Carbon Capture Journal

2023 and UK

COP 28 and keeping 1.5 alive

UK 'CCUS Vision' to develop a competitive carbon market

CCSA London: UK progress and perspectives

Jan / Feb 2024 Issue 97

Statera Energy first customer for H2NorthEast Teesside blue hydrogen project

Image: Statera Energy

Increasing the viability of CCS hubs - Paul Wann, Emerson

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How the EU can achieve its decarbonisation potential - Madhav Desai, KBR

Northern Lights value chain provides 97% net CO2 abatement

CCUS Forum 2023 – stocktake & where to go from here?

In light of the European momentum for CCS as a decarbonisation pathway, there has been an observed shift in the discourse and discussion surrounding it, says Bellona, that is now focused firmly on working out the details of how to create an optimal environment – regulatory, economic, as well as in terms of a collaborative infrastructure – to achieve the rapid deployment we need for reaching 2050 climate goals.

The third annual edition of the CCUS Forum was organised in Aalborg on the 27th and 28th of November reports Bellona. The forum was organised by the European Commission together with the Danish Ministry of Climate, Energy, and Utilities.

While some were disappointed that the planned publication of the Industrial Carbon Management Strategy (ICMS) was pushed from during the forum to early next year, the forum provided an opportunity to contribute to and highlight what should be part of the ICMS.

During the forum it was apparent that there is ongoing coordination between several Member State governments and the European Commission on CCS, as exemplified also by the European Commission's recommendation to establish the role of CCS in Member States' decarbonisation strategies in their National Energy and Climate Plans.

Several big announcements were made at the CCUS Forum 2023:

• The Aalborg Declaration was drawn up and signed by Denmark, France, Germany, the Netherlands, and Sweden – recognising the role of CCS in achieving emission reductions in hard-to-abate sectors. The declaration also recognized that cross-border cooperation is essential to meet this shared goal. The declaration is of particularly significance as it seeks to firmly dispel any notion and prevent that CCS is to be applied to prolong the fossil fuel age.

• The Project of Common Interest status was awarded to 14 CO2 transport and storage projects across Europe from the 1st Union list of candidate projects. These projects, in addition to facing fewer administrative hurdles and benefitting from faster permitting procedures, can now apply for funding from the Connecting Europe Facility (CEF) that has a ~ 480 million EUR budget earmarked for CCS projects.

An Industrial Carbon Management Knowledge Sharing Network will be established, to function as a knowledge sharing platform for CCS and CCU projects supported by the EU. More on the mission and structure of the Network will be published in the upcoming ICMS.

• A CCS Observatory will start its work next year, monitoring, reporting, and verifying the CO2 captured from two harder-to-abate industries: cement and waste incineration.

The discussions at the Forum centred around a number of key topics: market development and the commercialisation of CCS technologies, the role of national governments and the EU, CO2 transport and storage development, as well as public perception and community engagement. Different approaches to evolve carbon markets to self-sufficiency were highlighted.

Mechanisms ranged from subsidy schemes in the Netherlands, tax credits in the United States to direct funding in Denmark. Whichever shape it takes, one thing was made clear: public support is indispensable to stimulate innovation and achieve economies of scale, which in return drive down costs of technologies and kick-start carbon markets.

There is a clear case for public support of CO2 infrastructure, given significant upfront costs, and the lack of a sufficient business case due to inadequately priced CO2 emissions. Public support should serve to mitigate investment risks until a market can function on its own and should ensure public oversight in line with public interests. It is evident from the discussions of the forum, that CCS stakeholders view targets as crucial, providing clear investment horizons which accelerate CCS deployment throughout Europe.

Due to geographic dispersity in location of storage sites and emitters, CCS carries with it a cross-border characteristic in a European context. As such, there is a need for collaboration among CCS stakeholders across Europe. The European Commission was during the forum identified as the best positioned to provide a platform for such collaboration. As well as to coordinate among market players and stakeholders, bringing together emitters, transmission system operators, and storage capacity developers/providers.

The establishment of a robust legal framework was highlighted as a crucial factor in instilling market confidence and ensuring a timely roll-out of CCS initiatives and projects. Given that such a framework must be harmonised among Member States, it falls upon the EU to regulate and set the standards for a CO2 transport infrastructure – a piece of legislation many CCS stakeholders took the opportunity to call for. The upcoming ICMS will hopefully provide clarity on the expected timeline for this regulatory framework.

While the need for such a market legislation is evident, there was also a notable emphasis on the importance of legislators avoiding excessive regulation that could hinder market development. Instead, the recommendation is to establish a flexible framework that offers clarity to the market. As far as CO2 transport infrastructure development goes, the objective should be to 'oversize' it initially, capitalizing on economies of scale to make it more cost-effective in the long run. The most optimal location for the development of this infrastructure within the EU was modelled and presented and will be further refined by the European Commission's Joint Research Center.

Public perception was as a recurring theme not only in the one dedicated panel to this topic. It was stressed that even if other challenges in CCS deployment are effectively addressed, a negative public perception could ultimately undermine CCS projects.

More information

Read more at:

eu.bellona.org

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Front cover: Statera Energy's Saltholme Operations on Teesside – Kellas will supply low carbon blue hydrogen to decarbonise Statera's operations (pg. 6)

Back cover: a study has demonstrated that the Northern Lights CCS value chain is a viable concept and an efficient climate solution for transport and storage of CO2 (pg. 32)

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Leaders - CCUS in 2023 and progress in the UK

Projects and policy

Capture and utilisation

Transport and storage

What was achieved in 2023?

CCS saw another year of expansive growth according to the Global CCS Institute's flagship Global Status of CCS Report, which showed a significant surge in CCS projects across the globe with 198 new facilities added to the project pipeline – a 102% increase. However not enough progress is being made in the development of geological storage capacity to meet future demand. www.globalccsinstitute.com

In terms of both facility numbers and carbon dioxide capture capacity, the project pipeline for CCS is at an all-time high. The 41 CCS projects in operation now have an annual CO2 capture capacity of 49 million tonnes per annum (Mtpa). Meanwhile, the total project pipeline capacity has expanded to 361 Mtpa of CO2, a 50% increase from 2022 – the highest jump since 2018.

The Global CCS Institute's CEO, Jarad Daniels remarked on this progress saying: "The climate math is clear, carbon capture and storage (CCS) is an essential climate mitigation technology, without which it would be virtually impossible to achieve net-zero emission targets. However, the math also indicates that this past year's impressive step-up still has us near the bottom of the staircase, so to speak, and that CCS must reach gigatonne per annum (Gtpa) scale in order to reach our emission goals."

Authoritative analysis by the Intergovernmental Panel on Climate Change, the International Energy Agency, and others, consistently indicates that achieving global climate targets will require annual CO2 storage rates of approximately 1 Gtpa by 2030 and multiple Gtpa by 2050.

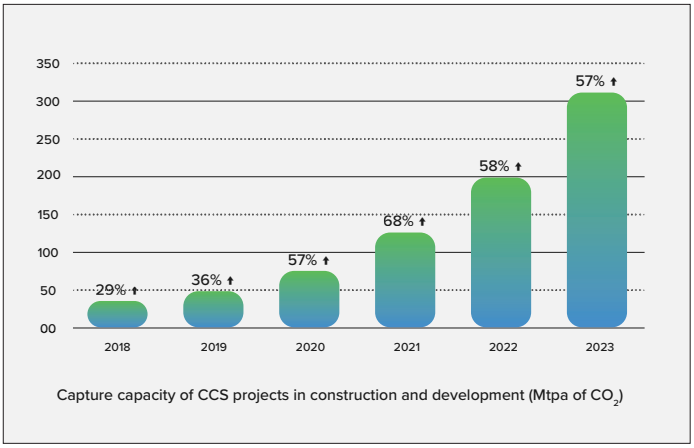
"Policy makers, industry leaders, investors and the general public, are all feeling a growing urgency to address climate change, and that is accelerating many forms of mitigation, including CCS deployment, in leading regions around the globe. However, to meet our climate change mitigation targets global investment in CCS deployment this decade must grow even faster," said Mr. Daniels.

Other key takeaways from the Global Status of CCS 2023 report include:

• As of 31 July 2023, there are 41 commercial-scale CCS facilities in operation, 26 facilities in construction and 325 in various stages of development.

• Between 2022 and 2023, 11 new countries registered CCS facilities in various stages of development.

• The US still dominates CCS deployment, with 73 new facilities entering the pipeline in 2023. The UK, Canada and China increased their facility counts and remained in the top five CCS deployment countries. Australia now has 12 facilities in development.



CCS project capacity grew 50% year on year since 2020

• CCS deployment through networks has become the dominant pathway as networks deliver both economies of scale that reduce cost and business model synergies that reduce risk. The ongoing development of CCS networks has resulted in a new industry category of "CO2 transport and storage" facilities in the Institute's dataset. In 2023, 101 of these facilities were identified globally.

• CCS is also becoming a more prominent feature of public policy, from inclusion in 27 countries' Nationally Determined Contributions (NDCs) to the provision of targeted policy to drive deployment and the drafting of appropriate regulations.

• CCS financing prospects have improved substantially in the past year in key jurisdictions due to increased policy support and other factors, including price signals, and there is every indication that the momentum will continue. This has precipitated a substantial increase in CCS investment, mostly in equity funding.

Scaling up through 2030

The report found that CCS is beginning to scale up. The year-on-year growth of the combined capacity of CCS projects in construction or development has exceeded 50% since 2020.

Significant policy incentives and targets have been created over the past few years that have driven unprecedented growth in the CCS project pipeline, mostly in North America and Europe.

Meeting the goals of the Paris Agreement will require a monumental policy effort across all jurisdictions. Policies similar to those driving investment in CCS in North America and Europe will need to become commonplace around the world, including the global south.

To achieve the rates of deployment needed, ensuring continued growth of the facility development pipeline, efficient progress to final investment decision (FID), and on-time construction and start-up are critical.

The rate of development of geological storage resources is also not keeping pace with potential future demand, even in leading jurisdictions and especially in Europe. Unless dedicated programs are put in place to identify and appraise geological storage, sufficient capacity may not be available when required.

Keeping 1.5 Alive – by Ruth Herbert, Chief Executive, CCSA

Ruth Herbert gives her views and impressions of progress at the COP 28 meeting, where the crucial role of CCUS as a key technology to mitigate climate change was recognised. www.ccsassociation.org

Attending my third Conference of the Parties since joining the Carbon Capture and Storage Association, I felt that familiar pang of excitement tinged with dread. Would this COP deliver real progress, what would be announced on carbon management, would the debate on fossil fuels be all-consuming, what would be the outcome of the global stocktake and would it lead to further action, and what does 70,000 people even look like?

Compared to previous years it felt bigger than ever, but when you consider the scale of what we need to achieve to decarbonise the lives of over 8 billion people living on this planet, delegates are a fairly small contingent (less than one thousandth of a percent of the world's population) and the clear message from the outset is that collaboration is essential if we are to achieve the Paris goal of limiting warming to 1.5 degrees (or "North Star" in COP-speak).

Although there had been a lot of debate about the role of business at COPs, I was buoyed by the messaging from Christiana Figueres in her recent podcast that the time for negotiating is drawing to a close and it is time to move into implementation. Implementation is definitely what business is interested in.

Moving into delivery

The past year has seen CCUS move into the delivery phase around the world. Many who follow this topic will be aware that in Europe, Norway has almost finished building its flagship Northern Lights facility, which will be ready to store CO2 from next year. With the capture on a cement plant in Brevik, Norway, close to completion and the Final Investment Decision on the Porthos Cluster in Rotterdam taken just over a month ago, Europe's first-mover full-scale CCS projects are underway, providing confidence to rest of the industry.

