Carbon Capture Journal

CCUS in the UK

Project updates from Endurance, Morecambe Net Zero, NZT

Government CCS perspectives - report from the CCSA Summit

Developing blue hydrogen in the UK

Jan / Feb 2025

Issue 103

Net Zero Teesside Power project proceeds

Image: Technip Energies

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- Europe-wide CO2 market could reduce storage costs by 20%
- Safeguarding offshore CO2 purity: tackling oxygen challenges
- Longship: potential for cost reductions in the CCS chain

A CCS Bank to propel European deployment

IOGP Europe has proposed the establishment of a CCS Bank - a CCfD auctioning mechanism to incentivise CO2 capture and, by extension, the development of CCS value chain projects and called on the Commission to urgently start a discussion with relevant industry stakeholders on a pilot scheme under the next call of the Innovation Fund.

CCS deployment is too slow in Europe and puts the EU's industrial competitiveness and industrial decarbonisation at risk, concludes a report by the International Association of Oil & Gas Producers (IOGP).

To accelerate CCS project deployment in the EU, IOGP Europe has called for the establishment of a "European CCS Bank", a competitive Carbon Contracts for Difference (CCfD) auctioning mechanism under the Innovation Fund as of 2025.

While CCS is now widely recognised as a key technology for industrial decarbonisation, project deployment is still too slow, says the report. Although a 50 Mt CO2 annual storage injection capacity target is set for 2030 under the Net Zero Industry Act (NZIA), the disparity between the cost of CO2 capture and carbon allowance prices under the EU ETS makes capture investments economically unviable for emitters, therefore preventing the conclusion of commercial agreements along the CCUS value chain.

Without a sustainable business case, delayed investments and project deployment prevent the EU from decarbonizing its industry while preserving competitiveness. The Industrial Carbon Management Strategy (ICMS) provides the needed framework for CCUS; it is now time to deliver the tools stemming from it, starting with financial incentives.

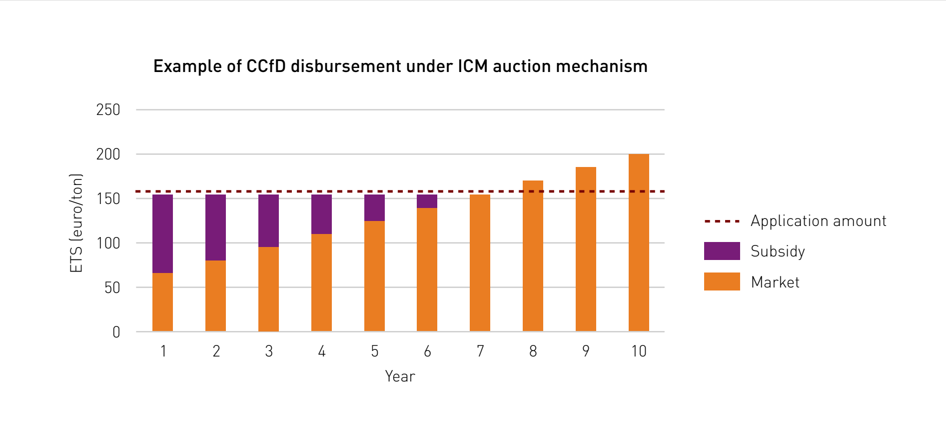
The European CCS Bank, a competitive CCfD auctioning mechanism, offers 4 key benefits:

• A transparent market-based instrument that rewards cost-efficiency

• De-risking capture projects by improving financial viability and predictability

• Price discovery and market formation

• Reduced administrative burden.



CCfD/ETS delta, example of the evolution of payments disbursement

"If we do not incentivize CO2 capture for strategic industries, we won't decarbonise, we will deindustrialize the EU. Contracts for Difference have helped scale up renewables and are now used for hydrogen projects. The European CCS Bank can create the value chain reaction needed to accelerate CCS deployment as of 2025," said François-Régis Mouton, Managing Director, IOGP Europe.

The European CCS Bank would operate through a competitive auction mechanism, similar to the existing European Hydrogen Bank, where project developers submit bids for CCfDs, specifying the financial support needed to bridge the gap between the cost of CCS and carbon market prices. Payments would be tied to verified CO2 capture and storage, ensuring accountability and incentivising cost-efficient projects.

The payments would be calculated on an annual basis, on the average difference between the bid and the actual ETS price realized that year (see Figure).

The European CCS Bank would offer an opportunity to accelerate CCS deployment, reduce industrial emissions, and safeguard Europe's competitiveness in the global market, the report says. If Europe is to meet its climate goals and industrial decarbonisation targets, urgent action and a clear financial mechanism like the CCS Bank are essential.

The report gives several policy recommendations for accelerating CCS deployment:

• Establish the CCS Bank as a competitive auctioning mechanism to provide cost-effective support to CCS projects.

• Integrate the CCS Bank with the EU's Innovation Fund to unlock private sector investment and accelerate deployment.

• Ensure payments are tied to verified CO2 capture and storage to incentivise accountability and cost efficiency.

More information

Read the full report at:
https://iogpeurope.org

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Front cover: NZT Power aims to capture up to 2 million tonnes of CO2 / year stored by the Northern Endurance Partnership while producing up to 742 MW of flexible, low-carbon power (pg. 5)

Back cover: The Greensand Project has reached a Final Investment Decision and aims to be first full scale CO2 storage facility in the EU (pg. 26)

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Leaders - CCUS in the UK

Projects and policy

Capture and utilisation

Transport and storage

Northern Endurance Partnership, Morecambe Net Zero - project updates

We heard an update on plans for CO2 storage with Endurance and Morecambe Net Zero at the GESGB CCS 4 Geoscientists event in London. By Karl Jeffery.

Northern Endurance Partnership is one of two CO2 projects in the UK with government funding under "Track One". It is a consortium of bp, Equinor and TotalEnergies developing the CO2 transport and storage infrastructure for the East Coast CCS Cluster.

James Hamilton-Wright, well planning geologist with bp, gave an update, speaking at the Geoscience Energy Society of Great Britain (GESGB) CCS for Geoscientists (CCS4G) event in London on December 17.

The Partnership has applied for four carbon storage licences in the Southern North Sea, with the Endurance field being CS001. The others are numbered CS006, CS007 and CS025. Endurance was awarded the UK's first ever carbon storage permit in December 2024.

The Endurance field is closest to shore. The storage is a saline aquifer, in the "Silver Pit" basin, within a Triassic Bunter sandstone. The rock has large scale faulting and structuration. The storage sites have 4-way dip closures.

The plan is to inject CO2 at up to 4 million tonnes a year (mtpa) for 25 years (up to 100 mt in total). Phase 1 has 5 injection wells and 1 monitoring well. The well pipelines are connected to two subsea manifolds. The monitoring well will collect appraisal data and is connected by a cable.

The wells are all vertical and go through the "mid flank" position in the structure, midway between the structural crest above and the lowest closing contour below, he said.

The project team need more work on CS006, CS007 and CS025 to eliminate uncertainties before CO2 storage can start. CS006 does not have any wells (and so less subsurface data is available). It has a low relief (relatively flat), he said. CS007 has legacy wells and some uncertainties about injectivity. With CS025 there are unknowns about the reservoir quality.

A 3D seismic survey was taken over areas CS001 and CS006 in 2022, which gave a much-improved image. There has also been bathymetry mapping of the seabed over CS001.

The Bunter sandstone has an outcrop to the seabed in one area, so it was possible to collect samples and drill a shallow geotechnical borehole to find out more about it.

As well as the monitoring well in the Endurance field, an exploration well is planned (BC39-1) and an appraisal well (BC37-1). Bp will collect vertical seismic profile (VSP) data from these wells, also NMR and image logs, pressure data, fluid samples and cores.

Over 2025-26 it plans further seismic surveys over CS007 and CS025, and more "postage stamp" surveys on Endurance.

There are many other hazards and infrastructure in the region, including a 1400 MW electrical interconnector cable crossing the site called Viking Link, and sandbanks which limit where wells and flowlines can be placed on the seabed.

Mr Hamilton-Wright recommends getting data about any legacy wells in your region as early as possible and engaging early with regulators to find out what they will need.

It is possible that the rate of injection could be increased, once initial appraisal data can be analysed.

The additional sites provide flexibility to shift around CO2 storage if it becomes clear that certain sites are better.

There will be periodic inspections of wells. They will be subjected to a flush with fresh water to dissolve any salt which might precipitate into the wellbores.

Spirit Energy and Morecambe Net Zero

Morecambe Net Zero is a plan to build CO2 storage in depleted gas reservoirs off England's Northwest coast. It will be developed and operated by Spirit Energy, an oil and gas operator.

The plan is for CO2 to be supplied by cement producers in the nearby Peak District, with a pipeline carrying 3.2m tonnes CO2 a year in place by 2031. There are further companies emitting 6-7 mtpa CO2 based close to the planned pipeline route. Further CO2 could be brought in by ship and rail, said Peter MacKintosh, subsurface leader for Spirit Energy.

Spirit Energy is owned by energy company Centrica and German energy and infrastructure firm Stadtwerke München (SWM).

Spirit Energy currently produces 300m standard cubic feet (SCF) per day of gas from gas fields in Morecambe Bay. The region has produced 6.6 trillion cubic feet (TCF) in the past 40 years. The peak production rate was 2 billion cubic feet (BCF) a day. Over this time, pressure in the fields reduced from an initial pressure of 700 psi to 140 psi now.

The fields already contain high levels of CO2. 6 per cent CO2 in the Northern field, and 34 per cent CO2 in the Rhyl field. So there is already evidence that the caprock is permanently sealing in CO2, he said.

The area has "a lot of wells stuck into it", which all need an integrity assessment. The project team plan to complete front end engineering and design (FEED) in 2026 and receive a carbon storage permit in 2027.

A wind farm is planned overlapping the southern part of the license area, so it is important to complete the latest seismic survey before the wind farm makes it very difficult.

Subsurface factors

During 2024 an initial risk assessment of the site for CO2 storage was completed, and seismic, passive seismic and 4D gravity surveys were carried out, Mr MacKintosh said. Full site characterisation is planned for 2025. The final seismic data should be ready in Q2 of 2025.

It is a Triassic reservoir with thick mudstone caprock.

The seismic survey for CCS has much more data points than the seismic for gas production. 640,000 data points per km2 for the 2024 CCS seismic survey, compared for 307,000 data points / km2 for the 2008 gas seismic survey.

To monitor CO2 containment, the project team do not think 4D seismic will be worthwhile, because injecting low-pressure CO2 will not make many big changes to the seismic image.

They are more optimistic about use of 4D gravity data. Concrete pads will be placed on the seafloor. Gravity sensors can then be placed on the concrete pads by ROV, so they have a solid base and take their reading in the same spot each time. There will need to be between 20 and 120 concrete pads per field. Collecting gravity data will take 15 minutes to collect from each pad.

The cost of gravity data is expected to be a tenth as much as 4D seismic, he said.

Further CO2 could be brought in by ship and rail, said Peter MacKintosh, subsurface leader for Spirit Energy

Freezing concerns

One concern is how much the CO2 will cool as it is injected into the reservoir and expands, and whether there is a risk of it freezing and blocking the system.

According to a standard CO2 phase diagram, at pressures between the triple point (75 psi) and about 1500 psi, CO2 freezes at -56 °C.

CO2 will expand as it is injected into the reservoir (currently at 140psi) and this expansion would cause a temperature drop. Initial modelling found it would cool to 0 °C at the injection point. More detailed modelling found it would reduce to -8 degrees, he said.

The temperature just 20cm away would be 20°C, as the CO2 is reheated by the reservoir.

One way to mitigate risk of CO2 freezing is to heat it at the well head. The temperature will still drop as it expands, but if the starting temperature is higher, the temperature after expansion will be higher.

For the injection area away from the injection point, the company's modelling showed that there would be minimal changes in temperature and pressure with injection of 1 mtpa CO2 over 3 years, with an average reservoir pressure of 34 °C, he said.

Getting CO2 storage regulatory approval

Quality storage operators may find regulations frustrating – but there are good reasons for them – particularly in ensuring that all wells in the area are decommissioned, said Nick Richardson of the UK regulator NSTA at the CCS4G event.

The purpose of CO2 storage regulation is to ensure that everything is done properly, said Nick Richardson, head of exploration and new ventures with the UK CO2 storage and oil and gas regulator North Sea Transition Authority (NSTA).

Quoting consultant Jim Collins, he said, "The purpose of bureaucracy is to compensate for incompetence and lack of discipline. You may not like what the regulator does [but] they are asking for things for a good reason. Through the eyes of the regulator, the world is quite different sometimes."

NSTA's role is "not to hand out sweeties" but to determine whether projects are safe, he said.

Mr Richardson drew an analogy to the famous story of musician Eddie van Halen, who put a clause in his show contracts with venues that the dressing room should have a supply of M+M sweets but with the brown ones removed.

If the venue staff had indeed removed the brown M+Ms, that could be taken by his crew as indication that they had followed all areas of the contract carefully, including items with safety implications. This would save them the trouble of checking every detail themselves.

While quality CO2 storage companies might be following every requirement, there have already been some companies submitting requests for CO2 storage licenses where the submitting company does not seem to give the project much priority internally, he said. They appear to be seeing the CCS project only as a way to add value to an oil and gas asset.

"The review process has been valuable in identification of risk," he said.

In some but not all cases, the permitting process could go more quickly if more work had been done before the application was made.

Over time, CO2 storage regulations could move to an "As Low as Reasonably Practicable" or ALARP model, to find the right balance of risk vs avoiding project delays. "Is it better to store with some minor leakage, than not do a project at all?" he said.

There will probably be another CO2 storage licensing round in the UK, but meanwhile NSTA is keen for companies interested in doing storage to nominate / make a case to NSTA for why they should have them. This is partly so NSTA can determine if the company has the right competence and discipline, he said.

Legacy wells

One of the trickiest parts of the any CCS permit application process is proving you have found all wells in the CO2 storage area and checked they are properly sealed, so could not allow any CO2 to escape.

NSTA defines "storage site" as the volume the CO2 will be injected into, and the "storage complex" as the wider area, including seals and secondary containment units, said Kirsty Simpson, geologist, North Sea Transition Authority.

The complex can include sand beds above, and whatever is below, since dense phase CO2 can travel downwards.

If CO2 moves from the storage site into the complex, it is classed as "migration"; if it moves outside the complex it is classed as "leakage".

It is necessary to examine data for any wells in the license area, and any wells in the surrounding area which may see a pressure increase in the subsurface (so can be considered in the same 'hydraulic unit'), said Margaret Copland, CCS lead with the North Sea Transition Authority.

If you have wells lacking appropriate cement-plug barriers in your project site, you will not be able to go ahead without remediation, so it is good to find this out as early as possible, she said.

What you are looking for specifically is evidence that they have been decommissioned properly. Does the well have a barrier (to potential upward flow of CO2 or other fluids), and has the barrier been properly tested.

There are also wells which have cement barriers but don't meet the modern guidelines. In this case engineering judgement is needed to assess whether it is safe, she said.

For example, the guidelines require 100 feet of cement plug. If there is only 98 feet, it is probably OK, but if there is 50 feet perhaps it isn't. Other factors can be considered such as whether the well is vertical or at an angle, how centralised the pipe is within the well, and any concerns raised while cementing.

Looking at the decommissioning data takes about 3 days' work of a well expert for each well, she said. There are 1400 wells on the current CCS licenses, and some of the potential storage sites each have over 300 wells.

"Well engineers are in high demand. Don't underestimate the resource you will need."

Data about producing wells is held in the UK's National Data Repository, which "is absolutely brilliant," she said. However, some wells were drilled in the 1960s and industry decommissioning practises have changed over the years. Some only have handwritten reports.

You also need to be sure you have identified all the relevant wellbores. There have been cases where a sidetrack to a well was drilled, but no logs were taken of the sidetrack.

This was not a problem in oil and gas production, but could be a problem for CCS, if the sidetrack penetrates a CO2 storage area.

CO2 storage projects require close working relationships between geoscientists and well engineers, perhaps more so than in oil and gas exploration, she said.

