ECCSEL ERIC as a European distributed research infrastructure for CCUS and CDR
- Open access models and how infrastructure can support both research and industrial users
- Link between ECCSEL and European policy frameworks, including the Industrial Carbon Management Strategy and Horizon Europe
- Ongoing efforts to expand ECCSEL ERIC membership and include additional countries
- Development of the Norwegian node through ECCSEL-ENC and strengthening of national research capabilities
- Importance of full value chain coverage across capture, transport and storage
- Measurement, traceability and fiscal metering as prerequisites for commercial CO₂ value chains
- Status of CCUS deployment and the gap between current project pipeline and climate targets
- Role of collaboration platforms and clusters in enabling project development and alignment across actors
- It was also agreed that innovation is not only about developing a smart product or service – innovation also means achieving commercial success.
- What comes after *Longship*?

Outcome and action points

- Strengthen coordination between research infrastructure and industrial needs through the whole CO₂ value chain.
- Improve access to and utilization of existing research facilities
- Support development of standardized approaches for CO₂ measurement and traceability
- Enhance collaboration across actors in the CCS value chain
- Facilitate integration of research results into industrial projects
- Position Norway and maintain Technological leadership

Overall topics

- Key learnings important for next generation of CCUS projects
- Need for further research and development in CO₂ measurement and traceability
- Importance of integrated value chain development across capture, transport and storage
- Role of research infrastructure in reducing risk and enabling scale-up

Topics specific for each workshop

- Distribution of responsibilities and risk related to CO₂ measurement and accounting
- Cross value chain alignment needs for project development and deployment
- Role of ECCSEL infrastructure in supporting industrial validation
- Need to link research infrastructure more directly to funding mechanisms and project pipelines

Recommendations and further work

- Develop harmonized approaches for CO₂ measurement and fiscal metering across jurisdictions
- Strengthen integration between ECCSEL infrastructure and industrial CCS projects
- Support coordinated development of full value chain CCS projects
- Increase focus on reducing systemic risks related to coordination and policy
- Promote collaboration platforms that accelerate project development and deployment

Conclusion

The workshop demonstrated that research infrastructure such as ECCSEL ERIC is a key enabler for bridging the gap between research and industrial deployment of CCUS. However, scaling CCS in Europe requires not only strong infrastructure, but also alignment across the value chain, reliable CO₂ measurement systems, and policy frameworks that enable investment and reduce risk. It shows also the benefit in close collaboration and dialogue within the whole CO₂ value chain, as well between RI's, Industries and public funding bodies

Links

- ECCSEL ERIC <https://www.Eccsel.eu>
- European Commission – Industrial Carbon Management Strategy https://energy.ec.europa.eu/topics/carbon-management-and-fossil-fuels/industrial-carbon-management_en
- CCUS Innovation <https://ccusinnovation.com/>

BioCCUS workshop

Moderators: Jasmin Kemper (IEAGHG),
Juho Lipponen (CEM CCUS&MI CDR), Johan Börje (Stockholm Exergi),
Noah Deich (Columbia University Center for Global Energy Policy)

Speakers:

Jacob Bang (Microsoft), Jannicke Gerner Bjerckås (Hafslund Celsio),
Danny Broberg (Stripe), Mike Carpenter (Inherit Carbon Solutions),
Mathilde Fajardy (AFEN), Jason Gadoury (NRCAN, Canada),
Jaffer, Monty (UK DESNZ), Jannicke Gerner Bjerckås (Hafslund
Celsio), Stuart Haszeldine (University of Edinburgh), Robin Hughes
(NRCAN), Gareth Johnson (Drax), Erika Laajalahti (Finnish Bioenergy
Association), Patrik Lippe (RWE), Kenneth Möllersten (IVL),
Ingunn Saur Modahl (Norwegian Institute for Sustainability Research
(NORSUS)), Glen Peters (Cicero), Codie Rossi (CATF),
Martijn van der Sande (RVO, NL), Valter Selen (Nordic Carbon Removal
Association (NCRA)), Henrik Sulsbröck (Danish Energy Agency, DK),
Jørild Svaalestuen (Gassnova), Antti Vihavainen (Puro.Earth),
Nathalia Weber (Brasil CCS)

Responsible



Five key takeaways from this workshop

1. BECCS is not a 'place holder' for other types of CDR in models, as they do not have the same co-benefits
2. Progressive yet stable policy frameworks are a crucial element of BECCS support
3. Sustainability of the biomass resource (source, processing, transport) is paramount, and operators have every interest in evidencing this in a transparent manner.
4. Double counting is not a major issue but 'inventory visibility' is
5. We do not need to reinvent the 'regulatory/MRV wheel' but can build on what is already there

Main topics/discussions

(0) The need for BioCCUS: What is the opportunity? What are the risks and unknowns?