In the US, hundreds of projects are moving forward on the back of the tax credits available under the Inflation Reduction Act. What was striking at COP, however, was how much CCUS China is building and how many developing countries are putting together deployment plans, having included CCUS in their NDCs. This was evident from pavilion agendas, many of which featured CCUS side events, as well as the traffic to our booth, where many officials from the global south discussed their plans for CCUS, driven by their desire to continue to industrialise whilst they also decarbonise.

Carbon Management Challenge

It was no surprise then that the Presidency Roundtable on the Carbon Management Challenge, chaired by James Mwangi, included five new joiners to the initiative, Iceland, Kenya, Mozambique, Netherlands and Senegal, who joined existing members Australia, Brazil, Canada, Denmark, Egypt, European Commission, Indonesia, Japan, Saudi Arabia, Norway, Romania, Sweden, UAE, UK and US.

Fatih Birol set the scene by saying that fossils fuels would need to be phased out and the purpose of the Challenge was to urgently deal with the emissions sources we have today. This was an important moment and a narrative echoed by several countries in their national statements, that CCUS should be prioritised on hard-to-abate sectors.

This chimed with the prior announcement on the same day of a demand-side policy from the governments of Canada, Germany, UK and US, who pledged to procure low emissions steel, cement and concrete – a policy move that, if followed by others, could really start to drive the business case for industrial CCS. US Climate Envoy John Kerry and Chinese Climate Envoy Xie both referred to the Sunnylands agreement on 14 November between President Biden and President Xi Jinping, where both countries had committed to advance at least five large-scale CCUS projects each by 2030.

However, the big news announced at the CMC Roundtable was the call to action – a new commitment by member countries to collectively aim to capture and store carbon dioxide at gigatonne scale per annum by 2030. That's a billion tonnes a year. To put this in context, the Brevik plant aims to capture around 800,000 tonnes per annum, so 0.08% of the target.

Netherlands stated that they were already well on the way to contributing 2.5Mtpa, a quarter of a percent of the target. The UK's four CCUS clusters, which the government hopes will deliver up to 30 million tonnes a year by 2030, would contribute just 3% of the goal. We heard about many plans from member countries, but it was clear that current commitments would fall short of 1 GT and developing countries would want support on costs to deliver projects.

No time to waste...

So my take away was that the Challenge is going to need more members or to step up existing national plans significantly. The good news is that China and Bahrain both made supportive statements during the roundtable and Netherlands suggested that other EU countries were likely to join going forward. For an initiative like this to launch in week 1, amidst all the tension of the debate on fossil fuels, looked like an impressive achievement for the Presidency and the secretariat of the Clean Energy Ministerial.

As an observer in the room representing CCUS businesses, it was clear to me that we were all going to be very busy indeed with projects, whilst at the same time needing to support regulatory, planning and incentive frameworks in countries that are starting out on this journey. A key pillar of the CMC, alongside putting in place national targets and policies, is participating in multilateral initiatives with other countries to share knowledge so we can all move quicker. It's clear there's no time to waste – we now need to implement.

enfinium to invest up to £800mn in CCS at Ferrybridge

Operational from 2030 the plant would remove over 600,000 tonnes of carbon dioxide from the atmosphere and generate over 90 MW of baseload carbon negative power.

With plans to be operational from 2030, the project would provide the UK with vital carbon removals by decarbonising unrecyclable waste.

Mike Maudsley, CEO of enfinium, said, "To deliver a net zero carbon economy, the UK needs to find a way to produce carbon removals, or negative emissions, at scale. Installing carbon capture at our Ferrybridge site would make it one of Europe's biggest carbon removal projects. All this while decarbonising unrecyclable waste, diverting it from climate-damaging landfill, and supporting the green economy in West Yorkshire and the wider community."

The technology will be installed at enfinium's Ferrybridge 1 and 2 facility in Knottingley, West Yorkshire. Once operational, it would capture around 1.2 million tonnes of carbon dioxide every year, including over 600,000 tonnes of carbon removals – equivalent to taking the carbon emissions of every household in Manchester out of the atmosphere.

The Climate Change Committee's Carbon Budgets make clear that the UK needs to deliver carbon removals to achieve a Net Zero economy. Around 50% of the unrecyclable waste produced by society is made up of biogenic content including organic material such as waste food, plants and paper, which has already naturally absorbed CO2 from the atmosphere.

Installing CCS technology at an energy from waste facility enables this CO2 to be permanently captured and stored rather than released back into the atmosphere, resulting in a net carbon removal from the atmosphere or 'negative emissions'.

With CCS installed, Ferrybridge, the UK's largest energy from waste site, would become one of the largest carbon removal projects in Europe, accelerate regional decarbonisation in West Yorkshire and support over 200 jobs across the supply chain during the development phase.

Despite progress in reducing waste and increasing recycling, the UK will continue to produce around 17 million tonnes of unrecyclable waste by 2042. enfinium's Ferrybridge site currently diverts up to 1.45 million tonnes of unrecyclable waste from climate damaging landfill. As recognised by the UK's National Infrastructure Commission, emissions from energy from waste plants are lower per tonne of waste compared to landfill.

The proposals will be put forward for grant support from the UK Government as part of their expansion of the Track-1 cluster sequencing process, due to launch this month. Planning and consenting for the site will move forward in 2024. This is the first step in enfinium's decarbonisation plans.

Olivia Powis, UK Director of the Carbon Capture and Storage Association, commented, "enfinium's planned £800 million investment in CCS at Ferrybridge marks a critical milestone for carbon removal and clean power. For the UK to host one of Europe's largest carbon removal projects, it demonstrates we are really leading the way in our journey towards a net zero future."

More information

www.enfinium.co.uk

UK sets out plan for competitive carbon capture market

The CCUS Vision sets out plans for a new competitive market in CCUS by 2035 to unlock investment and drive economic growth, adding a potential £5 billion to the economy by 2050.

The plan sets out how the UK will transition from early projects backed by government support to becoming a competitive market in this area by 2035, meaning UK companies will compete to build carbon capture facilities and sell their services to the world.

The UK holds a strategic advantage compared to other countries thanks to its unique geology, skills and infrastructure as an island nation. It also offers enough space under the North Sea for up to 78 billion tonnes of CO2.

This is the latest step in delivering a recently announced £20 billion investment to develop CCUS technologies – which aims to store 20-30 million tonnes of CO2 per year by 2030 and support 50,000 jobs by 2030.

Key updates in the announcement were:

• Invitation for expressions of interest for Track-1 cluster expansion in the Hynet cluster

• Agreed commercial terms with the Northern Endurance Partnership

• A streamlined process for Track-2 cluster anchor projects to deploy from 2028-2029

• Competitive allocation process for carbon capture projects from 2027

• Plans to enable CO2 transport by ship, road and rail and support longer term cross border CO2 transport

• Details on the proposed commercial frameworks and alignment of the GGR and Power BECCS Business Models, alongside indicative Heads of Terms

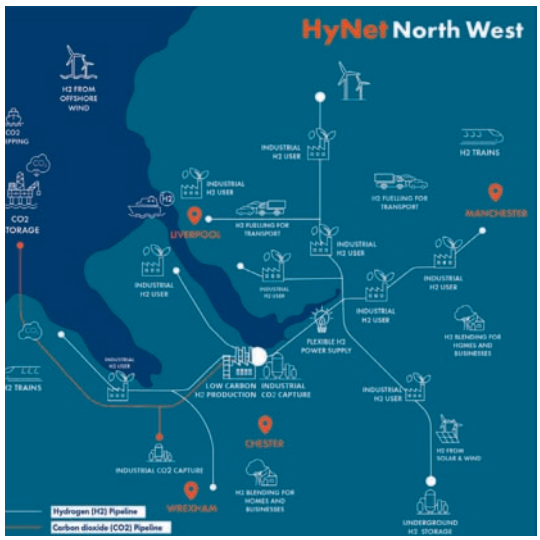
• An industry led working group to look into further reduction of capture costs will be established.

David Parkin, HyNet Project Director, Progressive Energy, said, “We very much welcome Government’s announcement on HyNet Track 1 expansion. This will provide further opportunity for industrial decarbonisation in the North West region, while optimising value for money for the taxpayer by maximising use of the HyNet assets.”

“More broadly, the CCUS Vision help sets a roadmap for longer term expansion of carbon storage, enabling a much broader range of industries across the region to decarbonise and open up storage opportunities across the Irish Sea.”

“This will enable vital industries, such as the cement and lime sector in the Peak District, to decarbonise through CCS in the medium term.”

Ruth Herbert, CEO, Carbon Capture and Storage Association, commented, "We welcome the CCUS Vision published today, setting out a long-term strategy for the UK’s CCUS industry to be able to store over 50Mt a year by 2035 to support the decarbonisation of domestic industries and take advantage of export opportunities."



The Government has invited more companies to connect to and expand the HyNet Cluster

"It is great to see CO2 transport by ship, road and rail will be enabled from 2025 onwards, which will also support longer-term cross-border CO2 transport solutions."

"The CCSA Delivery Plan detailed a development pipeline of over 90 carbon capture projects. Those project leaders will welcome the commitment to allocation rounds from 2027, provided they are of sufficient frequency and volume to unlock continued investment. We look forward to building on this pipeline through the proposed industry working group."

“Investors need to see accelerated progress on the first four CCUS clusters. Today's other announcement, inviting expressions of interest for Track-1 cluster expansion in the HyNet cluster is very welcome, along with the government’s agreement of Heads of Terms with the East Coast Cluster (ECC).”

“It is also good to see a more streamlined process for selecting Track-2 cluster capture projects. Projects on the East Coast will need more clarity on the timescales going forward for both Tracks if we are to meet the UK’s 2030 target to reach 20-30Mtpa by 2030.”

APPG CCUS Chair Alex Cunningham MP, commented, "As Chair of the All-Party Parliamentary Group on Carbon Capture, Utilisation and Storage I welcome the CCUS Vision published today. It’s not before time that a long-term strategy for CCUS has been published by the Government and I hope it provides clarity to industry, moves us closer to our Net Zero targets, and supports job creation in places like Teesside."

"The devil is always in the detail however and it is disappointing that Ministers have chosen to announce this now Parliament is in Recess as there is no immediate opportunity to question them on the strategy. That said, I will continue to champion CCUS in Parliament to ensure the Government is providing the proper support and resource to industries working in this sector."

More information

www.gov.uk

www.ccsassociation.org

First customer for Kellas Midstream's H2NorthEast Teesside hydrogen project

Kellas Midstream has signed a Heads of Terms agreement with Statera Energy, a leading UK developer of flexible energy generation and storage technologies, for the provision of low carbon hydrogen from Kellas' H2NorthEast project in Teesside to Statera's Saltholme power stations.

The agreement sets out how Kellas and Statera will work together to deepen engagement regarding the future supply of hydrogen from H2NorthEast, and the decarbonisation of Statera's Teesside operations.

Kellas' CATS (Central Area Transmission System) gas processing terminal in Teesside will deliver 355MW of hydrogen in Phase 1 to Statera's Saltholme power stations

Nathan Morgan, CEO of Kellas Midstream, said, "The signature of these Heads of Terms further enhances our collaboration with Statera and represents a hugely positive step for the H2NorthEast project. It follows on from our announcements earlier this year regarding the project successfully entering front end engineering and design (FEED), and securing government funding through the Net Zero Hydrogen Fund."

"The agreement is an important statement of intent by Statera and highlights our commitment to engage meaningfully with stakeholders to make Teesside one of the world's first decarbonised industrial clusters."