CO2 storage projects require close working relationships between geoscientists and well engineers, perhaps more so than in oil and gas exploration - Margaret Copland, CCS lead with the North Sea Transition Authority

Process for a permit

Margaret Copland outlined the process for applying for a carbon storage permit. Full details are in a document "Guidance on Applications for a Carbon Storage Permit" available on the NSTA website.

The first "Exploration and Appraisal" phase covers initial assessment of the site, also including CO2 transport and what needs to happen onshore.

The second "assess" phase involves putting together a measuring, monitoring and verification (MMV) plan, and corrective measures plan (to follow if something does not go as expected). This phase also includes looking at the legacy wells.

The third "define" phase includes making a development plan, and a provisional plan for how the field will ultimately be closed.

The final phase, leading to the permit, involves risk assessment, plans for development wells, plans for repeat monitoring, making a closure and post-closure plan.

More information

More about the event at:

www.ges-gb.org.uk

Technip Energies and GE Vernova awarded contract for Net Zero Teesside

The project, which aims to be the world's first gas-fired power station with carbon capture and storage, has received notice to proceed.

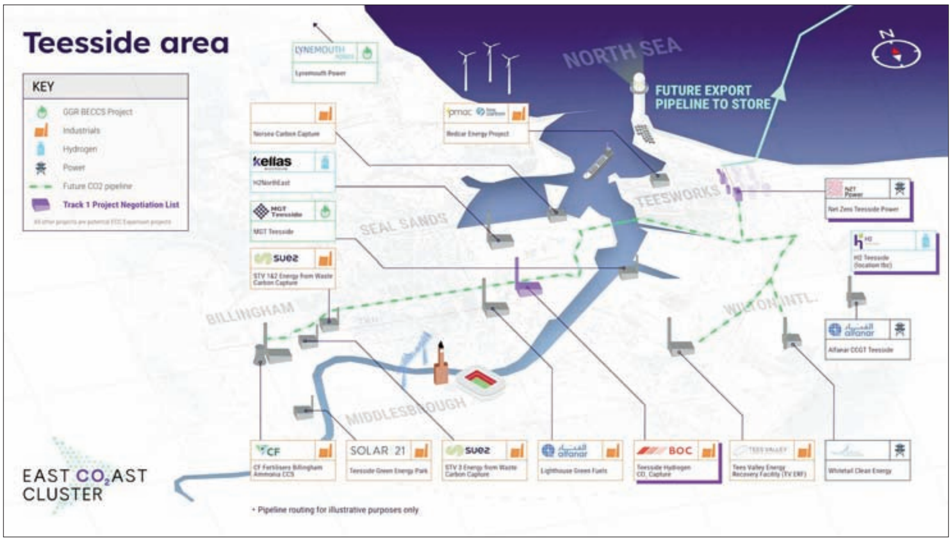
Technip Energies, leader of a consortium with GE Vernova and construction partner Balfour Beatty – with the support of technology partner Shell Catalysts & Technologies – received Notice to Proceed by NZT Power Limited to execute the major contract for the Net Zero Teesside Power (NZT Power) project in the United Kingdom.

NZT Power has reached financial close and has issued a Full Notice to Proceed to start the full Engineering Procurement and Construction (EPC) package for the onshore power, capture and compression contract. Financial close follows the UK government's recent announcement of a £21.7 billion pledge for projects to capture and store carbon emissions from energy, industry and hydrogen production.

Maví Zingoni, CEO, Power at GE Vernova commented, "We believe CCUS technology can be crucial to help decarbonize the planet, and we welcome the commitment from the UK government to invest in its implementation as well as NZT Power's trust in our technology. Flagship projects like Net Zero Teesside Power can give the industry foundations to grow."

The landmark project aims to be the world's first gas-fired power station with carbon capture and storage. Up to 2 million tonnes of CO2 per year will be captured at the plant and transported and permanently stored by the Northern Endurance Partnership. The plant could produce up to 742 megawatts of flexible, low-carbon power, equivalent to the average annual electricity requirements of more than 1 million UK homes, further supporting the UK's transition to a cleaner energy future.

Supported by the UK government, NZT Power could create and support more than 3,000 construction jobs and then generate 1,000 jobs annually during operations. This initiative is expected to attract private investment and help the UK to meet its climate goals and is aligned with the UK plan to reduce carbon emissions to net zero by 2050.



NZT Power is part of the Teesside area East Coast Cluster

The partners plan to deliver a highly efficient combined cycle plant and associated carbon capture plant. Technip Energies will lead the integration of a state-of-the-art carbon capture plant using its Canopy by T.EN solution, powered by Shell's CANSOLV* CO2 Capture System.

The plant will be powered by GE Vernova's advanced 9HA.02 gas turbine, a steam turbine, a generator, a Heat Recovery Steam Generator, an Exhaust Gas Recirculation (EGR) system and benefit from GE Vernova's maintenance service contract for 16 years.

Shell's proprietary CANSOLV CO2 technology, using an advanced amine solution, will enable the capture of up to 2 million tonnes of CO2 annually from the plant's combined-cycle gas turbine.

Shell Catalysts & Technologies and Technip Energies have also recently agreed to strengthen their relationship and will be moving towards global exclusivity for the delivery of amine-based post-combustion carbon capture based on the CANSOLV CO2 Capture System.

Balfour Beatty, supported by Shell Catalysts & Technologies, together form the Carbon Capture Alliance (CCA). Alliance members have committed to long-term investment in the UK and already possess a significant local footprint and supply chain.

Arnaud Pieton, CEO of Technip Energies, commented, "This groundbreaking project represents a significant milestone in our collective efforts to advance carbon capture technology at scale and support the UK's ambitious climate goals through low carbon power generation from gas combined with renewables."

"By leveraging our Canopy by T.EN™ solution powered by Shell's CANSOLV CO2 Capture System, we aim to set a new standard for low-carbon power generation. This project not only underscores our commitment to innovation and sustainability but also highlights the critical role of collaboration in driving the energy transition forward."

More information

www.gevernova.com

www.ten.com

Residual waste policy trajectory risks undermining carbon reduction goals

A study published by the Environmental Services Association has found that Energy-from-Waste plants fitted with CCS technology offer the most reliable and lowest-carbon solution for treating residual waste in future.

However the study also found that the current policy trajectory could put investment in CCS at risk and undermine the waste hierarchy.

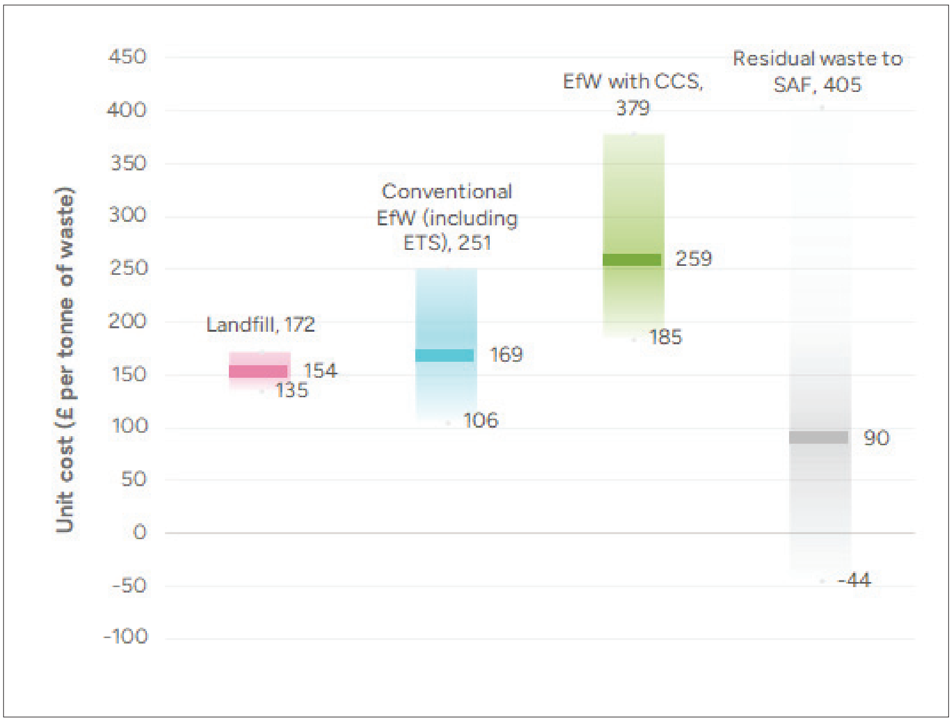
The independent report, authored by SLR Consulting, presents the findings of an appraisal of viable future residual waste treatment solutions on three grounds; cost, reliability and technological readiness, and carbon emissions performance.

The study found that, without further government intervention, development of CCS will not be financially viable for the majority of EfW facilities, even accounting for avoided Emissions Trading Scheme (ETS) costs which are due to come into effect from 2028. Additionally, proposed government subsidy support for producing Sustainable Aviation Fuel (SAF) from residual waste could allow these facilities to offer the cheapest waste disposal route.

This could divert waste from existing infrastructure despite the fact that SAF production via gasification and other processes has a low degree of demonstration at scale and is unlikely to outperform EfW with CCS on carbon emissions unless the waste has a very high organic content.

By capturing biogenic carbon, EfW with CCS is able to achieve net-negative carbon emissions and modelling suggests that this solution could be more beneficial than SAF on carbon emissions – although the report recognises that demonstration of applying CCS at scale to EfW is also in an early stage.

Additionally, the report concludes that large-scale development of less reliable or unproven waste treatment technologies poses a risk to established infrastructure, which is essential to the sanitary management of waste, and that unless suitable market adjustments are made to constrain landfill, the application of the ETS to energy recovery holds the potential to incentivise treatment by landfill under current policy considerations.



Comparison of estimated costs for landfill, conventional EfW, EfW with CCS, and waste to SAF (estimates for 2035, in 2024 real prices)

Head of Climate and Energy Policy at the ESA, Charlotte Rule, said, “Under current policy trajectory, there is a risk that residual waste material could fall down the waste hierarchy and that the treatment solutions favoured by present policy conditions – whether fully intended or not – risk becoming white elephants that strain essential public sanitation services, while not fully realising the maximum carbon emissions savings potentially on offer."

"As highlighted in the recommendations of the report, there is a need for more joint working across Government to ensure that the push and pull of various government departments with a stake in this issue – Defra, DESNZ, DfT and The Treasury – doesn’t result in unintended consequences that undermine the UK’s existing high-performing infrastructure, as well as the recycling and waste sector’s Net-Zero pathway."

"Building on the work set out in this report, we would like to see Government, along with the Climate Change Committee (CCC) produce a robust independent evidence base to inform relative support for EfW with CCS and SAF production for waste, by exploring the relative greenhouse gas emission impacts of each solution as well as issues around deliverability risk.”

More information
https://esauk.org

Manchester researchers unlock potential for renewable plastics from CO2

Scientists have achieved a significant breakthrough in using cyanobacteria—commonly known as "blue-green algae"—to convert CO2 into valuable bio-based materials.

Their work, published in Biotechnology for Biofuels and Bioproducts, could accelerate the development of sustainable alternatives to fossil fuel-derived products like plastics, helping pave the way for a carbon-neutral circular bioeconomy.

The research, led by Dr Matthew Faulkner, working alongside Dr Fraser Andrews, and Professor Nigel Scrutton, focused on improving the production of citramalate, a compound that serves as a precursor for renewable plastics such as Perspex or Plexiglas. Using an innovative approach called "design of experiment," the team achieved a remarkable 23-fold increase in citramalate production by optimising key process parameters.

Faulkner and team achieved a remarkable 23-fold increase in citramalate production by optimising key process parameters

Why Cyanobacteria?

Cyanobacteria are microscopic organisms capable of photosynthesis, converting sunlight and CO2 into organic compounds. They are a promising candidate for industrial applications because they can transform CO2 into valuable products without relying on traditional agricultural resources like sugar or corn. However, until now, the slow growth and limited efficiency of these organisms have posed challenges for large-scale industrial use.

"Our research addresses one of the key bottlenecks in using cyanobacteria for sustainable manufacturing," explained Matthew. "By optimising how these organisms convert carbon into useful products, we've taken an important step toward making this technology commercially viable."

The team's research centred on Synechocystis sp. PCC 6803, a well-studied strain of cyanobacteria. Citramalate, the focus of their study, is produced in a single enzymatic step using two key metabolites: pyruvate and acetyl-CoA. By fine-tuning process parameters such as light intensity, CO2 concentration, and nutrient availability, the researchers were able to significantly boost citramalate production.

Initial experiments yielded only small amounts of citramalate, but the design of experiment approach allowed the team to systematically explore the interplay between multiple factors. As a result, they increased citramalate production to 6.35 grams per litre (g/L) in 2-litre photobioreactors, with a productivity rate of 1.59 g/L/day.

While productivity slightly decreased when scaling up to 5-litre reactors due to light delivery challenges, the study demonstrates that such adjustments are manageable in biotechnology scale-up processes.

A Circular Bioeconomy Vision

The implications of this research extend beyond plastics. Pyruvate and acetyl-CoA, the key metabolites involved in citramalate production, are also precursors to many other biotechnologically significant compounds. The optimisation techniques demonstrated in this study could therefore be applied to produce a variety of materials, from biofuels to pharmaceuticals.

"This work underscores the importance of a circular bioeconomy," said Matthew. "By turning CO2 into something valuable, we're not just reducing emissions, we're creating a sustainable cycle where carbon becomes the building block for the products we use every day."

The team plans to further refine their methods and explore ways to scale up production while maintaining efficiency. They are also investigating how their approach can be adapted to optimise other metabolic pathways in cyanobacteria, with the aim of expanding the range of bio-based products that can be sustainably manufactured.

More information

https://futurebrh.com

Government CCS perspectives - report from the CCSA Summit in London

Representatives of US and UK government shared perspectives on how to get CCS moving at the CCSA annual event in London. Policy simplicity, project financing and the need for public acceptance were all highlighted. By Karl Jeffery.

The US government wants to see "high integrity volume carbon markets," said Noah Deich, Senior Advisor for Carbon Management, Office of Fossil Energy and Carbon Management, US DOE. "We see that market as essential to driving projects."

He was speaking at CCUS 2024, the annual event of the Carbon Capture and Storage Association in London on October 15-16.

One lesson "I think we've learned" is that policy simplicity is very important, he said. "The US carbon policy framework is workable."

While other governments may not want to copy what the US has done, they may wish to copy the intent behind it, of making something which is "workable and simple."

Delegates came together for a drinks reception at the annual CCSA event in London

"Policy simplicity is very important" - Noah Deich, Senior Advisor for Carbon Management, Office of Fossil Energy and Carbon Management, US DOE

The easier it is to finance projects, the easier it is for the whole of carbon capture to work, he said.

There is confidence in carbon capture technology and its affordability. But there is still a need for a business model which will drive demand for it, he said.

Communities must see a benefit from having projects. US carbon capture projects, like all big US energy projects today, face "nimbyism," he said.

UK

In UK government surveys, 10 per cent of the British public say they are opposed to carbon capture, said Sarah Jones, Minister of State at the Department for Energy Security and Net Zero (DESNZ).

The government is supporting it because it will help maintain energy security, support hard to abate industries to decarbonise, and because it is one of the best ways to decarbonise, she said.

Alex Milward, director of CCUS at DESNZ advised CCS companies to "lean in to the public acceptance and cost agenda." In other words, the lower the CCS costs, and higher the public acceptance, the easier it is for government to support CCS.

More information

See the Nov/Dec 2024 issue for more UK news from the event.

The full agenda and photos and videos from the event can be found at:

www.ccus.events

Blue hydrogen in the UK

The UK is developing a decarbonised hydrogen economy, using hydrogen for power, industry, ship and aviation fuels. It will not differentiate between "blue" or "green" so long as it meets a low carbon standard. By Karl Jeffery.

UK decarbonised hydrogen producer EET Hydrogen has a 350 MW blue hydrogen project in the HyNet cluster. It is expected to have a final investment decision "in a few months" from the date of the conference (October 2024), for production in 2028, said CEO Joe Seifert.

He was speaking at CCUS 2024, the annual event of the Carbon Capture and Storage Association in London on October 15-16.

This project should be followed by a second plant 1GW in size. EET is also planning a 40 MW green hydrogen project, he said.