According to IPCC AR6, the deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO₂ or GHG emissions are to be achieved. However, some sectors are harder to abate than others, and there remain questions about how this is defined and who defines it. Anyway, these sectors, e.g. aviation, shipping, long-distance transport, iron and steel, cement, load-following electricity, are often poorly modelled, so the only option to offset their emissions is with CDR. CDR/negative emissions also play an important role in 'overshoot' scenarios, as they allow emissions to decline slower in the short-term while still achieving the same temperature outcome in 2100. In AR6, in deep mitigation scenarios, most of the CDR comes from BECCS, 'other' CDR types (i.e. DACCS, afforestation, enhanced weathering) are often marginal. More recent scenarios use more 'other' CDR, but BECCS still remains dominant.

The rationale for using BECCS to achieve climate change mitigation is threefold: **(1)** For a given area of land, BECCS removes carbon continuously (contrary to afforestation, which removes it once); **(2)** BECCS has the co-benefit of producing energy (contrary to e.g. DACCS, which consumes energy); and BECCS, i.e. its components bioenergy and CCS, is already well modelled.

There are five main reasons why models/scenarios use so much BECCS, or CDR in general: **(1)** using a 2100 climate target compared to an all of century target; **(2)** structural design features, such as rationale behaviour, no irregularities, discounting etc.; **(3)** insufficient definition and detail on 'hard-to-abate' sectors; **(4)** insufficient demand modelling; and **(5)** incredibly ambitious climate targets. Care needs to be taken to not see BECCS as a 'place holder' for other types of CDR in models, as other types will not have the same co-benefits, i.e. energy production. When discussing the 'best' way to remove carbon from the atmosphere, BECCS is an easy to implement model solution, but the biggest question is: how easy it is to implement and scale in practice? Which BECCS pathways will get deployed on the ground will be a function of each country's energy and industrial systems, and while BECCS offers essential value in models, a diverse CDR portfolio will be necessary to meet climate targets without overextending planetary boundaries. Carbon management infrastructure planning will also need to account for smaller, dispersed plants to ensure no removal potential is left behind. Although, we have seen a few examples of BECCS projects raising private capital through project finance schemes in the US and Europe, this does not mean that BECCS markets have entered the commercial phase just yet. There is also the question of model projection vs project development reality, e.g. FID hurdles, revenue stack, permitting, sustainability. There will be different challenges delivering a scale of 9Gt or 2-3Gt.

(1A) Mobilising power and industry BioCCUS: How do we realise the potential? What are the challenges?

The 'BECCS Done Well' report published in 2022 had the main objective to identify problems around the BECCS value chain and to propose solutions to them, considering that many 'facts' about BECCS published seem contradictory and/or exclusive. The report was commissioned by Drax via the 'Forum for the Future', with an independent High Level Panel that had full editorial control over the contents of the report. Overall, the review was very useful in identifying roadblocks shared by many CCS projects. In a rules based economy, attribution, mitigation and tracking can work, but the details can be complex. E.g., regarding the attribution of emissions, historically emissions produced from coal combustion at Drax were attributed to the UK. But now, emissions produced from the combustion of imported biomass are attributed to the country of origin.

Another issue is the verification of biomass feedstock when it is purchased off third party companies, i.e. the trust in sustainability claims of the supplier. For this, reliable life cycle analysis and sustainability framework are necessary. Monitoring is required at harvest, transport and pelletisation stages for international traceability and fair risk sharing. Most technical problems are solvable, however, difficulties remain with public perception, monitoring harvesting in unmanaged areas and verifying/quantifying sustainable harvesting practices. VCMs can provide some financial support to first-mover projects, but the related credits are not treated as a reliable obligation for project income. This underlines the call for progressive yet stable policy frameworks that has appeared during other parts of the Summit.

During the panel discussion it was found out that many of the key points made in the "BECCS Done Well" report are still very much valid, and also applicable outside the UK in different jurisdictions, such as Brazil and Finland.

(1B) Mobilising BioCCUS across borders: How to foster international collaboration on CO₂ networks and biomass feedstocks?