H2NorthEast is a ground-breaking project to build a low carbon, CCUS-enabled blue hydrogen facility next to Kellas' CATS (Central Area Transmission System) gas processing terminal in Teesside. It will deliver 355MW of hydrogen in Phase 1, upscaling to more than a gigawatt by 2030 and contributing as much as 10% of the UK's target hydrogen capacity.

Statera operates two flexible generation power stations at Saltholme which are in close proximity to CATS. The Saltholme sites play a valuable role in the UK energy system by providing the flexible delivery of electricity to the grid to cover shortfalls in renewable generation and increases in demand. Statera plans to use the hydrogen from H2NorthEast to fuel switch from natural gas and help transition its sites into the first low carbon flexible generation facilities in operation in the UK in order to support a fully decarbonised power system.

Tom Vernon, CEO of Statera Energy, said, "Decarbonising thermal generation will be essential if the UK is to meet its objective of a net zero power system by 2035. Alongside power CCUS, Statera believes hydrogen fired generation will be critical in providing the long duration response required to support the intermittency of renewables."

"These heads of terms are an important first step in the decarbonisation of our flexible generation projects at Teesside. We look forward to working closely with Kellas as it progresses the exciting H2NorthEast project to an investment decision."

Kellas also recently formed a joint venture that will see SSE acquire a 50% share in H2NorthEast.

SSE said it will use its expertise to drive the continued progress of H2NorthEast to further strengthen its position as a major contributor to industry decarbonisation across the Tees Valley.

More information

www.kellasmidstream.com

www.stateraenergy.co.uk

UK carbon capture policy: out of step with Net-Zero goals

UK government incentives for carbon capture are disproportionately supporting the development of blue hydrogen projects, increasing long-term reliance on fossil gas within the UK energy mix according to a report from the Institute for Energy Economics & Financial Analysis.

Support for abating emissions from the UK's existing gas and bioenergy power stations is severely lacking, potentially putting at risk the UK's target to decarbonise the power sector by 2035. Government-sponsored projects are pointed towards oil and gas owners, accounting for 78% of the proposed emissions capture and presumably the majority of the £20 billion in public support available.

These are the key findings from the report by Andrew Reid, a partner at NorthStone Advisers and a guest contributor at IEEFA Europe, and Arjun Flora, Director, Europe, at IEEFA.

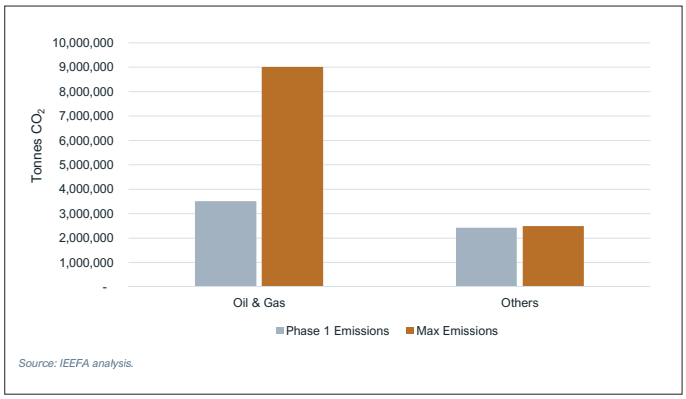
Carbon capture and storage is increasingly being championed by various stakeholders as a climate solution to support the decarbonisation of fossil fuels, be they governments with emissions reduction targets, project owners seeking to reduce emissions or fossil fuel producers supporting the prolonged use of oil and gas and their existing infrastructure, they say in the executive summary.

While big claims are being made regarding CCS's potential to help with decarbonisation, the underlying evidence from smaller scale demonstration projects is far less convincing. There exist significant technical, economic and environmental risks across almost all CCS applications.

Despite this, the UK government has pledged £20 billion in public money over the next 20 years to support the country's CCS ambition. A high-risk pillar of the UK's decarbonisation strategy, it is based on the forecast that around 22 million tonnes of carbon dioxide (MtCO2) will be required to be captured per annum by 2030, rising to 104 MtCO2 by 2050, in support of the nation's net-zero commitments.

The UK government has initially chosen eight CCS projects across the HyNet and the East Coast Cluster to prioritise over others as part of the 'Track 1' support. Presently, they are in bilateral dialogue to examine and consider the specific financial support the government will offer to each project to help kick-start a UK CCS market.

On closer examination however, the Track 1 projects are falling short of the UK's CCS requirements as set out by the Climate Change Committee (CCC) in its Sixth Carbon Budget. An overwhelming majority of the carbon to be captured is generated by expensive, fossil gas-based blue hydrogen projects, which, in the short term, will account for 4.5 times more captured CO2 than the CCC's 2030 requirements.



Carbon Capture Project Volumes by Project Owner (Tonnes of CO2): of the Track 1 projects proposed for support, some 81% of captured emissions are proposed to come from processes that require fossil gas use

This is coupled with a severe lack of support for decarbonising electricity supply or retrofitting gas-fired power generation with CCS. Currently, Track 1 projects will meet only 16% of the 12.4 MtCO2 per annum required to support the decarbonisation of electricity supply by 2030, putting at risk the target that all gas power generation will be abated by 2035 or that existing gas power stations will have CCS retrofitted.

Government support of new-build gas power generation with CCS, namely the Net Zero Teesside project, is also worrisome. The CCC recognises that the UK will continue to rely on gas power generation as the country progresses to net zero over the coming decades while lower carbon electricity capacity increases. It is unlikely that CCS subsidies were intended to support additional gas-fired power stations, when simultaneously the UK is working to expand its renewable and nuclear power generation capacity in a bid to reduce its reliance on gas.

It has often been argued that CCS is being used by the oil and gas industry to justify and support the continued use of fossil fuels within the global energy mix, and UK activity seems to support this. Of the Track 1 projects proposed for support, some 81% of captured emissions are proposed to come from processes that require long-term fossil gas use. Using our estimates of the volumes of carbon to be captured during the initial and ramp-up phases of the Track 1-supported projects, 78% of carbon capture will come from projects owned by oil and gas companies.

"While we cannot comment on the UK government's decision-making process to initially support such a high proportion of fossil-based CCS, we can make some observations. Firstly, when examining the information available and the progress of proposed CCS projects, it appears that the oil and gas sponsors are better organised and further progressed with their plans. By definition they are highly motivated—continued and long-term commitment to fossil gas use is core to their business model—but they are also well funded, in addition to being experienced and sophisticated lobbyists."

More information

www.ieefa.org

UK news

Westwood: UK's sizeable carbon storage pipeline at risk due to project delays

www.westwoodenergy.com

A new report from Westwood Global Energy Group reveals that while the UK has potential to far exceed its CCS targets, delays, cancellations and under-delivery still pose significant risk.

Following the UK's first Carbon Storage Licensing Round, the findings underscore the critical nature of setbacks in government funding, congested licence work programmes, and challenges in securing access to CO2.

Westwood analysis highlights that, based on current reported project schedules, the UK is on track to exceed its upcoming carbon storage targets. By 2030, there is potential for up to seven carbon storage sites with capacity for over 45 million tonnes per annum (MTPA), double the lower end of its target. Encouragingly, the research uncovers that the UK is also well-placed against its 2035 ambitions and could look to reach over double its 50 MTPA target.

Stuart Leitch, New Energies Research Manager, Westwood said, "While the forecast carries an optimistic outlook, project targets and reality can often differ. Delays and project under-delivery are not uncommon, and Westwood scenario analysis highlights the importance of the government's support to ensure the prompt commissioning of projects to reach its own targets."

Westwood assesses the implications of potential setbacks on the existing carbon storage project pipeline, unveiling that even minor delays will mean the UK misses its 2030 targets. By modelling a scenario where Track-1 clusters maintain phase 1 progress but have a two-year delay to subsequent phases and all other announced projects are delayed by two years (Figure 1), the research emphasises the need for timely project completion.

Catherine Horseman-Wilson, Senior Analyst - NW Europe, Westwood, said, "The industry is grappling with a series of challenges, from funding delays and congested work programmes, to access to CO2 and co-location and infrastructure re-use difficulties, so the likelihood of delays can't be ignored. The UK has a significant opportunity, with a strong capability to surpass its targets, but contingency planning will be a crucial element in securing its full potential, particularly in ensuring the strict adherence to schedules and maintaining a reliable CO2 supply."

Industrial decarbonisation essential for delivering net zero

www.missionzerocoalition.com

The latest report from the Mission Zero Coalition highlights why industrial decarbonisation must be part of the solution to delivering net zero not only by 2050, but the UK's National Determined Contribution of 68% emissions reduction by 2030.

We will not achieve net zero without placing industrial decarbonisation at the heart of the pathway to reduce carbon dioxide emissions says the report, "Decarbonise now, securing a greener, cleaner, better industrial future."

8% of business and industry is responsible for 80% of the UK's gas use. To meet 2035 commitments to decarbonise emissions by 78% on 1990 levels, those industrial emissions will need to be reduced by two thirds.

"The importance of acting now to deliver what is needed to achieve this cannot be overstated. Without industrial decarbonisation, net zero will not be delivered," said Rt Hon Chris Skidmore OBE Chair, Mission Zero Coalition.

Commenting on the report, Ruth Herbert, Chief Executive of the Carbon Capture and Storage Association (CCSA), said, "The Mission Zero Coalition is right to say industrial decarbonisation must be at the heart of efforts to reduce emissions and hit 2035 targets."

"Today's report makes clear the urgency of the challenge and the need for effective deployment of carbon capture, utilisation and storage (CCUS) technology, as the best way to protect and grow industries such as cement and glass in the UK. We estimate that around 77,000 industrial jobs can be protected and 70,000 new jobs created if we deploy CCUS to decarbonise existing industries."

"While the UK has made welcome progress this year, we urgently need to see allocation of the £20 billion previously announced for projects that can commission pre-2030. But this is only the start – CCUS needs to be available to all industrial regions, alongside expansion of the first four clusters."

"Our CCSA Delivery Plan, referenced in this report, warns that without long term stability one in three facilities are at risk of moving overseas, threatening jobs. Our members want to see clear committed actions from government now that guarantee they can access CCUS in the early 2030s, if they are to continue operating or investing in the UK this decade."

ADNOC makes strategic investment in Storegga

www.adnoc.ae

www.storegga.earth

ADNOC has taken a 10.1% equity stake in UK-based Storegga which focuses on the development of global carbon capture and storage projects.

The investment represents ADNOC's first international equity investment in carbon management and supports the company's strategy to use carbon management partnerships and technology to advance global carbon capture and storage projects that can accelerate decarbonisation.

The investment is part of ADNOC's initial allocation of $15 billion (AED55 billion) to low-carbon solutions and decarbonisation technologies. ADNOC is targeting a carbon capture capacity of 10 million tonnes per annum (mtpa) by 2030.

Musabbeh Al Kaabi, ADNOC Executive Director for Low Carbon Solutions and International Growth, said, "This strategic investment marks an important milestone in ADNOC's decarbonization journey and highlights our commitment to work with partners across industries to deliver practical solutions to enable a net zero energy future. Carbon capture is an important tool to responsibly reduce carbon emissions and meet global climate goals and ADNOC will continue to scale-up this technology as we work towards net zero by 2045."

ADNOC said its carbon management strategy aligns with the IPCC view that carbon capture and storage is a critical enabler for the world to achieve net zero by mid-century.

CCSA London event opening session

The opening session of the CCSA London event "Springboard to Net Zero" in October included perspectives from the UK government, Sir David King, Northern Endurance Partnership, ExxonMobil and SSE Thermal. By Karl Jeffery.