The hydrogen is expected to be supplied to "local industrial customers," he said. There are large industrial plants in the region, such as manufacturing glass bottles. For many of these companies, decarbonised hydrogen is the only way they can continue operating in a world where CO2 emissions are not allowed, because they have no way to electrify.

These initial potential clients are companies which operate on low margins. It may prove that other markets are willing to pay a bigger premium for blue hydrogen, he said, for example markets which have tougher regulatory requirements to use low carbon fuels, such as aviation and marine.

UK government

The UK government anticipates that blue hydrogen-based power generation will be essential as a fuel in the 2030s, providing decarbonised power when renewable power generation is low, said Steph Murphy, Director of Hydrogen and Industrial Carbon Capture, Department for Energy Security & Net Zero (DESNZ).

It can also be used to make fuels, including sustainable aviation fuel and maritime fuels, she said.

Ms Murphy said there are multiple factors which need to work simultaneously to get a hydrogen business running in the UK, including developing a demand, developing production, and transport and storage infrastructure.

The UK's low carbon hydrogen standard specifies what is required for hydrogen to qualify as "low carbon" without differentiating whether it is made from fossil fuel or renewables.

However, all modelling so far shows that blue hydrogen is likely to be "significantly cheaper," and project sizes are much larger, typically 300 MW plus, compared to 10-20 MW for green. Also, blue hydrogen costs are expected to come down over time.

Modelling shows that the costs of developing a decarbonised power system for the whole UK will be £13bn to £24bn less over 2030 to 2050 if blue hydrogen fuel is used, she said.

SSE

Power company SSE already "develops owns and operates every type of energy infrastructure," said Ian Cook, Head of Hydrogen Business Development, SSE Thermal. It has interest in hydrogen as both a producer and consumer.

The company already operates 5GW of wind and hydroelectric power generation, which could be used to make green hydrogen. This could then be used to make e-fuels.

Steph Murphy, Director of Hydrogen and Industrial Carbon Capture, Department for Energy Security & Net Zero

For many companies decarbonised hydrogen is the only way they can continue operating in a world where CO2 emissions are not allowed - Joe Seifert, CEO, EET Hydrogen

It also operates a large hydrogen storage site in Aldbrough, Yorkshire.

Developing low carbon hydrogen projects takes 5 years in the best-case scenario, he said. And that does not mean blue hydrogen will be available in five years, because not many projects are being started today.

SAF

Willis Lease Finance Corporation, an aviation engine leasing company, is planning a Sustainable Aviation Fuel (SAF) production project in Teesside. It is planning to produce 14k tonnes a year initially, with a final investment decision in 2025.

"I think it is the most advanced UK SAF project," said Amy Ruddock, SVP, Sustainable Aviation & Corporation Development with Willis Lease Finance Corporation.

For the UK SAF market, there are clear signs of market demand for a certain volume of fuel, although not yet certainty of the price it will be sold for, she said.

Decarbonised hydrogen still looks very expensive for a SAF project to purchase without subsidy, she said.

UK news

NSTA awards Endurance first ever UK carbon storage permit

www.nstauthority.co.uk

The UK's first ever carbon storage permit has been awarded by the North Sea Transition Authority (NSTA) to the Northern Endurance Partnership.

The site off the coast of the north-east of England is the first of scores which are expected to follow in UK waters, preventing hundreds of millions of tonnes of carbon dioxide from entering the atmosphere.

Endurance, also known as the East Coast Cluster, was named as one of the two locations in the Track 1 cluster alongside HyNet, in the East Irish Sea.

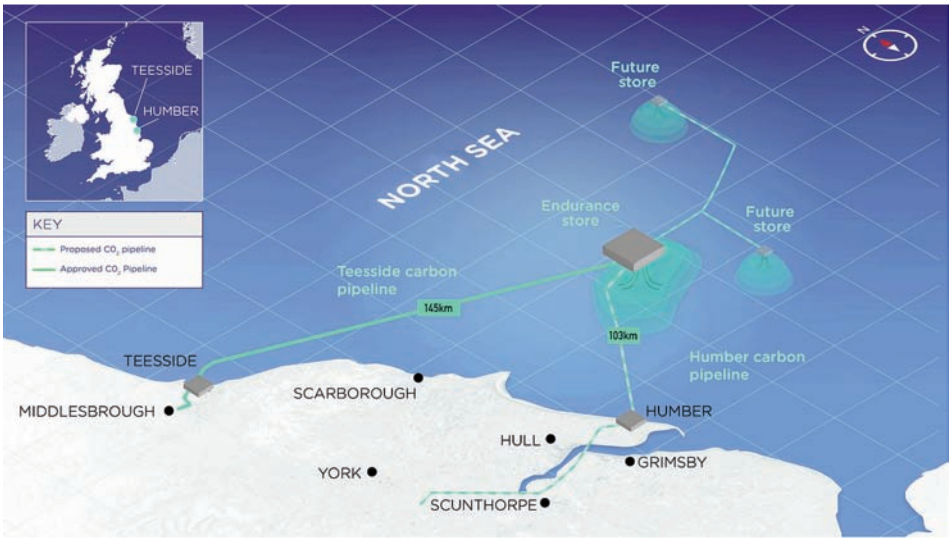
The Department for Energy Security and Net Zero also awarded an economic licence to Net Zero North Sea Storage, that will unlock £4bn worth of contracts, drive investment in innovative technology and industries and bring 2,000 jobs to the North East.

It follows an announcement by the government recently of £21.7bn investment into carbon capture and storage projects.

The permit allows for first injection by 2027 with a permitted injection rate of 4 million tonnes per annum. Averaged over a duration of 25 years, this could reach a total of 100 million tonnes, equivalent to taking 58.8 million cars off the road for a year.

It also allows Net Zero North Sea Storage Limited, an incorporated joint venture between bp, Equinor, and TotalEnergies, to start installing infrastructure on the site.

It is expected to serve Teesside-based carbon capture projects – NZT Power, H2Teesside and Teesside Hydrogen CO2 Capture.



UK achieves world first in 'clean hydrogen' production with carbon capture

www.biorenewables.org

A project led by the Biorenewables Development Centre at the University of York has become the first to successfully produce hydrogen at scale through a biological process, whilst also capturing the carbon dioxide.

The H2Boost project, an initiative under the Department for Energy Security and Net Zero's Hydrogen BECCS Innovation Programm, aims to develop a commercially viable and sustainable process for producing biohydrogen from organic waste.

In partnership with the University of Leeds and funded by the government's £1 billion Net Zero Innovation Portfolio (NZIP), the project transforms everyday waste into clean hydrogen through a unique process called dark fermentation, which converts pre-treated organic waste into biohydrogen.

The system then captures and reuses all by-products, whereby the waste material generates additional energy through anaerobic digestion; cultivated algae and bacteria capture carbon emissions. This approach means that virtually nothing goes to waste in the production of hydrogen.

Penny Cunningham, Programme Operations Manager at the Biorenewables Development Centre, said, "Successfully demonstrating integrated hydrogen production with carbon capture represents a significant technical breakthrough for the H2Boost project."

"Our novel approach to producing clean hydrogen from waste while removing CO2 is not only technically feasible but also holds significant promise for large-scale sustainable energy solutions in the future."

It is forecast that new technologies have the potential to play a crucial role in decarbonising the UK's transport sector, with low-carbon hydrogen technologies expected to provide up to 35% of the UK's energy requirements by 2050.

New material could capture millions of tonnes of atmospheric carbon

www.tees.ac.uk/netzero

A new material being developed by Teesside and Edinburgh University academics could play a major role in reducing carbon in the atmosphere at a fraction of the cost of traditional carbon dioxide removal technologies.

The material, which is being developed in collaboration with colleagues from the University of Edinburgh, has the potential to capture 3.5–5 million tonnes of CO2 in the UK and nearly 30 million tonnes of CO2 globally per year by 2030, at a cost of around £100 per tonne CO2 – considerably less than current direct air capture (DAC) technologies.

Known as CalyChar, the new material is an advanced form of hydrochar, a charcoal-like material formed by using heat and water to treat organic/bio waste in a process known as hydrothermal carbonisation (HTC).

Dr Humbul Suleman, the project lead and a Senior Lecturer in Teesside University's School of Computing, Engineering & Digital Technologies, said, "CalyChar represents an exciting step forward in our efforts to combat climate change. By enhancing the ability of hydrochar to capture CO2, we can develop a more cost-effective and long-lasting solution for reducing carbon dioxide levels in our atmosphere."

By combining hydrochar with materials like amino acids and metal oxides to create CalyChar the researchers aim to overcome the material's traditional limitations in CO2 capture and create a functionalised material.

Low carbon steel and cement

Are there customers who would pay more for cement or steel produced with less CO2 emissions from the manufacturing process, because CCS has been used? A session at CCUS 2024 reviewed the issues. By Karl Jeffery.

No more than 25 per cent of cement buyers are showing any willingness to pay any "green premium" for cement made with carbon capture, said Elliot Mari, Technical Lead – Materials with industry group "Industrial Transition Accelerator."

The situation could be solved by regulation, putting a limit on how much "embedded carbon" cement products could have, he said.

There is no firm standard for low carbon products, he said. "Low carbon" implies carbon better than average, "near zero" or "net zero" implies some form of CCS is used.

Robert Jan Jeekel, Head of European Union Institutional Affairs with steel company Arcelor Mittal agreed that a crucial part of the business case for low carbon products is customer willingness to pay more for them.

Low carbon steel can be made by recycling old steel, but this requires electricity, which is very expensive in the UK. And it must compete with new steel made using blast furnaces, and there is 600m tonnes a year excess capacity to make new steel in the world.

One solution is that money paid by steel companies to the emission trading scheme is made available for investing in decarbonisation, he said.

It is very important to develop standards for low carbon products, he said. Germany has started with this.

European steel companies support the principle of a Carbon Border Adjustment Mechanism (CBAM), which stops cheaper high carbon steel imports replacing expensive domestic low carbon production. But the system needs to be designed in an effective way, he said.

A crucial part of the business case for low carbon products is customer willingness to pay more for them - Robert Jan Jeekel, Head of European Union Institutional Affairs with steel company Arcelor Mittal

70 per cent of cement emissions are made as part of the chemical production process, only 30 per cent come from energy consumption, said Winston Beck, Global Head of Government Affairs with construction materials company Heidelberg.

Heidelberg has the intent to develop twelve large CCS projects, he said.

Its Brevik project in Norway will capture 400k tonnes CO2 a year for storage in the "Northern Lights" system. Heidelberg is already selling the product, "the first net zero cement in the world," with order books open for delivery in 2025.

One way to build a low carbon cement market would be for government buyers to commit to buying it - Winston Beck, Global Head of Government Affairs with construction materials company Heidelberg

In Europe, the emission trading scheme has "not been as promising as some people expected" in making CCS projects financially viable, he said.

But the costs for emitters are still enormous. Heidelberg expects to pay Euro 80bn in ETS credits in the next 10 years. If half of that money could be invested in CCS, European cement production could be decarbonised.

Concrete costs account for only 1-3 per cent of the cost of a new building; if it were made from green cement, that would change to about 5 per cent, he said. But intermediaries in construction would see much bigger cost increases.

It is not yet possible to include CCS as part of "Environmental Product Declarations" provided with concrete products, he said.

One way to build a low carbon cement market would be for government buyers to commit to buying it, he said. 30-40 per cent of all concrete goes to public projects.

One critical question about the EU's Carbon Border Adjustment Mechanism will be how the EU ensures it gets accurate data, he said.

More information

www.ccus.events

A European storage market?

No emitters in mainland Europe are planning to use UK CO2 storage facilities so far, although they may turn out to be Euro 10 cheaper per tonne. Could and should this be fixed? A conference session explored the issues.

Currently there are two separate CO2 storage markets in Europe – the UK and everyone else. Yet the UK may have storage costs much lower than the rest of Europe.

If it were possible for everyone to bring CO2 to the UK, it would benefit mainland European emitters and force mainland Europe CO2 storage costs to fall.

Issues were discussed at CCUS 2024, the annual event of the Carbon Capture and Storage Association in London on October 15-16.

The UK has the most cost-effective CO2 storage sites in Europe, with one hundred different possible sites and thousands of kilometres of pipeline, said Olivier Mette, Global Advisory Director of energy industry consultancy Xodus Group.

Xodus did a study to try to match emission and storage sites across Europe, designing a system where emissions were brought to 30-40 central collection sites, and then sent out to five hundred storage sites. It found that UK storage costs would be 40 euro per tonne and mainland Europe (EU) costs would be 50 euro a tonne.

In Europe there has perhaps been too much focus on target setting and not enough time on infrastructure planning - Lee Beck, Senior Director, Europe and the Middle East, Clean Air Taskforce

There would be big savings for emitters in Northwest Europe if they could send CO2 to storage in the UK's Southern North Sea - Olivier Mette, Global Advisory Director of energy industry consultancy Xodus Group

So, there would be big savings for emitters in Northwest Europe if they could send CO2 to storage in the UK's Southern North Sea. This would also open up more capacity for storage offshore Norway and Denmark, which could be more easily used by emitters in Nordic countries.

It might also make the whole system more resilient, with emitters having more than one option for a storage site.

Shell would like to see a "full integrated European [CO2 storage] market," said Els Jooris, Business Opportunity Manager CCS, Shell. "It will give emitters choice."

Any means of reducing CCS cost will be very welcome. "Emitters are all struggling with the same problem - decarbonising is too expensive, the cost needs to come down," she said.

"When we connect the clusters together we move from a nascent business to a very interesting business."

The Clean Air Taskforce modelling finds that 90 per cent of European storage areas being developed are in the North Sea, said Lee Beck, Senior Director, Europe and the Middle East, Clean Air Taskforce.

In Europe there has perhaps been too much focus on target setting and not enough time on infrastructure planning, she said.

Germany has a CO2 Storage Act which needs to be re-evaluated every four years, said Dr Sebastian Fischer, Policy Advisor for Carbon Management, Federal Ministry for Economic Affairs and Climate Action, German Government.

The most recent evaluation concluded that CCUS is needed to reach Germany's climate goals, "at least for hard to abate emissions."

"Scaling up [CCS] at industrial scale comes with a lot of challenges," he said. "Minimising risks is one issue. Public perception is still an issue."

Transporting CO2 by ship and rail

If an industrial facility wants CCS and is not near a pipeline, it will need to move CO2 by ship, rail or even road. Will this transportation be available?

Many coal and gas power stations and industrial facilities are located a long way from pipelines which could carry their CO2. If their CO2 is to be captured and stored, the CO2 will need to be transported another way, with the two main alternatives being rail or ship.

Speakers at the Further developments in CO2 non-pipeline transport breakout session

Issues were discussed at CCUS 2024, the annual event of the Carbon Capture and Storage Association in London on October 15-16.

Most European power stations were originally built to run on coal, and so built next to a railway line or port to bring in the coal.

The Carbon Capture and Storage Association has identified that over half of its members will require a means of transporting CO2 other than a pipeline.

But so far, there are very few CO2 ships and rail cars, and this is likely to be a much more expensive way to move CO2.

Northern Lights

Norway's Northern Lights project uses tanker ships to transport CO2 from emitting sites to an onshore terminal in Western Norway. This terminal is connected by pipeline to offshore storage. The initial stage of the project, "phase 1", handles 1.5m tonnes of CO2 per annum.

Northern Lights has four customers so far. Heidelberg Materials' cement factory at Brevik, Norway; Hafslund Celsios' waste to energy facility in Oslo, Norway; fertiliser company Yara's ammonia and fertilizer plant in the Netherlands; and Ørsted's bio-based power plant in Denmark.

The project team's challenge is to get "Phase 2" running, working on a purely commercial basis (without government support), to carry 5m tonnes CO" a year. This could be followed by a larger Phase 3, said Fridtjof Wisur, commercial director.

While most of the CO2 is delivered to the terminal by ship, there is also the possibility of delivering it by truck.

Two CO2 ships have already been built for the Northern Lights project, and two more are on the way.

Provided there is a standard ship-shore interface, the ships provide operational flexibility, because they can be easily deployed to different customers, he said.

Mr Wisur noted that companies need to be willing to collaborate for projects such as this to work. "It requires trust and alignment of objectives," he said.