The IEAGHG Technical Report 2026-02 aims at providing practical, policy-neutral guidance for agreements to transport CO₂ across national boundaries under the London Protocol. The London Convention and London Protocol (LC/LP) are global treaties protecting the marine environment from pollution caused by dumping wastes.

The 2006 amendment to Article 6 of the LP allowed CO₂ storage in sub-seabed formations under strict conditions, establishing the first international legal bases for CCS.

The 2009 amendment created an exception to the export ban, permitting cross-border CO₂ transport for storage subject to agreements between Parties, but is not yet in force. The 2019 resolution enables provisional application of the 2009 amendment, allowing Parties to proceed with cross-border CCS. Two scenarios can arise for cross-border CO₂ transport:

(1) export and import between two Contracting Parties (CPs), which is relatively straightforward; and (2) between a CP and a non-CP, where CO₂ is stored in the sub-seabed of the non-CP. In the latter case, the receiving non-CP must have a framework equivalent to the LP and must demonstrate full equivalence with the LP's standards. In addition, engagement in transboundary movement and storage of CO₂ triggers the following considerations: commercial agreements, business case, carbon markets requirements, and GHG inventory reporting. In many ways, commercial contracts for cross-border projects are equivalent to domestic contracts but additional issues arise, such as: compliance with the LP, choice/change of law, emissions reductions allocation, regulatory and contractual liabilities, permitting transparency, and eligibility for taxes/incentives.

(2A) BioCCUS: What should we measure? What counts as negative emission?

The importance of MRV is reflected in questions of additionality, gross vs net negative emissions, boundaries, technical measurement, i.e. accuracy, for verification, reductions vs removals, reversals, and baselines/counterfactuals.

The EU CRCF has been in force since December 2024 and in February 2026 BioCCS, DACCS and biochar methodologies were adopted, the methodologies follow a modular approach and have an annual reporting cycle.

In Canada, a BECCS protocol is under development. The following domestic challenges have been observed: biomass resources are distant from CO₂ storage and heavy industry is distant from both. Imbalances in the trade balance, i.e. exported vs domestically used biomass, can lead to local cost increases. Cultural differences in biomass use across Canada also need to be taken into account, as well as the fact that especially woody biomass is at risk from invasive species and climate change impacts.

The purposes of LCA in CDR are threefold: (1) Check if the pathway delivers net negative emissions over the whole value chain through project-based accounting; (2) Claim them in the VCM; and (3) Report them under NGHGs (i.e. inventory visibility, which is not double counting). In this context, it is important to note that VCM system boundaries are usually narrower than regulatory required ones. Thus, clearer accounting rules would help enable a 'better' VCM.

The off-take contracting and cumulative issuance of CORCs (CO₂ Removal Certificates) has increased exponentially for CCS and biochar, whereas carbonated minerals have seen a small but stable increase, and other methods have not seen any significant change. The role of the VCM can be seen as 'test and innovate', the results of which can then be translated into and adapted for compliance markets.

(2B) BioCCUS: How to allocate claims/credits and funding?

BioCCUS projects can have a combination of both private and public sector funding, which then leads to the question of how to allocate the removal credits.

To address the uncertainty in the whole value chain, realistic leakage assessments and joint and interpretable MRV frameworks are essential. The work on MRV done by the Northern Lights projects was highlighted as top notch. It was also mentioned that Microsoft and Carbon Direct have published criteria for high-quality carbon removal credits.

It might be most helpful if government subsidises removals as they do with other parts of the energy transition but does not directly purchase the credits. The point of inventory visibility was highlighted again, i.e. the removal still needs to show up in the countries NGHGI.

Double claiming is not the issue it is often made out to be, especially in the media, where it seems that there is confusion regarding double counting and inventory visibility. Most parts of the CCS/CDR chain are already regulated, so it will be important not waste too much time and resources reinventing the wheel but rather build upon what regulations are already there.

It will also be important to get more clarity of the definition of 'residual emissions', to close the circle opened by the introductory presentation.

Links

- **BECCS Done Well report and Drax response:**
<https://www.drax.com/sustainability/evidence-hub/beccs-done-well/>
- **IEAGHG report: Guidance for Agreements to Transport CO₂ Across National Boundaries Under the London Protocol:**
<https://ieaghg.org/publications/guidance-for-agreements-to-transport-co2-across-national-boundaries-under-the-london-protocol/>

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Photographer: **Per Christian Hestnæs**