The London based Carbon Capture and Storage Association (CCSA) has calculated that over £1bn has been invested to date in the UK in the CO2 capture projects and clusters, said Ruth Herbert, chief executive of the CCSA, in her opening remarks to the CCSA's annual conference in London in October.

"It is really challenging what we have to build by 2050," she said. "If anyone can solve the challenge it is the people in the room."

Claire Coutinho, UK government

Britain can help the world decarbonise, in the same way as it "was instrumental in helping the world industrialise" two hundred years ago, said Claire Coutinho, the UK government Secretary of State for Energy Security and Net Zero.

She was speaking at the first plenary session of the CCSA's annual conference in London on October 17, "CCUS - an essential pillar in Europe's decarbonisation strategy."

For the government to achieve its decarbonisation goals, it needs to "double down" on sectors with the greatest opportunities to decarbonise, while boosting jobs, investment and growth.

"Make no mistake, carbon capture and storage is one of those sectors," she said.

Ms Coutinho likes the "pragmatism" of carbon capture. "What's more common sense than taking advantage of our own geography to address one of the greatest threats facing mankind?" she said.

Paro Konar, Director of Hydrogen and Industrial Carbon Capture with the UK government's Department for Energy Security and Net Zero shared perspectives in the following session. She said that three things needed to keep carbon capture moving are a long-term business environment, viable business models and a cluster-based approach.

Claire Coutinho, UK government Secretary of State for Energy Security and Net Zero said for the government to achieve its decarbonisation goals, it needs to "double down" on sectors with the greatest opportunities

There is also a need to continue reskilling people, and there will need to be 'choreography' between industry and various government bodies, including planning agencies, she said.

"CCUS clearly is a critical pathway to managing a future which is manageable for our society."

World temperatures are already 1.32 degrees higher than pre-industrial levels. So, it is

Sir David King

CO2 in the atmosphere is already over 500 ppm, if we count methane in the atmosphere in terms of its CO2 equivalent, calculated at 120 x bigger global warming effect per molecule, said Sir David King.

Sir David is chair of the UK's Climate Crisis Advisory Group, and a former Chief Scientific Adviser to the UK Government (2000 to 2007).

Sir David King, chair of the UK's Climate Crisis Advisory Group, and a former Chief Scientific Adviser to the UK Government

probably already impossible to limit the global warming related overall temperature rise to under 1.5 degrees C, he said.

And the Arctic is warming 4.3 times faster than the average for the planet, he said.

Feedback loops are being created, such as warming causing more forest fires, which causes more soot landing in the Arctic, which causes snow to absorb more heat, he said.

SSE Thermal

There is a looming capacity gap in UK power generation of 30 GW by 2035, said Catherine Raw, managing director of power generation company SSE Thermal. We expect to have 46 GW but need 76 GW.

Decarbonised power generation options include gas with CCS, and hydrogen sent into a turbine power station. Hydrogen fuelled power could be possible if large volumes of decarbonised hydrogen were available, ideally both blue and green, and hydrogen storage, she said.

So far, there is one gas with CCS project with firm plans, which will not start "until 2027 at the earliest," she said.

In planning a net zero power system, it is critical to maintain flexibility, she said, rather than selecting specific technologies. We need what she calls an 'and .. and' approach, trying to do everything possible. For example, battery storage on the grid, and pumped storage, can be developed further.

"We would like a political mandate of how many GW low carbon power generation the government is targeting," she said.

SSE Thermal would also like clarity from the government on how it will fund CCS after its currently committed £20bn is spent, since this money "only gets us so far," she said.

Catherine Raw, managing director of power generation company SSE Thermal said they would also like clarity from the government on how it will fund CCS after its currently committed £20bn is spent

ExxonMobil

ExxonMobil is working on the world's largest blue hydrogen project near Houston, and FEED (front-end engineering and design) is finished, said Erik Oswald, Global VP Advocacy & Policy Development, Low Carbon Solutions with ExxonMobil. There is also a blue ammonia plant planned in Port Arthur, Texas.

In the UK, ExxonMobil has four licenses to test for CO2 storage, 3 together with Shell and 1 with Neptune Energy. These were announced in September 2023.

ExxonMobil is a founding member of the Solent CCS cluster in the UK. It is seeking to provide sustainable aviation fuel to Heathrow and Gatwick airports, which are already connected by pipeline to its Fawley refinery in the Solent cluster, he said.

Mr Oswald would like to see the UK and European Union recognise each other's emission trading schemes (ETS). This would make it easier for CO2 moved from the EU to UK storage (for example) to count as an emission avoided.

Erik Oswald, Global VP Advocacy & Policy Development, Low Carbon Solutions with ExxonMobil said he would like to see the UK and European Union recognise each other's emission trading schemes

Northern Endurance Partnership

The Northern Endurance Partnership, the CO2 transportation and storage company for Teesside and Humber, aims to store twenty-three mtpa by 2035 in the Endurance offshore storage, said Chris Daykin, General Manager.

Front-end Engineering and Design (FEED) will be completed in 2023. The Engineering, procurement and construction (EPC) contracts have been issued, with final selection expected in Q1 of 2024.

An agreement to lease the storage site has been signed with Crown Estate. The Final Investment Decision is scheduled for September 2024, he said.

CCS enabled hydrogen in the UK

While the largest single green hydrogen project so far in the UK generates 30MW, the first blue hydrogen project will generate 1GW. It gives an indication of how the market will evolve. By Karl Jeffery.

The biggest individual green hydrogen project in the UK so far is 30 MW, said Joseph Seifert, CEO of Essar Energy Transition (EET) Hydrogen, a subsidiary of Essar Group of India, an oil, ports, mining, and retail company.

But the first blue hydrogen projects in the UK will be much larger, sized in the gigawatts. This gives an indication of how the UK decarbonised hydrogen industry will evolve, he said, speaking at a breakout session of the Carbon Capture and Storage Association (CCSA) annual conference in London on October.

The UK could do multiple blue hydrogen projects at the gigawatt scale, he said. To illustrate the scale, a city the size of Liverpool (500,000 people) uses about 1.3GW of electricity, he said.

In the UK, hydrogen is considered low carbon when the CO2 emissions are under 20g CO2 equivalent at the point of production per megajoule of the lower heating value of the hydrogen produced. So, both 'green' and 'blue' hydrogen can be considered low carbon so long as they meet this standard. The UK has been at the forefront of establishing a standard for low carbon hydrogen, he said.

This metric aims to take the 'emotion' out of the question of what kind of hydrogen to use, he said. "As industry evolves and we get big blue projects – Norway and US – that will develop the argument."

EET has a vision to be the leading low carbon hydrogen producer in the UK he said.

Altogether, the first phase of UK hydrogen projects, online in 2027, will include 250 MW green hydrogen under a government funding scheme HAR1; 500 MW blue hydrogen from BP in Teesside; and 350 MW from EET's first blue hydrogen project in Northwest England. This connects to the HyNet CCS cluster and is expected to take FID in 2024 and start operations in 2027.

The second phase of projects, online in 2028, would include EET's second blue hydrogen production plant in Northwest England (1GW), expected to start production in 2028; 750MW green hydrogen under the HAR2 funding scheme; 600 MW blue hydrogen from Equinor (H2H Saltend in the Humber), and 350 MW blue hydrogen from Kellas midstream (Teesside), so a total of 2.7 GW.

Joseph Seifert, CEO of Essar Energy Transition (EET) Hydrogen said the company has a vision to be the leading low carbon hydrogen producer in the UK

HAR1 and HAR2 are UK government funding mechanisms for green hydrogen projects. HAR1 was launched in 2022. Seventeen projects, totalling 262MW, were invited to participate. Government intends to launch the second allocation round (HAR2) in Q4 2023 and aims to award contracts to up to 750MW of capacity in early 2025, he said.

UK regulators have learned a lot from the efforts to establish the offshore wind industry, when planning a decarbonised hydrogen industry, he said. "It's a sensible taxpayer subsidy."

Kellas Midstream

Kellas Midstream is planning a 1GW blue hydrogen project in Teesside, UK. The company has a vision for Tees Valley to be a "hydrogen super place," said Guy Appleton, managing director of New Energies with Kellas Midstream.

Kellas describes itself as a "critical infrastructure" company. Its pipelines and terminals carry 40 per cent of UK domestic gas production and 20 per cent of its consumption.

There are also plans for green hydrogen project in Teesside. using the green electricity from nearby Teesside Offshore Wind Farm along with a new solar farm, which EDF Renewables UK intends to construct near Redcar.

It seeks to deliver 300 MW by 2030, he said. In rolling out more blue hydrogen projects, the constraining factor is "access to CO2 storage," he said.

Blue hydrogen today has a "fraction of the cost of green," he said, although in the long term "green will be cheaper than blue." Green hydrogen will probably need large scale hydrogen storage, he said.

One possibility in future is that a new gas field could be connected to Teesside, reformed to hydrogen and CO2, and then CO2 sent back to offshore storage, he said.

Mr Appleton noted that there are plots of land around Teesside which have been empty for decades, and now companies are competing to build factories there. He often receives phone calls from global companies interested in investing in the area.

Markets for hydrogen

The first markets for blue hydrogen will be the easiest ones to serve, or the 'low hanging fruit' - big industrial customers, including the power sector, who can offtake large volumes of hydrogen in one contract, EET's Mr Seifert said.

Later, it is likely that buses, aircraft, and ships will use blue hydrogen, but the "volumes [used] are pretty small and a bit uncertain."

But as the hydrogen supply grows, "conversations will change," he said, potentially bringing in the transport sectors.

Guy Appleton of Kellas agreed, saying that his company already has potential customers nearby who are willing to purchase a gigawatt of hydrogen. Supplies to other customers "will come, but down the line," he said.

Other comments

35 per cent of UK fuel energy consumption in 2050 is expected to be from low carbon hydrogen, said Celia Greaves, CEO of the UK's Hydrogen Energy Association (formerly the Fuel Cell Association).

The UK hydrogen pipeline network is due online from 2033. There is a 10GW target for hydrogen production by 2030, although there may not be any pipelines for it at that point, she noted.

Guy Appleton, managing director of New Energies with Kellas Midstream said in rolling out more blue hydrogen projects, the constraining factor is access to CO2 storage

Chris Davies of CCS Europe noted that in the European Union discussions in Brussels, hydrogen is becoming very fashionable. But environmentalists are only happy when it is green hydrogen. It is uncertain whether the CCS industry is winning the argument for blue hydrogen.

Perspectives on UK CCS

Executives from Northern Endurance Partnership, Equinor, SSE Thermal and ExxonMobil shared overall perspectives on the UK's position with CCS at a closing plenary session of the CCSA forum in London on October 18.

Northern Endurance Partnership

Ben Kek, deputy general manager of Northern Endurance Partnership said he thought there has been a lot more energy at the CCSA annual conference this year compared to previous years. "Lots of aligned interest, everyone is working to the same target," he said. "It shows the determination of everyone."

The industry is starting to have "a collaborative feel to it," he said, with "companies playing to their strengths."

While there are high levels of confidence, we won't fully know how fast we can store the CO2 until projects start, he warned. "We need to get steel in the ground, scale up the infrastructure."

The UK is being very careful about how government money is targeted. This could be referred to as a 'scalpel' approach to government support, he noted. The UK also has a 'stick,' with taxation.

With regulation, "pragmatism is really important," he said. "Regulation isn't one size fits all."

Ben Kek, deputy general manager of Northern Endurance Partnership said the industry is starting to have a collaborative feel to it

Equinor

The UK has not yet actually started doing any CCS, and this is an important point to get past, said Dan Sadler,

VP, UK Low Carbon Solutions with Equinor. "We need to get first projects to FID [final investment decision], get first projects over the line."