Wales

The industrial facilities in South Wales, which include steelmaking and chemicals, form "arguably the largest cluster in UK that doesn't have access to [CO2] pipelines or storage," said Ben Burggraaf, CEO of industry body Net Zero Industry Wales.

For this reason, the Wales facilities can never be part of the UK government's "track" CCS current funding schemes, he said, which are built around clusters with both capture and storage. CO2 shipping will be required for South Wales to decarbonise.

VTG

Could CO2 be moved by rail? VTG is a rail logistics and wagon leasing company which already has "50-100" CO2 railcars available for lease.

It has also designed a CO2 rail tank car for the sort of volumes associated with CCS projects, with faster loading and unloading, which could be built whenever a customer required it.

"We are more or less ready now," said Stefan Siegemund, Business Development manager for New Energies, VTG.

VTG has its own facility to build rail tank cars, although it would not be large enough for a customer seeking three hundred new rail tank cars a year, he said.

The liquid CO_2 which vaporises from rail tank cars is a "manageable" problem, he said. "It will not be the biggest challenge."

Mr Siegemund believes political support for CCS leans more towards pipeline transport. This makes rail transport more expensive.

Network capacity is always a key question with anything relating to rail, but the limits are for specific hubs, not for the whole European rail network, he said.

Shipping

Mitsui O.S.K. Lines (MOL) has over eight hundred ships, making it one of the world's largest shipping companies, including bulk carriers, LNG carriers, ro-ro car carriers, tankers and container ships. It already transports ammonia.

For CO2 transport, it works in partnership with Larvik Shipping of Norway, which has been carrying CO2 by ship for 35 years.

Generally, in the maritime sector the costs of moving goods by ship are a tiny proportion of the total costs of the goods, said Bruce Moore, Director New Energy & Strategy, Energy, Decarbonisation and Offshore Business with MOL.

It might help if the CCS industry could agree on standard tanker sizes for CO2 shipping - Bruce Moore, Director New Energy & Strategy, Energy, Decarbonisation and Offshore Business with MOL (left)

But for CO2 projects, in contrast, the costs of moving CO2 by ship can be a large proportion of total CO2 transport and storage costs.

A large part of this is the cost of building the ship. "Building anything in a shipyard is incredibly expensive," he said. "There doesn't seem to be much prospect of that coming down."

Mr Moore's background is in LNG shipping. For LNG, as with CO2, there was a requirement to build an entire supply chain before anything could be done.

It might help if the CCS industry could agree on standard tanker sizes for CO2 shipping, he said, just as the maritime industry has standard sizes for tankers and bulk carriers.

Energy from waste with CCS

Burning waste to make energy, while capturing the CO2, sounds much better than what we usually do, send waste to landfill. For the half of waste which is biogenic, it means net CO2 removal. Can it be made commercially viable? By Karl Jeffery.

Most waste is sent to landfill where it rots and gives out methane, and the residue takes up space forever.

Waste incineration plants mean that CO2 from combustion enters the atmosphere rather than methane, a less potent greenhouse gas. No landfill space is taken up, and it may be possible to utilise the heat from combustion.

But it would be better if the CO2 could be captured and stored. The energy from combustion could power the CCS plant.

Issues were discussed at CCUS 2024, the annual event of the Carbon Capture and Storage Association in London on October 15-16.

Since about half of all waste is biogenic origin (such as paper and food), waste incineration with carbon capture means negative emissions over the full lifecycle, with CO2 taken out of the atmosphere as the biogenic material grows as a plant.

If all plastic, metal, and glass waste was recycled, everything left would be entirely biogenic, and waste to energy plus carbon capture plants would have much more carbon removal credits to sell.

The level of biogenic content in waste can be assessed by monitoring the flue gas for the Carbon 14 atom, which is more abundant in biomass waste.

Netherlands

In the Netherlands, the Twence facility installed a full scale (100ktpa) capture plant in 2023, with CO2 used to fertilise industrial greenhouses, said Brigitte Jacobs, Business

Leader Energy and Material Transition Industry with Dutch research organisation TNO (and program director of Dutch CCS association CATO).

This CO2 is of course not permanently stored but does displace CO2 generated by burning gas to make CO2 fertilizer, which would otherwise need to happen.

Today, all waste incineration plants in the Netherlands are looking at some CCS system, with a "small minority" only at the techno-economic feasibility study stage, she said. They must figure out what to do with CO2 once it is captured, and how to minimise project risk (such as if the receiving facility is not operational).

Waste incineration plants closer to the Dutch west coast are closer to offshore storage locations, and so more likely to consider CO2 storage, she said.

The Netherlands is investing "heavily" in CO2 transport infrastructure. "I see a blend of pipeline infrastructure, shipments, trains possible," she said. "It is going to make it more complex. We will be mixing different sources, different capture processes."

Some plants are seeking to benefit from carbon credits from storing biogenic CO2, she said.

Supplying CO2 to greenhouses typically does not create a viable business case by itself but can be made feasible with the help of government subsidy. This is normally enough to avoid losing money, but not enough to make it profitable, she said.

The CO2 quality specification is an issue, with many impurities possible in CO2 from waste incineration. CO2 stores typically require that NOx, SOx, and oxygen in the CO2 stream is at a parts per million level. Oxygen in the CO2 can degrade the solvent in the capture system, she said.

Oslo

In Oslo, efforts have been made for several years to find a way to capture and store CO2 from the Celsio waste to energy plant, said Jannicke Bjerkås, Director of CCS and Carbon Markets, Celsio.

There is currently a plan to capture 90 per cent of its flue gas and store in Norway's Northern Lights project, amounting to 350ktpa. The CO2 needs to be transported 10km by road from the capture site to a port for maritime delivery to Northern lights, which adds to the cost. Emission free trucks will be used for this.

There are many other energy from waste projects in Norway which have much bigger challenges handling the CO2, she said.

The project team made what they thought was a "final investment decision" in summer 2022, but subsequently paused in Spring 2023 due to cost inflation. As well as general price increases this related to the Ukraine war and "some internal complexity," including changes to the location of the site in the Port of Oslo.

Solutions have since been found for many problems, and the goal is a second final investment decision to be agreed at the end of 2024, to start operations in 2029.

The project has some state funding and investment from the city of Oslo. It will benefit from avoiding CO2 emission taxes. The heat from the plant will be used for district heat.

It will also sell CO2 removal credits for the biogenic waste. These will form a bigger part of the second plan than the original plan, she said.

Encyclis

UK energy from waste company Encyclis has four plants in operation, two more being built and one in development, said CEO Owen Michaelson. One of the operating plants is part of the HyNet CCS cluster in Northwest England.

While HyNet benefits from government funding, Encyclis is still trying to work out a "fundable" long term business model for CCS. "At the moment CCS is phenomenally expensive. It is about understanding what business model will help roll it out at scale," he said.

One plant can generate about 1,000 tonnes CO2 a day. This is relatively small compared to a gas fired power station, he said.

If the carbon price reaches £150 a tonne, that is a level which "triggers all of us to do something different" - Mike Maudsley, CEO of energy from waste company Enfinium

Enfinium

If the carbon price reaches £150 a tonne, that is a level which "triggers all of us to do something different," said Mike Maudsley, CEO of energy from waste company Enfinium. "At the moment it is £30-£40."

The capture plant on the waste incinerator flue gas is expected to consume 30-50 per cent of the energy from the combustion, he said. This is a "phenomenal" amount. But it is feasible, because selling the energy is not a core component of energy from waste operations.

"We are not there to make energy," he said.

Enfinium is looking for very tried and tested solutions for capture and considers amine solvent based capture "the only technology to capture CO2 at scale at the moment." For now, "amine technology is here, we grasp it and run with it," he said.

Mr Maudsley anticipates there may be technologies with lower energy requirement available from 2030. "Something which isn't an amine - more environmentally friendly - would be a good thing." This could include metal organic frameworks (MOF) or other solvents, he said.

ABB: monitoring CCS operations as they happen with CCS 360

Operating CCS systems day by day, to avoid situations which could lead to non-availability resulting from integrity breaches or corrosion, will not be easy. ABB has built a system called CCS 360 to do it. By Karl Jeffery.

Ensuring high availability is the number one target of any CCS network operator. But achieving high availability may not be straightforward when transporting CO2 from multiple sources.

Phase change, integrity breaches, corrosion, restricted injectivity are just a few challenges CCS operators will face. Having the right tools to aid operators overcome these challenges is key to making CCS a success whilst at the same time ensure CCS networks are operated at the minimum operating costs from an energy perspective.

A CO2 system can be complex, with multiple emitters (cement, hydrogen production from gas, power generation), connecting the pipelines together, leading to subsea pipelines and injection into depleted reservoirs or saline aquifers.

ABB has combined its operations technology expertise with CCS modelling systems from PACE CCS to build a software system called CCS 360. It can be used to monitor CCS operations in real time and guide operators' actions to mitigate operational risks before they occur.

CCS 360 can also be used as an offline simulator to test operator actions prior to deployment through a function called "what if" scenario modelling.

The software builds on a CO2 flow simulator developed by consultancy PACE CCS, which ABB acquired in December 2022. The simulator was developed for project design, not for operations, but the same concepts apply.

Nigel Greatorex, CCS Global Segment Manager at ABB presented the software at a webinar organised by Northeast Scotland CCUS association NECCUS on Dec 12.

The software covers both the above ground side (process equipment and pipelines) and the subsurface elements (wellbores and reservoirs), with separate models for both.

With CCS projects, "the margins are low - but the risks are very high," Mr Greatorex said.

If there is any downtime of the CCS network, the captured CO2 will probably be emitted to the atmosphere, which is likely to incur some form of financial penalty such as a carbon tax.

The more complex a CCS network is, such as with multiple emitters and multiple injection wells, the higher risks it can have, he said.

Modelling

The software will model the thermodynamic properties, mass and energy balance of the CO2 in a pipeline for every 100m along its length.

It is built on a thermodynamic model specifically designed for CO2. It uses well established equations of state established in industry, such as the GERG-2008 equation of state.

These equations are fine-tuned and simplified, with the benefit of laboratory data, so they can be used in a CCS network.

It also uses models for hydrate formations and the impact of sulphur. These were created in a joint industry project by PACE together with the UK's Net Zero Technology Centre.

The research looked at 4000 possible chemical reactions that could take place, one of which is hydrate formations.

The modelling is complex because the problems themselves are complex. For example, while we can see that sulphuric acid in a pipeline could cause corrosion, we don't know if the conditions are present for sulphuric acid to form.

The more complex a CCS network is, such as with multiple emitters and multiple injection wells, the higher risks it can have - Nigel Greatorex, CCS Global Segment Manager at ABB

Normally, CO2 is dehydrated downstream of being captured. But under certain operating conditions, you can experience condensing water which is induced from polar impurities that can cause chemical reactions resulting in the formation of sulphuric acid, Mr Greatorex said.

These risks can be mitigated through deployment of ABB's CCS 360 and its corrosion functionality. It models the composition of CO2 in real time under changing operating conditions, allowing operators to take actions as required.

For example, the system would notify operators if you are close to the water dew point, which would cause condensing water in the CO2 stream.

This would allow operators to increase the enthalpy somewhere within the network to give them an acceptable safety margin to mitigate this risk.

The tool also has subsurface modelling, using the reservoir simulation software "GEM" from Computer Modelling Group (CMG). GEM was initially developed for subsurface modelling of oil and gas production reservoirs. In 2019, CMG saw an opportunity and industrial need to be able to model the behaviour of CO2 when injected into subsurface formations.

Physics based subsurface simulation of CO2 can cover trapping mechanisms, fault reactivation, geomechanics of both the caprock and near wellbore, and determine the plume size and migration.

With this functionality, operators can satisfy regulatory requirements and ensure safe operations from an injectivity perspective.

Well integrity

Phase change within a wellbore is a common challenge when operating in dense phase due to temperature losses caused via Joule-Thomson effect. Salt precipitation is also a concern if injecting into saline aquifers. Both operating challenges could lead to non-availability of the network.

Phase change could cause back pressure and hence trip the network. Salt precipitation could cause restricted injectivity and lead to the shutting down of a wellbore whilst it is being flushed.

Either of these conditions would result in taking emitters offline resulting in breach of contract between the offtaker and emitters, that would ultimately result in some form of financial penalty.

Using the software

When using the software, the operator can see the mass energy balance and composition at all points of the system. There is a "traffic light" system of indicators, showing red if there are any problems. The system takes a snapshot of real time data from level 2 (control/SCADA system) and analyses it to see if there are any issues.

For example, there could have been an operational change that can impact the phase of CO2, or which could have introduced impurities into the CO2 which could cause corrosion.

The software has a 'scenario modeller' tool, where you can see what would happen under changing conditions i.e., an emitter goes offline. These scenarios are constantly running in the background, updated typically every 60 seconds and providing operators with the network's status in the event these scenarios become real.

The system will then advise whether an alarm will be generated or whether the network will trip altogether. It can provide corrective action to ensure the network can stay online under these changing conditions.

The system is an "open loop system", which means that it takes process variables from level two, runs it through the process models and then provides feedback to operators allowing them to make set-point changes in a manual form if required.

Many project developers have asked if it might be possible to have a "closed loop" system, where changes are automatically made by the system, Mr Greatorex said.

Technically it is possible, but there would need to be confidence that the models are accurate enough to ensure that the changes achieved the desired outcome. "In the early days it is unlikely to be deployed as a closed loop system," he said.

However, as CCS 360 gets deployed in the field, and field data becomes available, the process models will improve over time. This should provide operators with the confidence to deploy CCS 360 as a closed loop system.

ABB has integrated the process models into a platform called "OPTIMAX" which can be used for energy management of the complete CCS network. You can analyse energy consumption in all areas of the network such as by compressors and heaters.

Data can also be downloaded for later analysis or making reports. Once operators of CCS networks achieve good operability and hence high availability, they can then start to optimize the network from an energy consumption perspective.

The software can also be deployed for metering purposes, so a "virtual meter". As CCS 360 can accurately calculate the mass energy balance of any composition of CO2, virtual metering can be achieved.

This overcomes challenges of understanding flows when injecting into offshore aquifers and your complete offshore operation is subsea.

More information

https://new.abb.com/oil-and-gas

Europe-wide CO2 market could reduce storage costs by 20%

A report by Xodus released by the Carbon Capture and Storage Association (CCSA) says enabling cross-border CO2 transport and storage is critical for reducing emissions efficiently and on time.

The report "Accelerating a Europe-wide CO2 storage market" based on modelling and analysis by Xodus Group says expanding the CO2 market across Europe, including the UK, is an effective way to lower emissions and storage costs. As of right now, policy remains the largest obstacle to transporting CO2 across the EU-UK border, which would otherwise be technically feasible.

Olivia Powis, CEO of the CCSA said, "A Europe-wide CO2 market is within reach, but policies are standing in the way. We can cut storage costs by 20% and save billions annually if the EU and UK break down these barriers, and make cross-border CO2 storage happen now. The future of the European industry and climate action depends on it."

Cross-border CO2 transport and storage would create economic benefits for industrial emitters across EU Member States, other EEA countries and the UK, supporting existing and new jobs across Europe.

To do so, the European Commission and the UK Government can take concrete actions that would send a strong signal to European businesses. These key actions are:

• Establish a bilateral agreement between the EU and the UK under the Trade and Cooperation Agreement (TCA) to enable mutual recognition of each jurisdiction's CCS regulatory regime.

• Amend EU and UK Emission Trading Schemes to accommodate CO2 storage outside the EU and EEA.

• Explore the other legislative changes required to facilitate cross-border CO_2 transport and storage

• Make notifications and agreements under the London Protocol

As CCUS projects progress in the EU, Norway and the UK – with the first sites beginning operations as soon as 2026 – enabling cross-border CO2 transport and storage would make these systems more resilient, said the CCSA, but we need to act quickly before higher-cost options are locked in and the opportunity is lost.