"We should not be complacent that we are ahead of everyone else. PORTHOS (in the Netherlands) has [already] taken FID."

On the other hand, people should not say that the UK is falling behind, he said. "We have consented projects all over the UK. Others are catching up."

Shipping CO2 will also be required at some stage. This is possible, but it "is not easy," he said.

A project involving capture, shipping and storage would simultaneously need FID on capture equipment, port equipment, liquefaction systems, and new vessels. It would need storage to be ringfenced at the other end, he said.

Mr Sadler would like to know more about when the UK's "Track Two" clusters are likely to happen (Acorn in Scotland and Viking in Humber).

He would also like to know what the government's strategic approach is for projects in the Solent Cluster (around Southampton) and Wales.

A challenge today is that industry wants to see government share risk in these 'first of a kind' projects. But as we move beyond the first projects, "you will see industry take more risk," he said.

Hannah Bronwin, Director of Business Development, SSE Thermal (centre) said they are on the brink of deployment, which is incredibly exciting

SSE Thermal

Hannah Bronwin, Director of Business Development, SSE Thermal, also said she thought the 'energy' of the CCSA conference is different this year. "It feels more frenetic," she said. "There is more delivery happening.

"We are on the brink of deployment, which is incredibly exciting."

But making carbon capture work requires being both "near sighted and far sighted," she said.

Over the longer term, if CO2 storage is only going to be available in four regions of the UK, "that has huge implications."

While we do not need add CCS to more regions now, "people have to believe it is going to happen." Otherwise, people may start to think that their workplace will need to close in a few years, she said.

Ms Bronwin noted that the reason CCS needs subsidy is because there is no market mechanism to ensure people pay for emitting CO2, or regulation to prevent it. While this happens, government intervention will always be needed. "It is more expensive to tidy up after yourself then not to," she said. "It is a waste management problem."

The UK has done very well in encouraging offshore wind development. "Too well, most people in wind would say," she added, referring to secondary difficulties with wind projects, such as limited availability of grid transmission capacity.

ExxonMobil

2023 has been a remarkable year for carbon capture, particularly with the "big extinguisher of money" from the US Inflation Reduction Act, said Michael Foley, UK Low Carbon Solutions Executive with ExxonMobil.

However, the US does not have carbon capture regulation and policy as evolved as in the UK, he said. The UK is a "location for really good policy," he said. "The depth of thinking including transport and storage is really good."

Mr Foley stressed that global energy needs could be 15 per cent higher in 2050 than today, with a population with 2bn more people. That makes decarbonising an even bigger challenge.

Michael Foley, UK Low Carbon Solutions Executive with ExxonMobil said the UK is a location for really good policy

More information

www.ccsassociation.org

CO2 utilisation – chemicals, building, SAF

There are fairly large research and development projects in the UK to utilise CO2 to make chemicals, building materials and sustainable aircraft fuel, we heard in the CCSA conference.

Carbon8 is developing construction materials with captured CO2. Carbonated building products could replace Portland cement, the most common type of cement, a basic ingredient of concrete, explained Dr Paula Carey, Chief Scientific Officer, Carbon8.

She was speaking at a break-out session of the CCSA Annual Conference in London on October 17.

Dr Carey would like to see CO2 utilisation taken more seriously within the carbon capture world. 30 per cent of carbon capture startup companies are looking at utilisation, but they are only getting 6 per cent of investment. Globally there are "at least 30 companies" making construction products from captured CO2, she said.

Adding CO2 to most chemicals is an exothermic reaction (giving out energy), so it does not require energy inputs.

CO2 utilisation is commonly thought of as being expensive. Dr Carey insists this is a myth. "You take industry's liability, CO2, and make it an asset," she said.

It could be possible to 'store' gigatonnes of CO2 in this way, and re-use construction waste at the same time.

Dr Carey is frustrated that more money is available in the form of carbon credits when CO2 is taken from the atmosphere than from a flue gas, while taking it from a flue gas is less expensive while achieving the same overall result. "That seems idiocy to me," she said.

The construction industry is quite risk averse, which makes it hard to persuade people to use new products. "The construction industry wants 20 years of experience [before using new material]," she said. "But all these materials have to meet standards and specifications."

It could be possible to 'store' gigatonnes of CO2 in carbonated construction materials, and re-use construction waste at the same time – Dr Paula Carey, Chief Scientific Officer, Carbon8

Flue2Chem

Flue2Chem is a consortium of sixteen companies seeking to make useful chemicals from CO2. It includes consumer products giants Unilever (head partner), Procter and Gamble, and Reckitt, a manufacturer of health, hygiene and nutrition products, including Dettol.

The project team has £5.4m funding, including £2.7m from Innovate UK.

As a trial project, it is exploring an alternative means of making alkoxylate surfactants, which are used in laundry products, personal care and paints, explained Nima Roohpour, head of Polymer and Formulation Sciences with Reckitt.

6 MT a year of alkoxylate surfactants is produced globally, she said, including a key component sourced from imported palm oil.

Instead, captured carbon dioxide could be converted into hydrocarbon molecules and ethylene oxide, which could then be used to make alkoxylate surfactants, she said.

Alfanar

Alfanar, an engineering construction and technology solutions provider headquartered in Riyadh with $3.5bn turnover, has a project in the UK to develop sustainable aviation fuel (SAF).

It is looking at three pathways: "liquid to liquid", using waste cooking oil and fat; "solid to liquid", using municipal and commercial waste, and biomass; and "power to liquid," using green hydrogen and ammonia, said Noaman Al Adhami, Country Head UK with Alfanar.

Alfanar's "Lighthouse Green Fuels" project to make SAF in Teesside is thought to be the largest and most advanced waste to SAF project in Europe, taking one mtpa of solid waste to make 3.2k barrels of SAF a day, and five hundred barrels a day of green naphtha. There is CO2 produced in the process, which can be sent to permanent storage.

Whilst a million tonnes of waste a year sounds like a large amount, bear in mind that

UK waste is 26 to 27m tonnes a year in total, he said. About half goes to energy-from-waste projects, half to landfill.

Because the CO2 is initially from a biofuel (such as wastepaper), this makes the overall process net negative in CO2, he said.

The CAPEX and OPEX is much higher than making conventional fuels, but this net negative CO2 emissions should help justify the cost, he said.

The biggest challenges are "external factors," such as funding and availability of CO2 storage. The project was not selected for funding under the track 1 UK CCS cluster projects, he said.

The aviation sector is responsible for 2 to 3 per cent of CO2 emissions globally, and if other industrial and transport sectors would successfully decarbonise, the proportion of total emissions attributed to aviation would get much higher. So, the industry sees that developing SAF is a high priority. It anticipates a market of 128 MT a year by 2040, and 285 MT a year by 2050, he said.

The UK used 12.2m tonnes of aviation fuel in 2019 (before the pandemic driven decline in consumption) and has a target of 10 per cent SAF use by 2030, so 1.2m tonnes.

It is possible that short and medium haul flights could use hydrogen fuels or batteries, but for long haul flights SAF would probably be the only possible solution for a decarbonised fuel with high energy density.

More information

The full conference programme can be viewed here:

www.ccus.events

www.ccsassociation.org

CCSA / ZEP report: achieving a European market for CO2 transport by ship

The CCSA and ZEP have joined forces to identify barriers and enablers and provide recommendations to European policymakers to support the development of this market.

Policymakers across Europe should support the development of CO2 transport by ship as a credible and necessary component of carbon capture and storage and industrial decarbonisation says the report, which aims to provide an indicative description of the future European market for CO2 transport by ship and recommendations to ensure the full development of that market.

The report aims to provide policymakers with clear policy and technical recommendations, focusing on:

• Mapping the European market for CO2 transport by ship for 2030.

• Assessing the interoperability of CO2 transport by ship.

• Identifying barriers and enablers for the commercialisation of CO2 transport by ship.

The findings and recommendations are the result of the collaborative efforts of the CO2 transport by ship Working Group, convened by ZEP and the CCSA.

The report recommends that national authorities should incentivise investments to pre-invest in the expansion of key CO2 shipping infrastructure components and create mechanisms to make investments in CO2 shipping at least as attractive as investments in conventional shipping businesses. Early projects should also have sufficient funding support to demonstrate that CO2 shipping is a viable alternative to pipeline transportation.

A 20,000-tonne cargo liquified CO2 ship with a one-week round trip time can transport approximately one million tonnes of CO2 per annum in normal operations. As of today, in Europe, one project with a contracted CO2 shipping capacity of 2 million tonnes per annum has taken a Final Investment Decision. Based on a review of projects currently under development, it is estimated that up to 39.5 million tonnes of CO2 could be transported per year by 2030.

The report estimates that the number of vessels required by 2030 is in the range 10 to 20 vessels. However, should every project come to fruition in the short term, which is unlikely, the total number of vessels could exceed 50. The capacity of future European storage sites compatible with ship transport could exceed 50 million tonnes per year by 2030.

The report suggests that a future European market of CO2 transport by ship should develop on a commercial basis, while regulated tariffs are not recommended. Vessels are expected to be contracted for specific point-to-point CO2 transport and will not be available for spot-market transport by 2030.

As the cross-border transport of CO2 requires the recognition of storage by other countries and the proof that the captured CO2 is safely stored, the report also recommends that the EU and the UK should enter into an agreement to ensure that emitters located either in the EU/EEA or the UK do not have to surrender ETS allowances when storing CO2 in the other ETS system. Such an agreement is key to support cross-border CO2 transport in Europe it says.

To support the cross-border transport of CO2, European countries that are parties to the London Protocol should deposit a notice to provisionally apply the Article 6 amendment to the London Protocol with the International Maritime Organization and sign bilateral agreements where needed.

See the infographic on the next page for a summary of the key findings.

More information

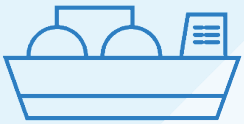
zeroemissionsplatform.eu

www.ccsassociation.org

The European Commission aims to store at least 50 million tonnes of CO_2 by 2030.

Shipping will play a crucial role in Europe for the development of carbon capture and storage .

1 million tonnes of CO_2 can be transported per year



by a 20,000-tonne cargo liquified ship with a one-week round trip

5 to 67 million tonnes of CO_2 per year

could be transported by ship by 2030

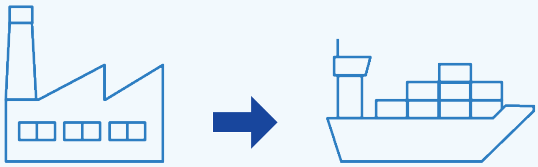
Future European storage sites compatible with ship transport could exceed

50 million tonnes of CO_2 storage

per year by 2030

26 storage projects

could use shipping to transport CO_2



European policymakers should support the development of CO_2 transport by ship for

industrial decarbonisation

Key recommendations

- Policymakers should incentivise funding and remove barriers to cross-border CO_2 transport by ship in both the UK and EU ETS systems.
- European countries parties to the London Protocol should deposit a notice to provisionally apply the Article 6 amendment of the Protocol with the International Maritime Organization and sign bilateral agreements where needed.
- Public authorities should support more research into the functioning of a multimodal transportation model where CO_2 is transported via ships, barges, trains, and trucks.

Driving CCS in the EU

Madhav Desai, Director – Consulting Operations, KSA, at KBR explores the progress of CCS in Europe, comparing it to US policy, discussing how the EU can best realise the decarbonisation potential of CCS and emphasising the imperative for a robust policy framework and financial backing.

We know that the road to establishing the widespread use of carbon capture and storage is complex, with a range of challenges to overcome. Progress on these issues varies around the world, with some commenting that the EU is lagging behind other regions in tackling them.

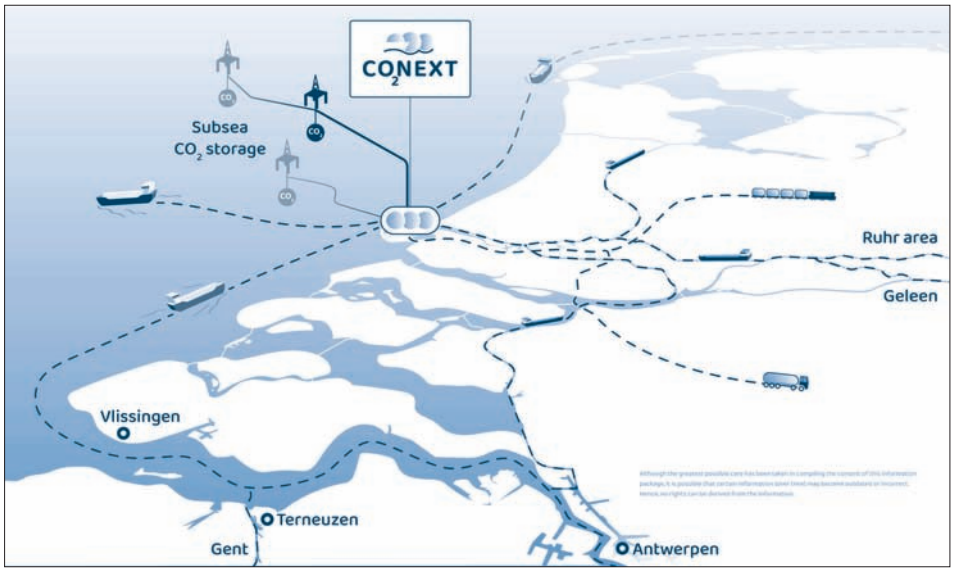
Let's first look at where we are to date. The US has historically led the world in adopting CCS, having deployed it since the early 1970s – primarily to support enhanced oil recovery (EOR) projects. 13 out of the 15 existing CCS projects in the US support EOR, and just two relatively small projects are dedicated to geological storage.

The US Congress has directed $14.6 billion (2022 terms) to CCS-related budgets under various Acts covering the 2010-2026 period. Budgets are being created to fund research and development activities with small-scale demonstration projects and storage validation and testing, totalling $5.0 billion over 2022-2026.

The EU has come to the party much later, and in recent decades has created a raft of policy and regulatory frameworks to promote and manage CCS projects. In a significant move, in March 2023, the European Commission rolled out the Net Zero Industry Act. This Act specifically identifies carbon capture, utilisation and storage (CCUS) as a strategic net-zero technology.

According to this pivotal legislation, ramping up the manufacturing capacity of CCUS technologies is crucial if the EU is to meet its ambitious climate goals. This Act also amplifies the EU's commitment to fostering CCS development and serves as a testament to the technology's importance in the decarbonisation journey.

Meanwhile, the EU's emissions trading system scheme has been amended to include CCS credits, if implemented. The site selection and safety assessment would be ensured through the CCS Directive, a legal framework for safe geological storage of carbon dioxide in the EU and EEA countries.



CO2NEXT is one of the projects that has received funding from the Connecting Europe Facility which provides support for EU-wide, cross-border CO2 transport networks

Broad schemes such as the Innovation Fund (€25 billion) and Horizon Europe (€95.5 billion) have been set up to promote research, pilots and small-scale demonstration projects related to CCS.

At the same time, the Connecting Europe Facility (€25.8 billion) provides support for EU-wide, cross-border CO2 transport networks. Cross-border transport may be needed, as the storage sites in the North Sea, for example, are accessible to nearby countries. Other countries may need to transport their captured CO2 to sinks via long-distance pipelines.

For both the US and EU, overcoming financial hurdles requires a multifaceted strategy. Governments play a pivotal role in this transformation. Implementing strategies such as subsidies, tax incentives, and risk-mitigation frameworks can provide the necessary allure for hesitant investors.

Moreover, fostering collaboration between regions to share knowledge and best practices can significantly enhance global progress in CCS projects. The EU's emissions trading system, for instance, offers a glimpse into such proactive measures, providing CCS credits to further encourage projects.

Overcoming key challenges in CCS implementation

The financial barrier

The financial barrier is without doubt one of the most significant challenges facing the adoption of CCS technologies globally. While the demand for sustainable solutions is on the rise, the high capital requirements for CCS projects often prove discouraging for potential investors. Securing funding for such ventures is often likened to navigating a financial maze, riddled with uncertainties.

A closer examination reveals several contributing factors. Firstly, CCS projects are capital-intensive from the onset. The substantial initial investments required often overshadow the potential for long-term returns, particularly in the eyes of cautious investors. Beyond these initial costs, continuous operations,

maintenance, monitoring, and potential upgrades puts further strain on the project's finances. Additionally, the evolving regulatory landscape and volatile carbon pricing can make the potential returns on CCS projects unpredictable, which only serves to deter potential investors further.

Another issue to tackle is that CCS costs will eventually trickle down to the invisible stakeholder in the equation: the consumer. This will either be in the form of higher prices (in the absence of industry subsidies), higher taxes (to fund the industry subsidies), or a combination of the two. As such, the costs must come down sufficiently to enable the deployment of CCS at scale.

Investment and policy

The trajectory of investment and policy support in CCS technologies present a multifaceted challenge. Although there's been a notable uptick in CCS-related projects over the last decade, the investment pace lags behind what is needed to meet the Paris Agreement's goals.

For energy companies venturing into CCS, there are several challenges including the need for technological refinement to enhance efficiency and safety. Building on that, there's an imminent challenge of constructing a new commercial value chain, a monumental task involving the creation of production, storage, transportation, and consumption systems. Collaborative endeavours, especially those that cross national borders, introduce another layer of complexity, as they necessitate the negotiation of diplomatic, economic, and regulatory landscapes, much akin to the dynamics observed in the LNG industry.

Furthermore, the nascent nature of these markets means investments come with a higher element of risk. Energy companies need assurance of both consumer demand and consistent government support to secure their investments. Public perception can't be overlooked either. The introduction of new technologies demands transparent communication to address safety, environmental, and cost-related concerns to win trust. As the energy sector evolves, there's also the pressing need to ensure that the workforce transitions smoothly, acquiring the right skills to handle emerging technologies.

Storage

Storage remains a highly challenging aspect of the CCS value chain. The 2005 Special Report on CCS by the IPCC highlights the importance of meticulously chosen geological reservoirs for long-term CO2 storage. These 'Goldilocks' reservoirs (porous rock structures) are required at the appropriate depth and with a high-integrity cap rock to keep the injected CO2 underground.

Harnessing the potential of depleted oil and gas fields can offer initial cost savings, but a vast storage potential lies within less understood saline aquifers. In short, this is an area that needs significant investment in research and development.

In addition, development of cutting-edge capture chemicals, with support from funding entities like Innovation and Horizons Europe, could help to drastically curtail costs and fast-track technological advancements.

Scalability, innovation, and infrastructure integration

As the urgency for CCS amplifies worldwide, it's evident that we require solutions that are scalable without losing efficiency. Yet, it's equally crucial that in scaling up, these solutions remain compatible with what's already in place. Innovations in CCS should not merely be groundbreaking; they should meld effortlessly into existing energy infrastructure, paving the way for a smooth transition to cleaner energy.

Adaptability is the cornerstone of addressing these challenges. It's not enough for CCS solutions to be cutting-edge; they must also evolve in sync with the ever-changing demands of the energy sector. By forging strategic alliances with technology-driven partners, modular CCS frameworks can be designed to be both flexible and geared for expansion. At the same time, a rethink of policy structures is vital to ensure that CCS technologies can be incorporated into current systems without friction.

The confluence of CCS and hydrogen, meanwhile, is a significant development that deserves more in-depth exploration. While CCS zeroes in on trapping emissions, the promise of clean energy from hydrogen becomes even more potent when paired with CCS.

These allies face mutual challenges in terms of storage, transportation, and large-scale deployment. By addressing these issues collaboratively, the energy sector stands to refine its strategies, reduce overlap, and optimise efficiency.

Madhav Desai, Director, KSA Operations, KBR

The journey towards a carbon-neutral future

CCS remains pivotal for sectors like cement and steel, which are harder to decarbonise. The current economic climate poses challenges, yet revenues from carbon taxes and the EU's Cross-Border Adjustment Mechanism might offer solutions. These funds can support crucial research on saline aquifers and propel technological advancements. Allocating a portion of these funds specifically toward CCS research and development can fast-track the advancements that are desperately needed to reduce carbon emissions.

Funding alone isn't the answer; effective utilisation of these resources is equally critical. And, while the EU might not mirror the US EOR-based success due to differing public perceptions, promoting research and development activities, and drawing from expert entities like KBR – with its rich heritage in pioneering technological solutions – are essential for the EU's CCS journey.

In conclusion, for the EU to carve a sustainable future and achieve its ambitious net-zero targets, it needs to amplify its CCS initiatives by reinforcing policy blueprints and capitalising on financial avenues for innovation and technology advancements. The energy sector isn't just bracing for change; it's on the cusp of a revolution. As contributors to this narrative, our collective responsibility is to ensure this revolution is green, sustainable, and encompassing.

More information

www.kbr.com

Increasing the viability of CCS hubs

Regional carbon capture and storage hubs enable multiple emitters to share infrastructure and pipelines, thereby reducing costs. Paul Wann, Emerson's sustainability and decarbonisation business director for the UK and Ireland, explains how advanced automation solutions can increase the operational efficiency and enhance the economic viability of these projects.

Corporate commitments to meet aggressive net-zero targets and qualify for government incentives are driving the need for carbon capture and storage capacity. However, the capital and operational costs of CCS have been largely prohibitive, which is why there are very few large-scale facilities operating worldwide.

One way in which economic viability is being increased is through regional carbon capture hubs, which operate using a 'carbon capture as a service' business model. By allowing major emitters of CO2 in a region – power stations, chemical plants and steel works, for example – to share the same infrastructure and pipeline network, these hubs enable significantly improved economies of scale, and more attractive commercial opportunities as a result.

Despite the advantages that carbon capture hubs enable, CCS still involves significant costs. Capturing and compressing the CO2 is highly energy-intensive, and the process can also decrease the operational efficiency of a plant and increase its water use. These inefficiencies and associated costs can ultimately challenge the business case for CCS.

It is therefore imperative from an economic viewpoint to optimise the efficiency of the carbon capture process, reduce operational costs and lower the cost per ton captured. Fortunately, there is a broadening range of advanced automation technologies, engineering tools and software solutions available that can help to achieve this.

Improving capture process efficiency

Post-combustion amine-based absorption is the most mature carbon capture process. It consists of an absorber unit, where a chemical solvent captures CO2 from flue gas, and a stripper, where the chemical solvent is regenerated and the CO2 is extracted. The efficiency of the carbon capture process depends on the solvent circulation rate – increasing the circulation rate increases the energy required for the stripper reboiler. There is a trade-off between carbon capture efficiency and the cost of the energy required to regenerate the solvent, so the challenge is to achieve the target CO2 capture rate in the most efficient manner.

Monitoring the capture percentage with online analysis allows for process optimisation through multivariable control and analytics. Automating the lean amine concentration measurement with Coriolis mass flow and density meters enables the solvent circulation rate to be accurately determined, so that the desired capture efficiency can be achieved at the lowest cost. Precise control of rotating equipment can reduce energy consumption, while online machinery health monitoring reduces downtime and costs.