	Estimated unit cost to emitters		Estimated unit cost reduction with EU/EEA-UK cross-border transport and storage	
	Without EU/EEA-UK cross-border CO_2 transport and storage	With EU/EEA-UK cross-border CO_2 transport and storage	Cost reduction	Percentage reduction
Europe (EU, EEA & UK)	€52/t	**€41/t**	**€11/t**	**21%**
EU	€57/t	**€41/t**	**€16/t**	**28%**
UK	€40/t	**€39/t**	**€1/t**	**3%**
Norway	€59/t	**€56/t**	**€3/t**	**5%**

Average cost to emitters of offshore storage under each scenario, in 2040, in € per tonne CO_2.

Research findings

The research found that UK stores are among the most cost-effective and well-located in Europe, so enabling access to these means emitters in the EU are likely to see considerable cost savings compared to the status quo. UK emitters too would benefit from slightly lower storage costs due to the efficiency and savings from having more resilient networks that are likely to be developed in a near-term timeframe.

CO2 volumes from Europe can be critical to unlocking the business case for investing in new CCS Clusters, hence allowing European emitters, including those in the UK, to access CCS networks to decarbonise their operations.

The research demonstrates that Europe as a whole would benefit in a scenario where access to UK storage is enabled. In 2040, in particular:

• Emitters in Europe using offshore CO2 storage would benefit from a 20% cost saving (€11/t). With the market expected to grow to 243† $MtCO_2$pa by 2040, this would represent €2.7 billion in annual savings.

• Emitters in the EU-27 countries could, on average, benefit from a €16/t reduction in the cost for offshore transportation and storage (T&S) of CO2. This represents a 28% reduction in transport and storage costs.

• The UK would benefit from lower CO2 storage costs for its emitters due to CCS projects with a higher scale factor, as well as the ability to make the most of its geology by offering CO2 storage to support other countries and the associated economic benefits through tax receipts and job retention and creation that this would bring.

• Reduction in transport and storage costs for North-West European (NWE) emitters are shown to be even greater than the average percentage (28%) mentioned above for the EU-27 countries.

• Any delay in enabling cross-border solutions would lock emitters into higher-cost storage.

More information

www.ccsassociation.org
www.xodusgroup.com

CSIRO releases feasibility analysis for 'low emissions hub' concept in Darwin

CSIRO has published a series of reports exploring the technical and economic feasibility of a low emissions CCUS hub concept near Darwin, to support carbon management and economic growth goals in the Northern Territory.

CSIRO has worked with the Northern Territory Government and industry to develop the low emissions hub concept which could involve co-location of existing and potential new industries at the Northern Territory Government's proposed Middle Arm Sustainable Development Precinct in Darwin Harbour.

These industries would have access to shared infrastructure to enable CO2 to be captured or imported, and then converted to low emission products, or compressed, transported, and permanently stored offshore and deep underground.

The reports provide an assessment of macroeconomic drivers, Northern Territory and South East Asian regional emissions, the regional context, markets for low emission products, and key learnings from other low emissions hubs being developed globally.

In addition, the analysis outlines technical requirements and technical risks, including infrastructure, renewable power requirements, CO2 transport, cross-sector coupling where outputs from one industrial process can be used by adjacent industrial processes, and opportunities for existing and potential future industries to convert CO2 into low or zero emission products. The technologies outlined in the reports are currently operating around the world.

The Low Emissions CCUS Hub would be based on Darwin's Middle Arm Peninsular in the NT. Image: Wayne Zerbe

CSIRO scientist and project lead, Dr Andrew Ross, said CCUS was one of several critical pathways for the Northern Territory to reach net zero emissions by 2050.

"CSIRO engages with governments, industry and communities to provide robust, independent research to support science-based decision-making as we transition to a low emission economy," Dr Ross said.

"While there is no single technology solution to reducing emissions, our analysis shows CCUS can be an important part of a well-planned and integrated approach that includes electrification, renewable energy, hydrogen, and hydrogen-derived products in pursuit of the Northern Territory's goals.

"Understanding the business model for CCUS and low emission hub development will help resolve financial and deployment risks for investors and government for low-emissions hub development in the Northern Territory."

The analysis reports are a desk-top synthesis of CSIRO's modelling, analysis and research using publicly available data and data provided by the Northern Territory Government and industry. They build on CSIRO's 2021 CO2 Utilisation Roadmap and 2023 Opportunities for CO2 Utilisation in the Northern Territory reports.

Findings from the eight reports released now will be incorporated into a final overall business case project analysis to be published next year.

More information

www.csiro.au

Projects and policy news

bp and partners to invest $7 billion in Tangguh CCUS project

www.bp.com

A final investment decision has been taken on Indonesia's first at-scale enhanced gas recovery CCUS project, aiming to store around 15 million tonnes of CO2 in its initial phase.

Project UCC has the potential to unlock around 3 trillion cubic feet of additional gas resources in Indonesia to help meet growing energy demand in Asia.

“This project not only unlocks a fantastic gas resource, it also represents an Indonesian first through the use of CCUS to maximise gas recovery," said Murray Auchincloss, bp CEO.

"bp has operated in Indonesia for more than fifty-five years, and the strength of our relationships enables us to bring deep technical experience in helping to deliver this innovative development. We deeply appreciate the continued support of the Government of Indonesia and partners and look forward to helping the region meet its growing energy needs.”

The UCC project, which comprises the Ubadari gas field development, enhanced gas recovery through CCUS and onshore compression, expands existing infrastructure at the Tangguh LNG facility in Papua Barat, Indonesia.

Once completed, Tangguh EGR/CCUS will have three injection wells, one offshore injection platform, one offshore CO2 pipeline, and onshore facilities for CO2 removal, processing, and compression. Production at the Ubadari field is expected to start in 2028.

The UCC project has been designated as a national strategic project by the Government of Indonesia and represents the continued development of Tangguh, following the addition of the third LNG train which began operation in 2023 and brought total plant liquefaction capacity to 11.4 million tonnes per year.

The investment meets bp's returns hurdle rates and is fully accommodated within bp's disciplined financial framework, reflecting bp's drive to focus on value and returns. Tangguh is in a strategic location to access high value regional markets, and the investment reflects bp's commitment to continue to meet energy demand for Indonesia and the region.

Report: U.S., China must collaborate on carbon dioxide removal

https://cgs.umd.edu

The world's two biggest emitters must cooperate to accelerate the development of methods that actively remove carbon dioxide from the atmosphere, according to a new report from researchers from the University of Maryland and Chinese Ministry of Science and Technology.

The report offers a comprehensive overview of policies and practices on carbon dioxide removal (CDR) at both national and subnational levels, aiming to increase understanding of how different approaches could mitigate climate change while identifying key opportunities where the two countries can work together to accelerate CDR.

“In tackling the urgent challenge of climate change, stakeholders in both the U.S. and China must collaborate in accelerating the advancement of CDR technologies and commercializing CDR projects,” said CGS Research Assistant Yingtong Li, the report's lead author.

The study analyzes about 900 CDR-related policies and some 350 CDR projects from both countries, and provides policy recommendations to enhance future U.S.-China collaboration on CDR.

The report shows that policy instruments for CDR development vary significantly between the U.S. and China. Federal laws and diverse economic incentives, particularly the 45Q tax credits that encourage power plants and other industrial sources to decarbonize, are driving state-level interest in developing CDR in the United States, while China has primarily focused on strategic planning and voluntary programs.

CDR projects in the United States focus on industrial processes, natural gas, bioenergy with carbon capture and storage and direct air capture, supported by a mix of federal and state-level policies. States including Illinois and California offer targeted incentives to meet local energy needs while others lack strong economic support for CDR technologies, leading to a heavy reliance on federal funding.

In contrast, CDR projects in China are largely based in the chemical industry, power plants, steel production, and the oil and gas sectors, with CO2 used primarily for enhanced oil recovery. China places less emphasis on government funding and financial incentives. While regions like Shandong and Tianjin are pioneering the use of carbon markets, many provinces lack specific financial incentives for CDR, revealing gaps in infrastructure and support.

The report highlights that the U.S. has clear, enforceable regulations like the EPA's New Source Performance Standards, with some states, such as Colorado, requiring feasibility assessments for carbon capture. In contrast, China's CDR policies are still developing, focusing on point-source emissions with stricter policies in certain provinces but a lack of comprehensive frameworks elsewhere. While the U.S. has an established tracking and reporting system, China's efforts are in the early stages, primarily focused on pilot projects and regional initiatives.

CRC receives approval for California's first CCS project

www.crc.com

California Resources Corporation and its carbon management business, Carbon TerraVault (CTV) have received approval from the EPA for the Elk Hills cryogenic gas plant in Kern County.

Project approval follows CRC's recent receipt of final Class VI well permits from the Environmental Protection Agency (EPA) for underground injection and storage of carbon dioxide into the 26R reservoir, located at CRC's Elk Hills Field in Kern County, California. The 26R reservoir is part of CTV's joint venture with Brookfield.

CRC plans to capture and, through its joint venture with Brookfield (CTV JV), permanently store up to 100 thousand metric tons of CO2 per annum from its Elk Hills cryogenic gas plant in the 26R reservoir. Operations are expected to commence in late 2025.

CRC is expected to qualify for $85 per metric ton in 45Q tax credits, with potential for Low Carbon Fuel Standard (LCFS) credit generation and reduction in Cap-and-Trade (C&T) liabilities. CRC said its internal rate of return from this capture and storage project is expected to be at the high-end of its previously disclosed range of 10% - 30%.

New chemical structures show vastly improved CO2 capture

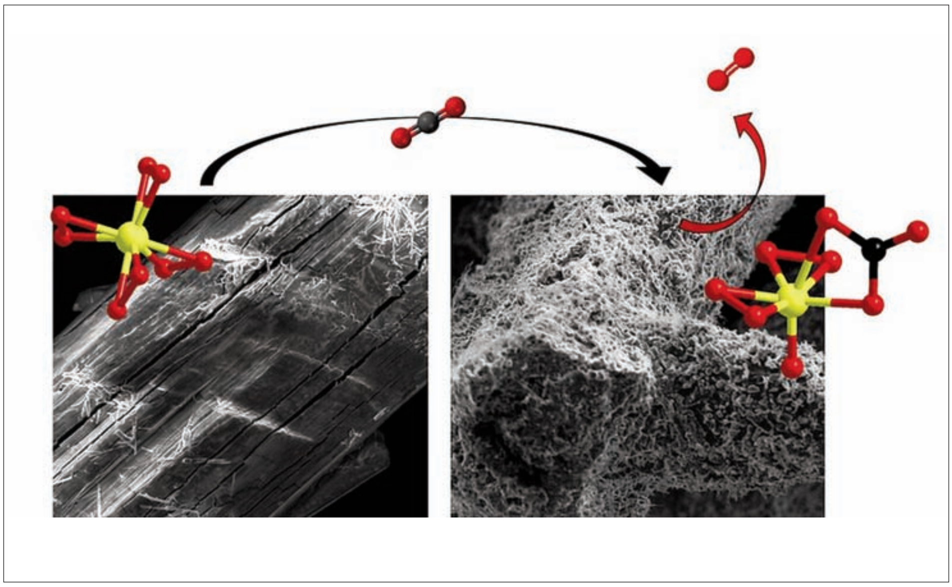
Oregon State University researchers have synthesized new molecules able to quickly capture significant amounts of carbon dioxide from the air.

The study, which focused on titanium peroxides, builds on their earlier research into vanadium peroxides. The research is part of large-scale federal effort to innovate new methods and materials for direct air capture of carbon dioxide.

Findings of the research, led by May Nyman and Karlie Bach of the OSU College of Science, were published in Chemistry of Materials.

In 2021 Nyman, the Terence Bradshaw Chemistry Professor in the College of Science, was chosen as the leader of one of nine direct air capture projects funded by the Department of Energy through an initial investment of $24 million.

Her team is exploring how some transition metal complexes can react with air to remove carbon dioxide and convert it to a metal carbonate, similar to what is found in many naturally occurring minerals.



Scanning electron microscope images of the carbon capture titanium molecules before (left) and after (right) exposure to air. The molecules release oxygen gas upon capture of carbon dioxide, creating a spongelike substance that enables reactivity throughout the crystals, not just on the surface. Image provided by May Nyman and Karlie Bach, OSU College of Science

"We opted to look into titanium as it's 100 times cheaper than vanadium, more abundant, more environmentally friendly and already well established in industrial uses," said Bach, a graduate student in Nyman's lab.

"It also is right next to vanadium on the periodic table, so we hypothesized that the carbon capture behavior could be similar enough to vanadium to be effective."

Bach, Nyman and the rest of the research team made several new tetraperoxo titanate structures – a titanium atom coordinated with four peroxide groups – that showed varying abilities to scrub carbon dioxide from the air. Tetraperoxo structures tend to be highly reactive because of the peroxide groups, which are potent oxidizing agents.

Related peroxotitanates have been studied for their potential uses in catalysis, environmental chemistry and materials science. However, the tetraperoxotitanates in this study had never been definitively synthesized; Bach was able to use inexpensive materials for high-yield chemical reactions.

"Our favorite carbon capture structure we discovered is potassium tetraperoxo titanate, which is extra unique because it turns out it is also a peroxosolvate," Bach said.

"That means that in addition to having the peroxide bonds to titanium, it also has hydrogen peroxide in the structure, which is what we believe makes it so reactive."

The measured carbon capture capacity was about 8.5 millimoles carbon dioxide per gram of potassium tetraperoxo titanate – roughly double that of vanadium peroxide.

"Titanium is a cheaper, safer material with a significantly higher capacity," Bach said.

Named for the titans of Greek mythology, titanium is as strong as steel but much lighter. It's non-toxic, does not easily corrode and is the ninth most abundant element in the Earth's crust – found in rocks, soil, plants and even the human body in trace amounts.

Other Oregon State authors on the paper included assistant professors Tim Zuehlsdorff and Konstantinos Goulas, postdoctoral researcher Eduard Garrido Ribó, graduate students Jacob Hirschi, Zhiwei Mao and Makenzie Nord and crystallographer Lev Zakharov, interim manager of OSU's X-Ray Diffraction Facility.

The Murdock Charitable Trust also supported this research through an instrument grant.

More information

https://science.oregonstate.edu

Holcim Group to test Capsol's carbon capture technology

The agreement includes the delivery of a CapsolGo® carbon capture demonstration campaign at a plant in southern Germany as the first step in a broader collaboration.

The delivery of the CapsolGo® unit is scheduled for Q2 2025, with testing set to commence in late Q2 2025. The project will span 4 months. The partnership is aimed at eventually decarbonising Holcim's global portfolio of industrial plants.

"This marks a significant milestone for Capsol Technologies as we initiate the demonstration of our CapsolEoP® technology at a Holcim cement plant. We are eager to collaborate closely with Holcim, showcasing our capability to contribute to their ambitious climate targets," said Philipp Staggat, Chief Product Officer of Capsol Technologies.

As part of its efforts to drive sustainability, Holcim has committed to deliver 8 million tons of fully decarbonised cement per year by 2030 and has 2030 and 2050 net-zero targets validated by the Science Based Targets initiative.

"This cooperation with Capsol Technologies reflects our commitment to identifying and deploying the most suitable carbon capture technologies for reducing emissions. The CapsolEoP® (End-of-Pipe) unit's design, requiring no external steam supply and exhibiting low energy consumption, makes it an attractive option for our Dotternhausen plant," said Dieter Schillo, Plant Manager of Holcim (Süddeutschland) GmbH.

If the demonstration campaign at the Dotternhausen plant is successful, Holcim Group would consider deploying Capsol's carbon capture technology based on the Hot Potassium Carbonate (HPC) solvent at full-scale cement plants across multiple sites.

As part of this agreement, the CapsolGo® demonstration campaign at the Dotternhausen plant will be delivered as a turnkey solution, including testing and validation services to provide Holcim with critical data and insights on Capsol's carbon capture technology.

This cooperation builds on an earlier engagement between the parties, including a feasibility study completed with Capsol Technologies by Holcim Group's Aggregate Industries UK Ltd for its Cauldon cement plant in Stoke-on-Trent.

Holcim Group would consider deploying Capsol's carbon capture technology at multiple sites if the Dotternhausen cement plant pilot is successful. Image courtesy of Holcim South Germany

Capsol Technologies was also recently awarded a feasibility study for the CapsolEoP® (End-of-Pipe) carbon capture technology at an energy-from-waste (EfW) plant in Germany. The study focuses on implementing a CO2 capture solution for a large-scale operation.

Energy-from-waste plants that use biomass as an input factor can generate negative emissions credits from carbon capture and storage (CCS) which can be utilized or sold, improving the economics of decarbonization.

CapsolGo® demonstration projects are designed to provide emitters with carbon capture data using Capsol's HPC-based process on their specific plants, supporting accelerated decision processes towards full-scale carbon capture.

A standard CapsolGo® demonstration campaign is offered on a rental basis, typically has a duration of six months, and includes transportation, installation, operation, and testing services.

Capsol's HPC-based process is using potassium carbonate as the CO2 solvent, a process which is well-documented and used in more than 750 plants globally in multiple industries. A patented energy re-circulation process offers low capture cost and the flexibility to monetise heat and electricity.

More information

www.holcim.com
www.capsoltechnologies.com

CO2-eating bacteria recycles captured CO2 directly into new products

Researchers from Aarhus University have developed a new technology that uses microorganisms to convert the CO2 in flue gas directly for fuels or feedstock for the chemicals industry.

The technology can exploit CO2 as a raw material, unlike conventional CCS which captures carbon from flue gas and converts it into solid matter that can then be stored underground, for example. The research has recently been published in the scientific journal Nature Communications.

"In a net-zero future, we need to use technology that recycles the CO2 we capture instead of continuing to extract more from the ground," said Amalie Kirstine Hessellund Nielsen, a PhD student at the Department of Biological and Chemical Engineering and one of the main authors behind the research.

Hyper-specialised process

In conventional carbon capture, the carbon is separated from the chemicals at high temperatures in a closed circuit. The concentrated CO2 can then be refined further in other demanding processes.

The alternative technology proposed by the researchers from AU propose is a new form of bio-integrated carbon capture and utilisation (BICCU), whereby carbon is reused directly in the circuit, avoiding many of the conventional intermediate process steps. The researchers at AU use microorganisms that both remove and convert CO2 from the flue gases directly in the capture unit instead of having to apply high heat.

"Microorganisms are hyper-specialised in the process of absorbing and converting CO2 and they have refined this process over billions of years. We exploit this in our bioreactors. So instead of using heat, we add microorganisms that can extract CO2 from other chemicals allowing us to save money on our heating bills," said Mads Ujarak Sieborg, a postdoc at the Department of Biological and Chemical Engineering and the main author of the new research.

The microorganisms absorb the carbon through their metabolism and convert it into other products, such as methane, which can be reused directly in industry

"What comes out of the microorganisms is green natural gas or acetic acid or other chemical building blocks that industries can use instead of extracting carbon from the ground," continued Mads Ujarak Sieborg.

Incentive for carbon capture

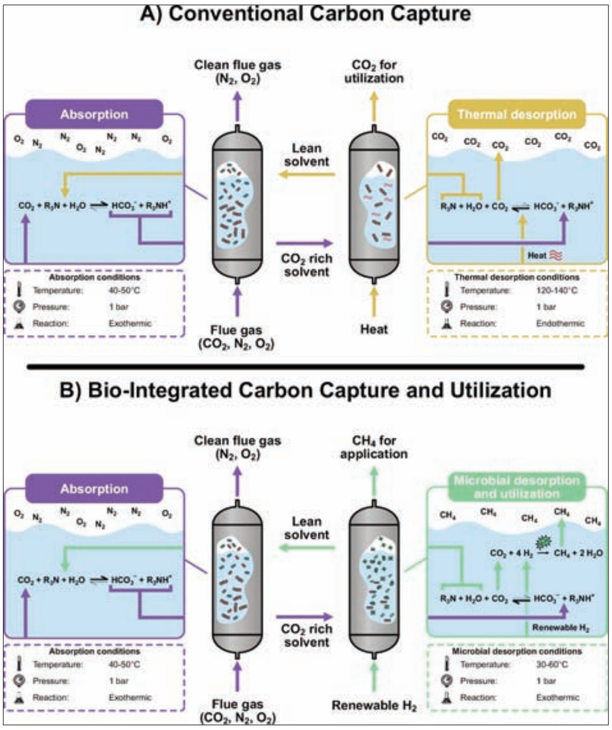
So far, carbon capture is still a new technology that not many industries have embraced. Biogas plants have started to capture CO2 from their production, because of the high fraction of CO2 in waste gases - up to 50%. However, in ordinary chimney smoke from industries, the fraction of CO2 is much less, about 5-10 per cent.

Implementation of carbon capture is so limited because the heating process to separate the carbon from the chemicals is very expensive. The amount of energy it costs makes up about 30 per cent of all the energy that the power plant produces.

Therefore, the researchers hope that the microbiological approach can create a greater incentive for carbon capture, because the costs are much lower, and because the CO2 is transformed into new products at the same time as it is captured:

"The biological process operates at much lower temperatures, and our microbes are resistant to the other gases in the flue gases. But microorganisms need hydrogen for their process, which we get via electrolysis. Hydrogen is the limiting factor in the system today, so there remain some challenges before we have a finished technology, but there are also solutions to the problems. We already have a wide range of different reactors to test – it's primarily a question of putting the system together correctly," said Amalie Kirstine Hessellund Nielsen.

"CCU is a small but necessary element in reaching the goals of a green transition of industry and net zero, such that emissions of greenhouse gases and removal of these gases are in balance. However, the technology cannot replace renewable energy sources, which are still the most important tool in the green transition."



A In the conventional carbon capture using a tertiary amine, the CO2 is absorbed in the absorption unit and transported to the desorption unit, where heat pushes the equilibrium toward CO2, thereby regenerating the amines. B In the BICCU process, the CO2 is also captured by amines in the absorption unit and transported to the desorption unit, where microorganisms pull the equilibrium toward CO2 by continuously converting it to CH4 while regenerating the amines

More information

www.au.dk

SINTEF develops tech to make carbon capture easier

A team of researchers at SINTEF has recently developed a new and simpler technology, called CSAR, for the capture of CO2 from industrial flue gases. CSAR stands for Continuous Swing Adsorption Reactor. It is based on a heat pump, a vacuum pump and the efficient use of electricity.

A recent innovation has the potential to accelerate the introduction of essential carbon capture processes in a range of industries. The technology has recently been demonstrated at a waste combustion plant in Bergen, with excellent results.

“Our studies have shown that the CSAR technology competes very well with technologies that utilise heat. This applies in particular if reasonably-priced electricity from renewable sources is available. The advantage is that both pumps require just a single conventional source of electricity. This makes the technology ideal for installation on existing plants," said Jan Hendrik Cloete, a Research Scientist at SINTEF.

“The CSAR technology utilises two reactors in the capture process. The CO2 is initially captured in the first reactor by a sorbent, which binds the gas to its surface. This binding process occurs at low temperature and generates heat. The heat is then transferred to the other reactor, where it is used to release the CO2 from the sorbent, this time at a higher temperature. The heat pump is used to transfer the heat between the reactors, while the vacuum pump assists in releasing the CO2."

The combined action of the two pumps makes the transfer of heat very efficient, and is also the reason for the low levels of energy consumption involved in this technology.

Highly competitive

“Our studies have shown that the CSAR technology competes very well with other technologies that use heat,”, said Cloete. “This applies in particular if reasonably-priced electricity from renewable sources is available."

This summer, the CSAR technology was demonstrated by SINTEF and the Norwegian company Caox at the BIR AS waste combustion plant outside Bergen. Every year, BIR processes about 220,000 tonnes of household waste for electricity and district heat generation, resulting in the emission of 250,000 tonnes of CO2.

“After 100 hours of operation, we found that we were able to capture the same amount of CO2 from real exhaust gases as we had in our laboratory tests”, says Cloete.

“This was an important step because it confirmed that the CSAR concept also works at an industrial scale. It also helped to boost confidence in our economic estimates,” he said

The pilot reactor is designed to capture 100 kg of CO2 per day. BIR is working to install a facility designed to capture 100,000 tonnes of CO2 annually by 2030. It will achieve this using commercially available technologies. At the same time, the company is also considering the use of new and more efficient technologies, such as CSAR, for capture of the remaining CO2.

Researcher Schalk Cloete operating the CSAR pilot at BIR AS. Photo: SINTEF

Contributing to CCS technology development

Results from the BIR plant in Bergen are paving the way for scaling up the CSAR technology for application across a range of industries. The pilot reactor has now been returned for upgrading at SINTEF’s multiphase laboratory in Tiller outside Trondheim.

Following this, the plan is to install the pilot in a cement factory in Spain. This is part of an ongoing EU-funded project called CAPTUS, which is looking into sustainable methods for the capture and utilisation of CO2 from energy-intensive industries.

More information

www.climit.no

www.sintef.no

Capture & utilisation news

Launch of demo for CO2 capture from chemical recovery boilers at paper mills in Japan

www.mhi.com/news/240919.html

Mitsubishi Heavy Industries Ltd. (MHI) and Hokuetsu Corporation, one of Japan's leading paper manufacturers, have launched a CO2 capture demonstration test at Niigata Mill.

The demonstration test aims to capture CO2 from a chemical recovery boiler that produces the steam and electricity needed for paper manufacturing, by using MHI's "CO2MPACT™ Mobile", a compact CO2 capture system. This is the first case in which MHI's CO2 capture technology is being applied to the pulp and paper industry. The test will allow MHI to analyze and evaluate data for commercial application and accelerate decarbonization in this industry.

Chemical recovery boilers use "black liquor" as their main fuel, which is generated as a by-product in the pulp production process, the raw material for paper. The wood chips are dissolved in a sodium-containing solvent known as "white liquor" to extract the pulp, and the white liquor component is recovered from the black liquor residue that remains after combustion and is re-circulated for reuse.

As the need for decarbonisation grows around the world, Japan is also actively engaged in decarbonisation efforts in various industrial sectors. And the pulp and paper industry is one of them. This demonstration test is expected to provide the pulp and paper industry with a solution that contributes to further global environmental measures by directly capturing CO2 emissions in the production process.

SLB Capturi completes CO2 capture plant for Heidelberg cement factory

https://capturi.slb.com
www.brevikccs.com

The carbon capture plant is designed to capture up to 400,000 metric tons of CO2 annually from the Heidelberg Materials cement facility in Brevik, Norway.

With the full-scale carbon capture plant now complete, including the carbon capture system, compression system, heat integration system, intermediate storage, and loadout facilities, the plant is now ready for testing and commissioning. When operational, this world-first commercial-scale carbon capture plant at a cement facility will enable production of net zero cement, without compromising on the product strength or quality.

Due to the inherent emissions of cement production, the sector is dependent on carbon capture and storage to reach net zero. The carbon capture plant is designed to capture up to 400,000 metric tons of CO2 annually from the cement facility. Strong execution support from Aker Solutions and the local industry has been instrumental in completing the construction of this project.

Up to 400,000 metric tons of CO2 will be captured annually from Heidelberg Material's cement facility in Brevik, Norway.

"The mechanical completion of the Brevik CCS project is a landmark achievement in the decarbonization journey of the cement industry," said Giv Brantenberg, general manager Northern Europe, Heidelberg Materials. "This project exemplifies our commitment to innovation, collaboration, and the pursuit of solutions that address the pressing issue of climate change. We are immensely proud of the dedication and hard work of our teams and partners."

The Brevik CCS plant is part of The Longship CCS project, Europe's first complete value chain for the capture, transport, and storage of industrial CO2 emissions. The Brevik plant will now move into commissioning phase, with operations starting during 2025.

From e-waste to gold: a pathway to CO2 sustainability

www.cornell.edu

A Cornell-led research team has developed a method for extracting gold from electronics waste, then using the recovered precious metal as a catalyst for converting CO2 to organic materials.

The method could provide a sustainable use for some of the approximately 50 million tons of e-waste discarded each year, only 20% of which is recycled, according to Amin Zadehnazari, a postdoctoral researcher in the lab of Alireza Abbaspourrad, the Yongkeun Joh Associate Professor of Food Chemistry and Ingredient Technology in the College of Agriculture and Life Sciences.

Zadehnazari synthesized a pair of vinyl-linked covalent organic frameworks (VCOFs) to remove gold ions and nanoparticles from circuit boards in discarded electronic devices. One of his VCOFs was shown to selectively capture 99.9% of the gold and very little of other metals, including nickel and copper, from the devices.

"We can then use the gold-loaded COFs to convert CO2 into useful chemicals," Zadehnazari said. "By transforming CO2 into value-added materials, we not only reduce waste disposal demands, we also provide both environmental and practical benefits. It's kind of a win-win for the environment."

Greensand Project to be first full scale CO2 storage facility in EU

The project partners have reached a Final Investment Decision (FID) to commence the first commercial phase 'Greensand Future' with storage operations set to begin at the end of 2025/early 2026.

The first full-scale carbon storage in the EU will become a reality, marking a critical step to mitigate climate change by achieving the storage volumes necessary to support Danish and European climate targets. This decision paves the way for expected investments of more than $150 million across the Greensand CCS value chain.

Greensand has entered commercial agreements throughout the entire supply chain, from CO2 emitters, to logistics, storage and shipping, backed by the funding necessary to make final injection and permanent storage a reality for Denmark and Europe.

Sir Jim Ratcliffe Chairman of INEOS, said, "Greensand Carbon Storage is a far better way to decarbonise Europe than deindustrialise. That just moves the problem elsewhere, doesn't solve it, and destroys jobs. Our Investment in Greensand helps secure a sustainable future for both the planet and the economy."

INEOS, the day to day operator, of 'Greensand Future' and its partners, Harbour Energy, and Nordsøfonden will now proceed to safely and permanently store carbon dioxide from Danish emitters in a depleted oil field in the Danish North Sea.

With the aim of initiating storage operations into the INEOS-operated Nini field in the Danish North Sea at the end of 2025/early 2026, 'Greensand Future' will become the EU's first operational CO2 storage facility intended to mitigate climate change. The FID paves the way for expected investments of more than $150m across the Greensand CCS value chain to scale storage capacity.

Greensand Future is a full industrial CCS value chain built on a scalable platform. This platform allows for the gradual expansion of storage capacity as CO2 volumes increase. It is directly applicable to other onshore and offshore storage projects, contributing to the much-needed global acceleration of CCS deployment.

The Greensand Project will have the potential to store up to 8.000.000 tons of CO2 per annum by 2030

Mads Gade, Head of Denmark, INEOS Energy, said, "With Greensand Future and the establishment of the full value chain we are sending an important message to the Danish and European emitters currently considering large-scale capture projects, that it can be done."

Greensand Future aims to capture and store 400.000 tons of CO2 each year as a start allowing for the gradual expansion of storage capacity towards 2030 as CO2 volumes increase with a potential to store up to 8.000.000 tons of CO2 per annum.

The European Commission has estimated that the European Union will need to establish a carbon storage capacity of 250 million tonnes of CO2 per year by 2040 to achieve the objectives of the Paris Agreement. CCS is also considered a key technology in reaching the Danish 2045 net-zero targets.

The CO2 in the first phase of Greensand Future will be captured and liquified at Danish biomethane production plants, transported to the port of Esbjerg, and then shipped by Royal Wagenborg to the Nini field in the Danish North Sea for safe and permanent storage.