In addition, implementing an energy management information system (EMIS) that detects poor energy efficiency will help to increase process visibility and facilitate improved decision-making. An EMIS provides up-to-the-minute, meaningful information about site energy performance, so that any inefficiencies or irregularities can be better identified. This data helps operators to take real-time corrective action to save energy, and can lead to a reduction of up to 15% in a site's energy usage.

Liquefaction efficiency

Liquefaction is an essential process for the long-distance transportation of CO2. Once the carbon capture process has removed CO2 from the source, it is then usually liquefied under compression at low temperature and pumped through pipeline so that it can be stored underground or used in other chemical processes downstream.

The efficiency of the liquefaction process depends on reliable measurement and control. It is vital to increase visibility within each stage of the process, but the cost of infrastructure required to support sensors for collecting actionable data can be high. Control systems offering seamless integration of plant visualisation tools help to maintain full asset visibility, while smart wireless networks reduce installation costs and enable continuous monitoring to ensure a fast response to any issues that might occur.

To keep the CO2 stable in its liquid phase for long distance transport, it must be kept under constant pressure, which requires compressors at various stages along the pipelines. It is also important to maximise the availability of the compressors. Unexpected failures can result in capacity outage, equipment damage, excessive maintenance, increased costs and scheduling delays. Should a single compressor go down, this can cause the entire liquefaction unit to go offline.

Automation solutions help to mitigate the risk of failures and downtime. Anti-surge control valves and optimised digital valve solutions ensure stable flow to the compressor, preventing damage and increasing compressor life, while appropriate pressure safety valves enable operation nearer to optimal pressure setpoints and reduce fugitive emissions. Pervasive sensing technologies and data analytics are also available to provide continuous compressor health and performance monitoring.

Accurate and reliable measurementsThroughout the CCS chain, there are critical points where accurate, reliable and traceable measurement of the flow and density of the CO2 is vital. It is essential to know precisely how much gas each emitter is injecting into the shared pipeline network, and for all parties to have confidence in financial transactions based on these measurements.

Whether companies are quantifying CO_2 for tax credits or monetising CCS in other ways, they need to implement dependable custody transfer solutions such as high-accuracy flow meters that can tolerate extreme pressures, low temperatures and large swings in density. It is also important to measure the amount of CO2 being injected into the storage location.

The changes that occur in CO2 phase and density at this point can affect the accuracy of volumetric flow meters, so direct mass measurement provides the best option.

To make it easier, carbon dioxide is transported in a supercritical state, where it has the density of a liquid but the viscosity of a gas. This is achieved by holding CO2 above its critical temperature and pressure. The instability of the density can pose a challenge in terms of measurement accuracy. The use of Coriolis mass flow and density meters enables challenging multiphase measurements to be performed when the CO2 is in, or near, a supercritical state.

These meters can be used as part of a complete solution – also including flow computers as well as temperature and pressure transmitters – that provides measurement assurance in compliance with the European Measuring Instruments Directive (MID) that applies to custody transfer applications.

Loss of containment during transportation

An important challenge in CCS projects is ensuring that the captured CO2 is transported safely and reliably. Loss of containment undermines the whole purpose of capturing CO2, so leaks that occur during transportation as a result of pipeline corrosion and erosion are a significant concern.

Dry gaseous CO2 is not corrosive but the presence of moisture in the gas stream can cause the formation of carbonic acid, which presents a significant threat of severe corrosion to the carbon steel pipelines through which the CO2 is transported. Two-phase flow at the feed to the stripper also results in erosion concerns. In addition, sheer rates, turbulence and steam velocities are key for corrosion and erosion control.

Being able to detect and localise pipeline leaks in real time enables operators to address issues faster, so it is essential to implement a monitoring system that provides visibility into pipeline corrosion and erosion. Automation solutions that help operators to maintain a leak-free process include wireless ultrasonic sensors to enable continuous monitoring of pipeline wall thickness, real-time monitoring and alarm solutions to quickly identify leaks and ruptures, and high-performance valves with superior sealing.

In addition, software solutions can aggregate disparate pipeline and asset integrity-related data to help identify issues and perform more accurate risk modelling.

CO2 Integrity

To be permitted to enter a shared pipeline network, the composition of the CO2 must fall within certain parameters relating to impurity levels, as well as water content, pressure and temperature. Different types of impurities, including water, O2, SOX, NOX, triethylene glycol and H2S, may be present in the stream, depending on whether the carbon source is natural gas, post-combustion processes or direct air capture.

The presence of impurities can cause damage that leads to dangerous leaks and explosions as the compressed fluid rapidly expands to a gas. Accurate and reliable concentration and composition measurement of the CO2 and its impurities is therefore vital for operational, safety and compliance reasons, and it is the responsibility of emitters to demonstrate compliance.

Among the advanced automation solutions helping to ensure CO2 integrity are conventional continuous gas analysers which provide real-time analysis of the CO2 composition to a very high degree of accuracy, enabling multiple possible contaminants to be identified, even at very small parts per million. In addition, gas analysers based on chromatography or quantum cascade laser technology offer fast, high-resolution spectroscopy measurements that deliver near-live data and trend information. This visibility into the process allows an emitter to take quick action if impurity levels exceed agreed limits.

Organisations can implement a pre-engineered advanced work package known as a CO2 integrity station, which incorporates a range of automation solutions to ensure that CO2 integrity requirements are met through accurate and reliable measurement, monitoring, analysis and control. CO2 integrity stations can be deployed at every point in the process where measurement and integrity checks are required.

In addition to continuous gas analysers, their base components include Coriolis mass flow and density meters for extremely accurate and reliable measurements; emergency shutdown (ESD) valves and pressure safety valves to protect equipment; and a remote terminal unit (RTU) or flow computer that carries out flow rate computations and sends data from the measurement system package equipment to a central control point.

Corrosion and leak detection sensors are among a range of optional value-add technologies that can be implemented to enhance CO2 integrity stations. Other options include an RTU with edge analytics capabilities, and/or ESD valve diagnostics to help understand the health of hese critical valves and ensure they will operate when required.

Storage capacity and CO2 containment

The success of underground CO2 storage projects depends on the accurate and reliable assessment of storage capacity. The highly variable nature of subsurface geological formations and rock characteristics makes such assessments challenging, but the latest exploration and production software, combined with digital twin solutions, provides dynamic simulation modelling of physical environments, which enables accurate mapping and measuring of underground storage complexes.

Reliable assessment of storage containment integrity is also crucial, as CO2 leakage can undermine the value of storage. It is therefore important to continuously monitor the injected CO2 to verify that it is being contained within its storage complex and enable fast response should any leaks occur. Downhole gauges provide continuous, real-time data from the storage reservoir and ensure wellbore integrity and process reliability, while the software analyses and interprets subsurface changes observed on seismic data through the project lifetime.

Conclusion

While regional carbon capture hubs enable large industrial organisations to reduce their costs by sharing infrastructure and pipelines with other CO2 emitters, the cost of CCS projects can still be prohibitive. To minimise costs, the whole CCS chain needs to be operated as efficiently, safely and reliably as possible, and end users can implement a broad range of advanced automation technologies, engineering tools and software solutions to help them achieve this.

More information

www.emerson.com

Analysis of biomass to fuel, CO2 to methanol and refinery CO2 capture

The report from the Industrial Energy Transition and Decarbonization (IETD) Consortium (formerly the CO2CC Program) offers expert analysis on three different processes for CO2 reduction and the ongoing activities to develop, commercialise and scale them.

The recent report, published September 2023, "Techno-economic Analysis (TEA) Case Study Series – Vol 1: Biomass to Renewable Fuel, CO2 to Methanol, and Refinery Carbon" aims to give readers an understanding of the techno-economics of various processes to reduce CO2 emissions.

Biomass: hard-to-abate sectors including aviation, maritime and industrial manufacturing are relying on sustainable fuels as they cannot be fully electrified and require drop-in replacements for gasoline, kerosene, diesel, and heating oils.

It is a serious challenge to scale sustainable fuels and many approaches are required to take advantage of local natural resources such as biomass and organic waste.

In some instances it is possible to use captured CO2 and combine it with other sustainable feedstocks to make fuels with a lower carbon footprint.

Regions building renewable electricity that can produce hydrogen via electrolysis at a favourable cost, may favour power-to-x routes. These include green methanol and associated methanol-to-hydrocarbons as well as Fischer-Tropsch fuels.

Methanol: demand for low carbon methanol is being driven by the need for decarbonisation efforts especially in areas where electrification options are limited such as marine and aviation transportation, remaining internal combustion engine (ICE) passenger vehicles as well as more mature uses in the petrochemical industry.

Refineries: legislative pressures and fiscal incentives are driving the CO2 capture opportunities from refineries. These include the EU Emissions Trading System (ETS), the 45Q US federal tax credits and state-level incentives such as California's Low Carbon Fuel Standard (LCFS).

Key takeaways from the report

- Biomass: currently techniques relying on pyrolysis and hydrogenation are the most popular and these are moving to scale for providing biofeeds to refineries that can be co-processed with fossil fuels, thereby reducing the carbon footprint of the final product blends. Co-processing is a trend seen across the different technologies studied.
- Bioenergy is a sustainable solution to meeting the needs of a growing population and national energy security and decarbonisation goals. First generation (1G) biofuels have been successful and widely adopted in the transportation sector.
- In the long-term, the challenge is to close the gap of the minimum selling price (MSP) with the market price of fossil fuels such that the market can be supplied with a sustainable alternative without putting an unnecessary economic burden on the energy consumer.
- Methanol: the technology for converting CO2 and H2 to methanol has been around in its current form since the 1960s although it is only more recently that conversion of CO2 and H2 to methanol has been carried out commercially at industrial scales.
- The best long-term prospect, although one that is expensive at the current time, is to use H2 generated from renewable electricity and captured CO2. Initially this H2 would be used with CO2 captured from industrial sources as this is currently the cheapest source of CO2. The ultimate goal for provision of CO2 also includes direct air capture, but that technology still has a long development path until costs are competitive with CO2 from point sources.
- Refinery: compared with 10 years ago, the prospects for CO2 capture are much stronger, with considerable experience having been gained with 1st generation technologies, and larger projects which have provided CO2 streams for enhanced oil refinery (EOR) applications.
- For hydrogen manufacturing the interest and willingness to go ahead with demonstrations has been strong. Likewise, innovations that allow combinations of refinery CO2 streams to be co-processed have been demonstrated.
- Deployment of CCS in the refinery sector is set to grow between now and 2040 and this will offer possibilities to integrate CO2 utilisation, especially as green hydrogen and renewable energy becomes more available.

The report will be of interest to companies currently seeking opportunities to produce biofuels and seeking ways to adopt CO2 capture and utilisation technology.

In summary the report provides techno-economic benchmarks of the different routes in these three areas:

- Detailed techno-economic analyses on leading processes to create sustainable fuels, including thermo- and bio-catalytic approaches.
- Comprehensive review on the existing and emerging technologies for using and transforming CO2 to produce methanol.
- Insights on the technological and techno-economic aspects driving refinery CO2 capture with an emphasis on emissions from fired heaters, combined heat and power units, and SMR and FCC units which constitute the larger CO2 emitters within the refineries.

More information

More information about this report and other deliverables of the IETD Consortium can be found at:

www.catalystgrp.com/tcg-resources/member-programs/industrial-energy-transition-and-decarbonization-ietd-consortium/

Hubs could help pave the net zero way for Western Australia

The Government will invest more than $4 million to establish a CCUS industry in Western Australia as a new study reveals the State's enormous potential as a hub for carbon storage.