More information

www.greensandfuture.com

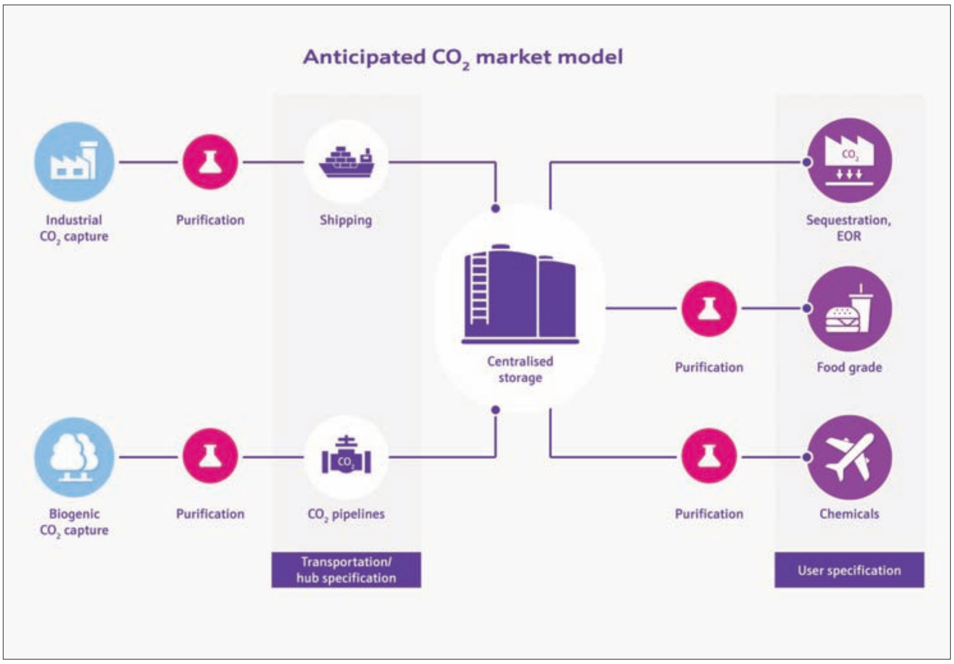
www.ineos.com

Safeguarding offshore CO2 purity: tackling oxygen challenges

A critical aspect of CCUS is maintaining the purity of carbon dioxide streams, particularly for offshore transport. Offshore CO2 transport infrastructure, whether pipeline-based or in liquefied form, faces unique environmental and operational challenges, says Ekaterina Novakova, Business Manager and Global Commercial Lead - Gas Processing, Johnson Matthey.

The global drive to mitigate greenhouse gas emissions has placed CCUS at the forefront of industrial sustainability strategies. The challenges of offshore operations go far beyond those encountered onshore with variable environmental conditions, including high humidity, fluctuating temperatures, and restricted accessibility.

Oxygen impurities pose a significant risk in these systems by reacting with nitrogen and sulphur oxides to form corrosive acids, which can lead to extensive pipeline damage and operational failures. In response to these challenges, catalytic deoxygenation has emerged as a highly efficient and reliable solution to ensure CO2 purity under the rigorous conditions of offshore operations, providing operational flexibility, cost-effectiveness, and ability to function in diverse conditions.



While alternative technologies like chemisorption and cryogenic distillation are technically viable, their high energy consumption and capital requirements often make them impractical for offshore applications. In contrast, catalytic oxidation is not only more efficient but also has a well-established track record of reliability in industrial processes, such as urea production. This experience provides a solid foundation for its adaptation to the unique demands of offshore CO2 conditioning.

CO2 streams derived from various industrial processes such as pre-combustion, post-combustion, and biogenic sources often carry diverse impurities. These impurities, if not properly managed, can compromise downstream transport and storage infrastructure. To mitigate corrosion risks and maintain operational integrity, stringent oxygen limits are enforced: below 10 ppmv for pipeline transport and less than 1 ppmv for liquefied CO2.

Achieving these purity levels is vital for long-term reliability, particularly in remote offshore environments where maintenance and repair operations are costly and logistically complex.

How catalytic deoxygenation works

Catalytic deoxygenation relies on the use of platinum group metal (PGM) catalysts, including platinum and palladium, to promote a chemical reaction between oxygen and hydrogen in CO2 streams. The process converts oxygen into water, a reaction that is both highly efficient and well-understood. Johnson Matthey's PURAVOC BLUE™ catalyst has been specifically engineered for this purpose, offering reliable performance even in the challenging conditions of offshore applications.

The continuous operation of catalytic oxidation provides a significant advantage over batch-based technologies, particularly in offshore environments where interruptions can lead to costly delays. This method also requires lower energy inputs and capital investment, making it an attractive option for operators seeking to optimize both performance and cost-efficiency.

Critical considerations in catalytic deoxygenation

1. Managing water production and dehydration

Water is another key impurity that must be carefully managed to prevent issues in CO_2 transport systems. CO2 streams captured from processes like amine-based units often have high moisture content. Water is also a key byproduct of the catalytic deoxygenation therefore it is advantageous for the offshore operation to integrate the dehydration process downstream to simultaneously remove moisture from both sources

Water is known to block the active sites of PGM catalysts, reducing their efficiency.

Johnson Matthey's PURAVOC BLUE catalysts are designed to operate effectively in high-humidity environments, maintaining performance at temperatures just above the dew point of the gas mixture at the operating pressure. This capability minimizes the need for upstream drying steps, simplifying the overall process and reducing costs.

2. Addressing catalyst poisoning

CO2 streams can contain trace impurities such as sulphur compounds, heavy metals, and other "catalyst poisons," which degrade catalyst performance over time. Proper placement of the catalytic deoxygenation unit within the overall process flow is crucial to mitigate this issue. Positioning the unit downstream of bulk gas conditioning allows many contaminants to be removed before they come into contact with the catalyst, enhancing its durability and effectiveness. Johnson Matthey PURASPEC™ absorbents are proven solutions for sulphur compounds and heavy metals removals and can be integrated with the catalytic deoxygenation technology.

Johnson Matthey also supports sustainable operations through circular PGM management, enabling the recycling of spent catalyst materials. This not only reduces environmental impact but also lowers the total cost of ownership for operators.

3. Adapting to operational variability

Offshore CO2 conditioning systems frequently experience variable flow rates or intermittent operation, often due to fluctuations in CO2 production rates. While catalysts generally perform best under steady-state conditions, PURAVOC BLUE catalysts are specifically engineered for resilience under such variability. Testing has demonstrated that these catalysts can recover full performance after periods of reduced or halted flow, making them ideal for offshore operations where production rates can be inconsistent.

Additionally, the ability to handle flow interruptions without significant performance degradation offers operators greater flexibility in managing their CO2 capture and transport systems. This adaptability is a crucial advantage in dynamic offshore environments.

Economic and environmental benefits of catalytic deoxygenation

In addition to its technical advantages, catalytic deoxygenation provides significant economic and environmental benefits. Its relatively low energy and capital requirements make it a cost-effective choice for oxygen removal compared to chemisorption and cryogenic distillation. Furthermore, the circular management of PGMs supports sustainable operations by enabling the recovery and reuse of valuable catalyst materials, minimizing waste and reducing the overall carbon footprint of the process.

These benefits align with the broader goals of CCUS, which seek to not only reduce greenhouse gas emissions but also promote sustainable and economically viable solutions for industrial decarbonization. By ensuring the long-term reliability and safety of offshore CO2 transport systems, catalytic deoxygenation contributes to the success of these initiatives.

Conclusion

Catalytic deoxygenation is a proven and practical solution for ensuring CO2 purity in offshore applications. By effectively removing oxygen impurities, this technology reduces the risk of corrosion and enhances the reliability of transport infrastructure in challenging offshore environments. Johnson Matthey's PURAVOC BLUE catalysts offer a tailored solution for these demanding conditions, combining robust performance with operational flexibility and sustainability.

As CCUS continues to play a critical role in global efforts to combat climate change, the importance of reliable and efficient oxygen removal technologies will only grow. Catalytic deoxygenation has become a key enabler of safe, long-term offshore CO2 transport and storage, providing operators with the tools they need to meet the challenges of today while preparing for the demands of tomorrow.

About the author

Ekaterina holds the position of Global Commercial Leader - Gas Purification at Johnson Matthey, looking after the catalyst and absorbent solutions for Gas Processing and CO2 Purification. Over the 18 years in the company, she has held market manager and other techno-commercial roles.

More information

https://matthey.com

"A statement of intent" - Johnson Matthey responds to government commitments on CCS

The UK Government has pledged up to £21.7bn in funding for the country's first two major carbon capture and storage clusters – HyNet in Merseyside and the East Coast Cluster on Teesside.

In addition to capturing carbon dioxide from industry, both clusters intend to produce low carbon hydrogen to decarbonise hard-to-abate sectors. Johnson Matthey's Low Carbon Hydrogen Technology is at the heart of both major projects, converting natural gas into hydrogen and leaving the carbon dioxide produced ready for capture and storage.

Maurits van Tol, Chief Executive, Johnson Matthey Catalyst Technologies, said, "Hydrogen will be pivotal in making the energy transition a reality and reaching net zero. This is a real statement of intent and is a huge opportunity for the UK to cut emissions, create quality jobs and become a global exporter of leading technologies."

"Decarbonising heavy industry has to be the starting point on this journey. The Government's funding commitments to these clusters sends a strong signal to investors that they are serious in making the UK a clean energy superpower."

"This is a big step forward in accelerating the UK hydrogen economy and the Government should continue on its twin track approach in the development of both so-called blue and green hydrogen production."

Shipping poised to play vital role in APAC cross-border CCUS initiatives

A joint study by the Global Centre for Maritime Decarbonisation (GCMD) and Boston Consulting Group (BCG) has identified shipping is to play a key role in enabling CCUS initiatives, particularly when there is a large geographical mismatch between potential captured CO2 sources and sequestration hubs.

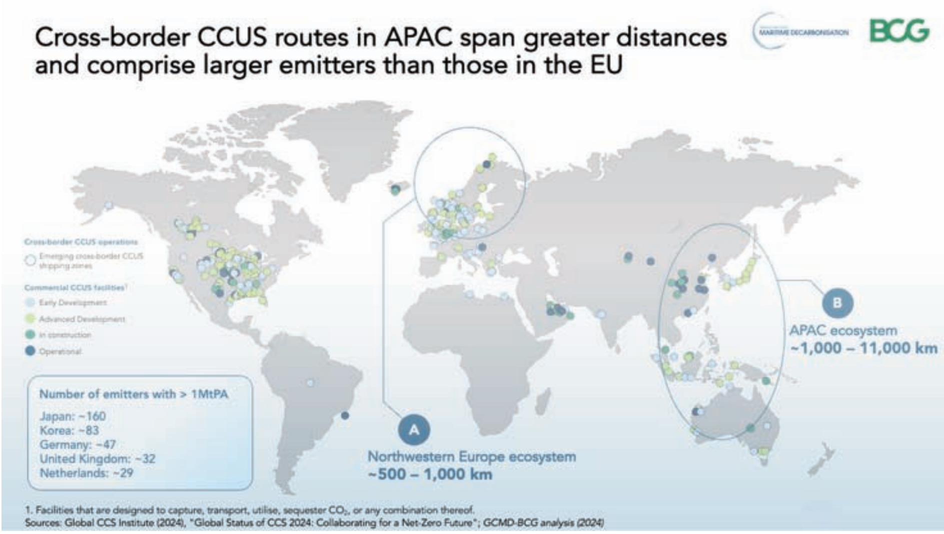
The report, titled “Opportunities for Shipping to Enable Cross-border CCUS Initiatives”, found that shipping CO2 will be especially important in Asia Pacific (APAC) due to the vast oceans and seas that separate emitters and sequestration sites, when compared to Europe.

To address this, several APAC governments, including Australia, Indonesia, Japan, Malaysia, Singapore and South Korea, are pursuing cross-border partnerships and initiatives to support cross-border CO2 transportation and sequestration.

Professor Lynn Loo, CEO, GCMD said, “Our study shows that APAC has the potential to lead in CO2 shipping. In APAC, emitters and sinks are often separated by large bodies of water over vast distances, unlike Northern Europe where CCUS facilities are more geographically concentrated. This makes shipping a more attractive mode of CO2 transport in APAC, underscoring the importance of building up a shipping ecosystem.”

“This effort entails constructing CO2 carriers, developing port-side infrastructure, establishing standards and guidelines for transporting and offloading CO2, and upskilling crew with requisite training. In this context, our earlier study that examined the challenges and opportunities for offloading CO2 provides complementary insights applicable to the downstream stage of the value chain. It’s by piecing all the different parts of the value chain that we can collectively enable cross-border CCUS activities.”

The study estimated that approximately 100 million tons per annum (MtPA) of CO2 captured using carbon capture technologies is expected to be transported across national borders in APAC by 2050. Transporting this annual tonnage would require between 85 to 150 liquefied CO2 carriers of 50 kt capacity where the total investments needed for these vessels by 2050 could reach up to USD 25 billion.



Creating a market of this scale will necessitate concerted efforts from both the public and the private sector, including economic incentives, long-term contracts for midstream players, and greater clarity on key standards.

Shipping CO2 is more economical over long distances compared to pipeline transport

Engaging approximately 60 individuals from 17 industry stakeholder organisations in group workshops and interviews, the study explored scenarios where shipping could play a role in CO2 transport. The study found that shipping becomes economically advantageous compared with pipeline transport of the same amount of CO2 at longer distances. A threshold distance of 500 km was identified to be economically viable for transporting 5 MtPA CO2 transport via shipping.

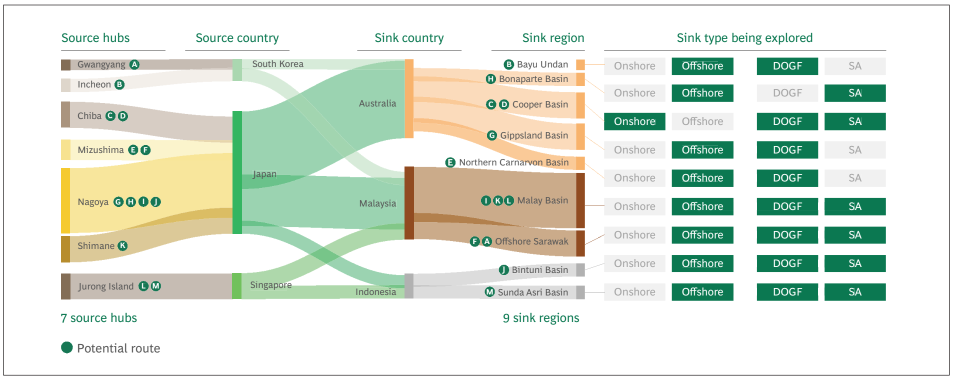
The emerging cross-border CCUS hubs and routes that are aligned with this criteria for CO2 shipping include the Northern Lights project, which spans 500 to 1,000 km; intra-Southeast Asia routes ranging from 450 to 970 km; and the longest routes, Northeast Asia to Australia, which extends from 6,000 to 11,000 km.

Economic and regulatory gaps to address

Several financial and regulatory gaps also need to be addressed before cross-border CCUS materialises.

The investment required to scale up cross-border CCUS, including shipbuilding, port and terminal infrastructure development, is substantial. The end-to-end levelised cost of cross-border CCUS with shipping ranges from USD 141-174 per ton of CO2 for Southeast Asia routes to USD 167-287 per ton of CO2 for Northeast Asia-Australia routes. Capture and shipping costs constitute 60-80% of the estimated total expenses.

A significant gap exists between levelised cross-border CCUS costs and domestic carbon pricing in APAC. Current carbon taxes and emissions trading system prices range from USD 2 to 18 per ton of CO2, representing approximately a ten-fold gap with the range of levelised CCUS costs in this region.



Seven source hubs and nine sink regions could possibly develop by 2030 from announced APAC cross-border CCUS projects

Without additional financial support, the economics of cross-border CCUS could impede its development.

Nascent regulations could also hinder the development of cross-border CCUS in the region. Countries need to establish domestic regulations governing carbon accounting and verification methodologies for CCUS, as well as permitting procedures for cross-border CCUS projects. Additionally, bilateral and multilateral frameworks are required to clarify jurisdictional authority for cross-border projects and allocate commercial and operational liabilities for CO2 leaks during transport across the value chain. Establishing these regulations and frameworks can provide greater certainty for project developers, mitigating policy risks and supporting CCUS projects and offtake agreements.

Greater harmonisation of CO2 shipping technical standards needed

To stimulate cross-border CCUS investment, stakeholders need clear technical specifications for CO2 pressure, temperature, and purity, as these have significant cost, operational, and safety implications.

While shipping CO2 under low pressure may offer economic benefits, such as increased vessel capacity and lower capital expenditure, it is operationally disadvantaged because storing CO2 at such conditions, which are closer to the triple point will increase the risk of dry ice formation.

Impurities in CO2 may also have implications on infrastructure buildout. The purification process to remove impurities can be costly, presenting a trade-off for companies who must decide between the cost of purification and the risk of accommodating impurities impacting the infrastructure system.

CO2 purity specifications and responsibility for purification need to be aligned within a project's value chain from capture to sequestration, to provide clarity and interoperability among participants along the value chain.

In APAC, the prevalence of sizeable emitters (defined as > 1 MtPA CO2 emitted) reduces the need to aggregate captured CO2 from different emitters. This opens the possibility of relaxing impurity thresholds compared to open-source models, which are more prevalent in Europe, that need to maintain more stringent CO2 purity specifications to accommodate the aggregation of captured CO2 from a diverse set of emitters.

Enabling factors for shipping in CCUS initiatives

The study identified three components that governments and private sector players must provide to activate the shipping industry for cross-border CCUS.

Direct economic support: Governments can extend economic assistance to midstream players, such as shipping and port providers, through financial incentives and new business models. These measures can reduce upfront capital expenditure and overall project costs, making cross-border CO2 shipping more viable.

Long-term contracts and minimum volume guarantees: Emitters need to provide long-term contracts to shipping and terminal providers – ideally 10 years or more – and commit to transporting a minimum volume of CO2. This will give value chain participants greater certainty for planning and obtaining necessary financing for investments in vessels and terminal capacity.

Clarity on standards and specifications for shipping: Shipping providers need clear regulations and guidelines on the standards governing tolerance limits for impurities in CO2 cargo, operating pressures, and temperatures along the value chain. Early alignment on specifications will enable midstream players to develop interoperable infrastructure.

Simultaneous development of all value chain elements

The success of CCUS hinges on the simultaneous development of all parts of its value chain, including midstream activities like shipping and intermediate storage. By collaborating and addressing the challenges identified in this study, both public and private stakeholders can successfully develop the full CCUS value chain, unlocking the decarbonisation opportunities offered by this solution.

Carl Clayton, Partner & Associate Director, Global Co-Lead for BCG's CCUS Topic said, "The unique distribution of large emitters and sequestration sites across APAC offers significant opportunities for CO2 shipping and cross-border CCUS. Northeast Asian emitting countries have a chance to drive technological innovation and strengthen their leadership in commodity shipping, while Southeast Asia and Australia can utilise their vast depleted oil and gas and other storage assets, to foster green economy growth and international collaboration."

"Government support will be essential in the short term to ensure economic viability and to address cross value chain risks. Additionally, the industry must align on technical specifications, including CO2 pressure, temperature, and purity specifications, to enable seamless operations and infrastructure interoperability."

The research was a collaboration between GCMD and BCG. GCMD and BCG engaged with approximately 60 individuals from 17 industry stakeholder organizations when developing the report. This included more than ten hours of group workshops and 16 interviews.

More information

https://gcformd.org

www.bcg.com

Longship: potential for cost reductions in the CCS chain

Longship provides valuable insights into cost drivers and opportunities for cost reductions in CCS chains. Gassnova shares findings from the project.

Gassnova's expertise has accumulated detailed and unique knowledge about Longship over several years – from the early phases, through FEED (Front-End Engineering and Design), to the construction phase and follow-up with Heidelberg Materials and Northern Lights.

In November 2024, the government proposed continuing Hafslund Celsio's capture project at Klemetsrud in Oslo, with increased state support of NOK 4.4 billion (2024 currency). This came after the project had entered a cost-reduction phase and was put on hold.

Cost Reductions

Uncovering cost drivers and identifying opportunities for cost reductions in the Longship value chain, is crucial. Based on this premise, Gassnova's experts have conducted analyses that can help establish correct priorities and directions for further research, development, and innovation in the CCS industry. The goal is to achieve more cost-effective CCS solutions.

Longship is an extensive CCS project covering the entire value chain from capture to permanent storage. The first phase will capture 400,000 tons of CO2 annually from Heidelberg Materials' cement production facility in Brevik. The liquid CO2 is then transported by ship to Northern Lights' interim storage facility in Øygarden, before being permanently stored in the North Sea, 2,500 meters below the seabed.

The project has faced economic challenges, including a 20% increase in capital expenditures (CAPEX) during the construction phase. Some contributing factors include significant global price increases, such as for essential raw materials like steel, during the COVID-19 pandemic and the war in Ukraine.

Cost Drivers: There is substantial potential for cost reductions in several areas, particularly in improving technological maturity, regulatory readiness, and CCS-adapted industrial practices. In Longship's CCS value chain, the largest costs are associated with capture, compression & intermediate storage, and the development of the CO2 hub.

Abatement Costs: These have risen by 15% since KS-2. KS-2 was the "final check" before the investment decision and the start of the project implementation. Abatement costs compare the net present value of investment and operating expenses, with the amount of CO2 captured and stored over 25 years of operation.

At KS-2, the abatement cost for Brevik CCS was calculated at NOK 842 per ton of CO2 (2020 currency). Updated estimates for investment and operating expenses have increased this to NOK 965 per ton of CO2 (2020 currency). Adjusted to today's currency value (2024), this equals approximately NOK 1,150 per ton of CO2.

Cost Drivers

In some areas, land-based industrial practices were used, often involving local contractors experienced in land-based projects. This limits the potential for further cost reductions. In other parts of the project, methodologies and standards from the offshore oil and gas industry were applied.

These standards can be unnecessarily extensive for land-based industries, leading to solutions and material choices that are overly expensive. This highlights the need for a better approach to reduce costs without compromising safety and quality.

Regulations present another challenge. Current regulatory frameworks are immature from a CCS perspective, particularly regarding the storage segment. Longship's experiences may contribute to the development of a more adapted regulatory regime, leading to cost reductions in future projects.

The use of standards and established industrial practices in Longship reveals significant variations throughout the CCS chain. Technological maturity is a critical factor, especially concerning integration with emission sources and the capture process. Several solutions are being tested at full scale for the first time, which introduces substantial uncertainty. The supplier market primarily consists of a few players with backgrounds in the oil and gas industry.

To reduce costs, it is necessary to strengthen the market with knowledge and experience from land-based industries.

Economic Viability

"Longship contributes to a deeper understanding of cost drivers in the CCS chain, and Gassnova identifies opportunities for significant cost reductions. We have pinpointed cost-intensive areas in the CCS chain and matched them with various cost drivers – where technological maturity, regulatory readiness, and CCS-adapted industrial practices stand out as areas with the greatest savings potential."

"With comprehensive analyses like this, Gassnova can help make CCS projects more economically viable. This is a prerequisite for achieving significant reductions in global carbon emissions," said Senior Advisor Ingrid Sørum Melaaen.

Ingrid leads the Gassnova project analysing cost-reduction measures in the CCS value chain, based on extensive data from the development of Longship. This work will continue in 2025.

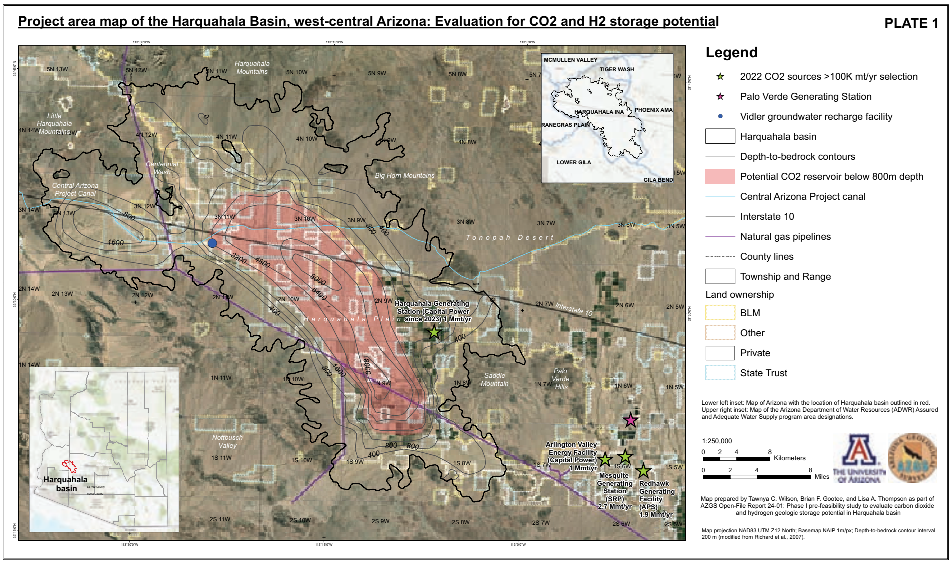
More information

www.ccsnorway.com

www.gassnova.no

University to lead $12M study on underground carbon storage in Arizona

The Arizona Geological Survey at the University of Arizona is leading a $12 million feasibility study to explore carbon dioxide storage in the deep subsurface of the Harquahala basin, approximately 60 miles west of Phoenix.



A pre-feasibility study found Harquahala has thick accumulations of basin fill sediments with sufficient volumes for storage of supercritical CO2

The feasibility study, funded by the Department of Energy's National Energy Technology Laboratory, is part of a broader national effort to characterise geologic locations suitable for carbon dioxide storage in the United States.

Set to begin in March, the CarbonSAFE II project could lead to a reduction of Arizona's overall carbon emissions by 25% in the next 40 years.

The project brings together experts from the University of Arizona, the New Mexico Institute of Mining and Technology, the University of Utah, and Los Alamos National Laboratory, with the U of A receiving $9 million of the funding. Their research will examine sedimentary and volcanic rocks in the Harquahala basin, which shows promising characteristics for carbon dioxide storage.

The Arizona Geological Survey – based at the U of A – will lead the project's technical evaluation and data integration efforts, and the university's Office of Societal Impact will evaluate community impacts and benefits.

The U of A researchers believe that rocks more than 5,000 feet beneath the ground have suitable permeability and porosity for carbon dioxide storage The team's selection of the Harquahala basin site was informed by a pre-feasibility study completed earlier this year, which indicated the basin's potential for carbon storage.

"This particular location is advantageous due to multiple factors," said Tawnya Wilson, a research scientist at the Arizona Geological Survey, who is serving as project co-principal investigator alongside principal investigator Brian Gootee, senior research geologist at the Arizona Geological Survey.

"There are promising rock formations at depth," Wilson said. "The storage site is in close proximity to nearby power generating stations that emit carbon dioxide. There is access to the Interstate I-10 transportation corridor with existing pipeline infrastructure. There is likely a large volume of saline groundwater, and there is a very low risk of earthquakes."

The project builds upon nearly 15 years of carbon sequestration research at the Arizona Geological Survey, including participation in previous Department of Energy regional initiatives. Recently, the project team conducted preliminary research through the Carbon Utilization and Storage Partnership, a multistate coalition involving three national laboratories, geological surveys and universities across 14 Western states.

The CarbonSAFE II project will use well drilling and advanced geological investigation methods, including 2D seismic imaging – a technology that uses sound waves to create detailed pictures of underground rock layers – to assess the basin's carbon dioxide storage potential and build a 3D geological reservoir model to track the size and position of the carbon dioxide plume over time.

The project will also examine potential risks of underground storage in the area.

"This comprehensive data collection will help us determine if this site is suitable for long-term carbon storage and support our efforts to meet the government's 2050 carbon emission reduction goals," Wilson said.

Based on the existing carbon dioxide source emitters nearby, about 50 million metric tons of carbon dioxide could be captured and stored over 30 years. This would reduce Arizona's carbon emissions by 25% over that time period, Wilson said.

More information

www.arizona.edu

https://azgs.arizona.edu

Transport and storage news

Two new licences for CO2 storage on the Norwegian continental shelf

www.sodir.no

The Norwegian Ministry of Energy has awarded two new exploration licences for CO2 storage in the North Sea.

One of the licences is offered to a group consisting of Harbour Energy Norge AS (operator) and Equinor Low Carbon Solution AS, the other licence is offered to a group consisting of Equinor Low Carbon Solution AS (operator) and Aker BP ASA.

'Norway has a unique opportunity to take a leading role in large-scale commercial CO2 storage in Europe. The government is committed to making CO2 storage a profitable and sustainable industry in Norway. Today's awards are an important step in ensuring that the entire value chain is in place, so that our ambitious plans can be realised,' said Minister of Energy Terje Aasland.

The permits are offered with a binding work programme, with built-in milestones to ensure efficient progress, or relinquishment of the acreage if the licensees do not complete the storage project.

'These exploration licences are offered to companies that have presented good plans for the development of CO2 storage. A number of players in the industry have shown interest in new storage areas. This makes me optimistic about further progress in the work to make CO2 storage part of the solution to the world's climate challenge,' said Aasland.

DNV certifies first CO2 storage site in the Middle East for ADNOC

www.dnv.com
www.adnoc.com

DNV has certified the feasibility of ADNOC's West Aquifer CO2 storage site in the UAE, marking a significant milestone in the Middle East's CCS efforts.

This certification supports the decarbonisation of the Ruwais industrial site and forms a key part of ADNOC's broader CCS ambitions, which align with the UAE's strategy to reach Net Zero by 2050.

The issuance of the Certificate of Feasibility for the West Aquifer project covers the initial subsurface assessments of the Simsima and UER saline reservoirs. The project, guided by DNV-SE-0473, which is based on the ISO 27914 standard, is a vital first step in verifying long-term CO2 storage feasibility.

Santiago Blanco, Executive Vice President & Regional Director Southern Europe, Middle East, Latin America and Africa, Energy Systems at DNV, commented, "Certifying the West Aquifer CO2 storage site is an important milestone, not just for ADNOC but for the region's commitment to addressing climate challenges. This project serves as a tangible step toward meeting the UAE's Net Zero goals and highlights the vital role that CCS will play in shaping a sustainable energy future."

Langh Tech launches innovative onboard carbon capture

www.langhtech.com

A unique feature of the system is the possibility to sell and use the sodium carbonate, which results at the end of the chemical process, for diverse applications in other industries.

Finnish tech company Langh Tech has expanded its portfolio of exhaust gas treatment solutions with an innovative system for onboard carbon capture (OCC). The solution combines the environmental benefits of decarbonisation with creating additional value by selling and using the waste product, which marks a significant contribution to creating a circular economy.

A pilot project with an OCC installation onboard one ship of sister company Langh Ship was successfully run in test-mode during 2024. The pilot plant has shown that it is possible to capture rates over 80 percent from the exhaust gas flow coming into the system. The overall CO2-emissions can be reduced at least by 20 to 30 percent, depending on the available space, and other ship and product specifications.

The first commercial installations will take place early in 2025 onboard of four bulk carriers. Langh Tech has sold the OCC components to Damen Shipyards Group, who will do the installation on the bulk carriers. The ships will be equipped with a hybrid scrubber and an additional onboard carbon capture system from Langh Tech.

Rutger van Dam, Business Development Manager of Damen Shipyards Group explained, "The decision to choose Langh Tech was simple. CO2 capturing is the only economic way to drastically reduce emissions as of now. My main concern was the value of the CO2 end product being created onboard the ship. Langh Tech delivered on every front: a high capture rate, a high-value CO2 end product, and a significant reduction in emissions. From a commercial perspective, it made perfect sense. On a personal note, we share the same vision and goal: to greenify the global fleet. That alignment made Langh Tech the natural choice."

The installations by Langh Tech are part of a project between Atal Solutions, BAM Shipping and Damen Shipyards Group. It aims at retrofitting ships with different technologies and to reduce fuel consumption to achieve a maximum reduction in CO2, SOx, and NOx emissions, while using traditional fuels. The ultimate project goal is to bring CO2 emissions down by up to 60 percent with onboard carbon capture. This could be achieved through the continuous development of the system itself, as well as optimizing other limiting factors, such as installation size and onboard space, ship efficiency, loading and operations, or voyage planning.

"Our onboard carbon capture solution gives shipowners and operators the possibility to decarbonize and balance their costs. The scarcity and significantly higher costs of carbon-neutral fuels are a substantial hurdle to the decarbonisation of shipping. It will take time until those fuels can be widely used and afforded. We are here to bridge this gap and help companies to decarbonize efficiently and according to their abilities", said Laura Langh-Lagerlöf, Commercial Director of Langh Tech.

"At the same time, it is important to emphasize that the captured CO2 can also be used in the production of biofuels and synthetic fuels. Thus, our technology – if applied smartly – contributes to a green-fuel transition by setting up a circular economy."

Throughout the whole development process Langh Tech followed a circular approach.

Greensand Project to be first full scale CO2 storage facility in EU

Image: INEOS