The study, commissioned and co-funded by the WA LNG Jobs Taskforce and undertaken by CSIRO and the Global CCS Institute, has found WA is capable of storing its own carbon and turning existing infrastructure into CCUS hubs.

To help progress CCUS in WA, the Cook Government will invest $4.3 million towards a CCUS Action Plan – putting WA at the forefront of the industry globally.

The Action Plan will aim to accelerate deployment of proven CCUS technologies in WA, support research into new CCUS technology and attract investment in CCUS.

The Cook Government is expected to introduce legislation to allow for the transport and storage of greenhouse gasses by the end of the year, supporting CCUS opportunities.

“We are going to be using gas for at least the next two decades, but we need to do something about the emissions now,” said Dr Karsten Michael, Principal Research Scientist with CSIRO’s Energy team and co-author of the report.

“The combination of concentrated high emissions industries, geological storage opportunities and a skilled workforce mean WA is in a unique position to establish a CCUS hub for industry decarbonisation in a relatively cost-effective way.”

Resource industries, including mining, oil and gas, make a vital contribution to WA's economy. In 2021, these industries added a combined $170 billion AUD to the gross state product and supported 120,000 jobs.

Industries across WA are working to reduce their greenhouse gas emissions in support of state and federal targets. There are plans to retire all the state’s coal-fired power plants by 2030.

This means natural gas will have an important role to play as the state transitions towards a low carbon economy. Particularly as a reliable energy source for energy intensive sectors like resources and manufacturing.

The study focussed on the potential for decarbonising LNG production and other industries in WA through the development of CCUS hubs.

The research included:

• Compiling emissions data and assessing geological storage options

• Undertaking techno-economic analysis of example CCUS hubs

• Assessing CO2 utilisation opportunities

• Identifying barriers and enablers for different options

• Identifying potential funding sources

The researchers modelled an example site in the Pilbara region. The models produced a range of options and found, under the right circumstances, a Pilbara Hub could meet 33 per cent of WA’s emissions reduction target. It would simultaneously generate 37,000 jobs during construction. It would additionally support 500 permanent jobs and boost WA state GDP by $55 billion between 2030 and 2050.

"The Pilbara is an obvious CCUS hub option because the existing cluster of gas processing plants produce a relatively pure CO2 stream that can be captured and stored at relatively low costs in the initial hub stage," Karsten said.

"Additional emissions sources can be added in later stages, including import of CO2 from other sources, for example the Perth-Kwinana area or internationally.

"You also have existing infrastructure like pipelines, port facilities, a skilled workforce, and highly prospective geological storage sites for safe and permanent CO2 storage.”

Key findings

Concentrating CCUS infrastructure in a hub model provides economies of scale in development. It can make the CCUS process viable for the high-emitting CO2 capture industries, including electricity generation, aluminum, and cement processing. It could also make the technology viable for smaller operations that would otherwise not be able to afford the associated costs.

"The costs of the capture itself would be higher for these sources because they have low CO2 concentration emissions streams, or lower volumes, and require additional processing," Karsten said.

“But that’s where a hub model can be very helpful. If you already have a facility nearby that will take the captured emissions and store them, it will change the economies of scale and allow you to decarbonise at a lower cost.

“The Pilbara CCUS Hub is also an ideal location for low-emissions hydrogen (blue hydrogen) production, involving steam methane reformation of the natural gas in combination with CCUS."

Like all CCUS hubs globally, there are several enablers that will be needed to turn the modelled CCUS hubs in Western Australia – or something like them - into a reality.

The study identified several key enabling factors that would be required. These include recognition of CCUS as an essential part of the state’s emissions reduction portfolio and appropriate policy and regulatory frameworks. It would require community support and the immediate need for certainty regarding the price of carbon, to allow for the long lead times required for large infrastructure investment.

More information

www.wa.gov.au

www.csiro.au

Projects and policy news

Ørsted begins construction of Denmark's first carbon capture project

www.orsted.com

Ørsted began construction of two CCS facilities designed to capture and store carbon emissions from the woodchip-fired Asnæs Power Station in Kalundborg and the straw-fired unit at Avedøre Power Station in Greater Copenhagen.

This project represents Denmark's first full-scale carbon capture project and signals the dawn of a new era for carbon capture and storage in the country.

The project, which was awarded a 20-year contract by the Danish Energy Agency in May 2023, will capture 430,000 tonnes of biogenic CO2 annually from the two combined heat and power plants starting from early 2026. The capture and storage of carbon from straw- and woodchip-fired power stations remove CO2 from the atmosphere, making a substantial contribution to Denmark's climate targets for 2025 and 2030.

The 'Ørsted Kalundborg CO2 Hub' project aims to capture and store 430,000 tons of CO2 annually from early 2026, equivalent to the annual carbon emissions from approximately 200,000 petrol-powered cars.

Ørsted will capture 150,000 tonnes of biogenic CO2 per year from the straw-fired unit at Avedøre Power Station. The CO2 will initially be transported by lorry to Asnæs Power Station until a shared pipeline infrastructure across Zealand has been established.

The straw-fired unit at Avedøre Power Station converts locally sourced straw into electricity and district heating. The straw used is a by-product of agriculture.

Ørsted will capture 280,000 tonnes of biogenic CO2 per year from the wood chip-fired unit at Asnæs Power Station, which will also function as a CO2 hub, handling and shipping biogenic carbon from both the Avedøre and Asnæs combined heat and power plants to the Northern Lights storage reservoir in the Norwegian part of the North Sea.

The wood chip-fired unit at Asnæs Power Station converts wood chips, primarily sourced from the Baltics, into electricity, district heating, and process steam for local industry.

Connecting Europe Facility: nearly €600M for energy infrastructure

energy.ec.europa.eu

Five carbon dioxide networks projects, one gas storage project, and two projects in the electricity sector have been selected for funding.

EU Member States have endorsed a Commission proposal to invest €594 million of EU funds in eight cross-border energy infrastructure projects under the Connecting Europe Facility (CEF) for Trans-European Networks for Energy.

At a time when there is increasing momentum for the development of CCUS to decarbonise hard-to abate sectors, an unprecedented amount of CEF funding for works (almost €480 million) will be awarded to four CO2 transport and storage projects.

They constitute the first building blocks of a future Europe-wide carbon value chain that are scheduled for completion before the end of the decade and are therefore expected to contribute to the EU's 2030 decarbonisation objectives.

€189 million is intended for a multimodal CO2 export hub in the port of Dunkirk in France, called D'Artagnan. CEF will support the construction of a collecting pipeline and an export terminal to provide industrial sites in the port and its hinterland with a route to export their captured CO2 to storage sites abroad.

€157 million will be awarded to CO2 infrastructure in the port of Rotterdam in the Netherlands, consisting of an import terminal for the reception of CO2 from carbon capture sites in various Member States (CO2NEXT project, €33 million in CEF grant) and of a 200 km undersea trunkline (Aramis project, €124 million in CEF grant) connecting the port to the future CO2 storage site in a depleted gas field offshore.

Finally, €131 million is intended for the Northern Lights initiative, a cross-border project linking CO2 capture initiatives in several EU Member States with a future storage site at sea on the Norwegian continental shelf.

The proposed CEF grant will support the expansion of the CO2 import terminal in Øygarden in Norway and the construction of a 100 km offshore pipeline to the storage site.

The EU CCS Interconnector, a CO2 infrastructure project Gdansk in in Poland, and the project to reinforce the Lonny-Achêne-Gramme electricity interconnector between France and Belgium will both be awarded CEF funding for studies necessary to their implementation, worth €2.54 million and €1.22 million respectively.

DOE invests over $45 Million for nine CCUS projects

www.energy.gov/fecm

$45.6 million in federal funding will advance CO2 capture technologies and help establish the foundation for a successful carbon transport and storage industry.

Large-scale deployment of carbon capture, transportation, and storage infrastructure is crucial to meeting the Administration's climate goal of achieving a net-zero emissions economy by 2050, while also delivering a healthier environment and economic opportunities.

"DOE is mobilising historic levels of private sector investment in the United States to capture, transport, and safely and permanently store hundreds of millions of tons of carbon dioxide per year from our industrial and power sectors," said Brad Crabtree, Assistant Secretary of Fossil Energy and Carbon Management.

"These demonstration and pilot projects bring us one step closer to effective and responsible deployment of carbon management infrastructure necessary to achieve our climate goals, while also providing good paying and jobs and health benefits to communities in every corner of the nation."

Some projects selected under this funding opportunity announcement will focus on developing lower cost, highly efficient technologies that will capture CO2 from power and industrial facilities for permanent geologic carbon storage or for conversion into long-lasting products.

This will include carbon capture in the cement, steel, and glass industries, as well as natural gas power plants. Others will focus on accelerating the deployment of multi-modal transport of CO2 through the creation of transportation hubs.

First step towards synthetic CO2 fixation in living cells

Researchers at the Max-Planck-Institute for Terrestrial Microbiology have developed a synthetic biochemical cycle that directly converts CO2 into the central building block Acetyl-CoA.

Synthetic biology offers the opportunity to build biochemical pathways for the capture and conversion of carbon dioxide. Researchers were able to implement each of the three cycle modules in the bacterium E.coli, which represents a major step towards realising synthetic CO2 fixing pathways within the context of living cells.

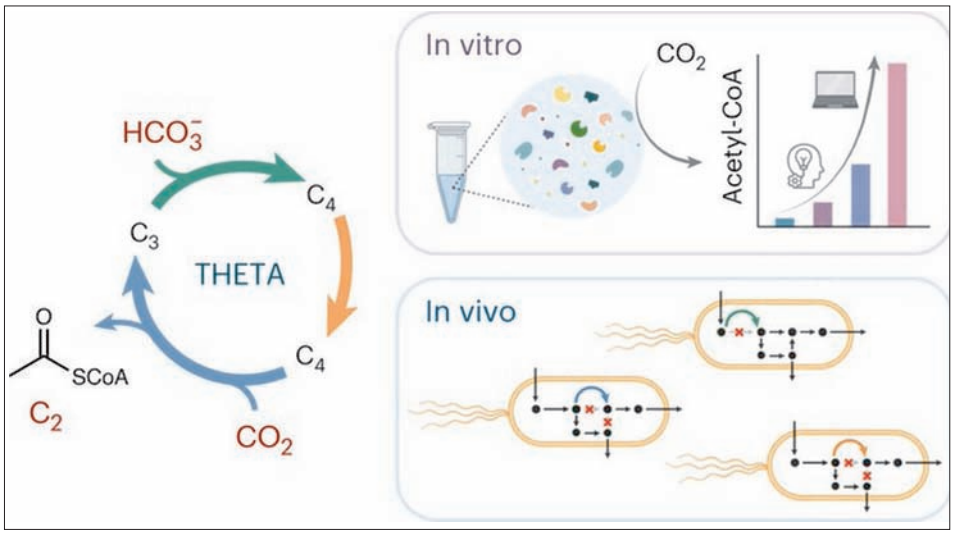
Developing new ways for the capture and conversion of CO2 is key to tackle the climate emergency. Synthetic biology opens avenues for designing new-to-nature CO2-fixation pathways that capture CO2 more efficiently than those developed by nature. However, realising those new-to-nature pathways in different in vitro and in vivo systems is still a fundamental challenge.

Now, researchers in Tobias Erb's group have designed and constructed a new synthetic CO2-fixation pathway, the so-called THETA cycle. It contains several central metabolites as intermediates, and with the central building block, acetyl-CoA, as its output. This characteristic makes it possible to be divided into modules and integrated into the central metabolism of E. coli.

The entire THETA cycle involves 17 biocatalysts, and was designed around the two fastest CO2-fixing enzymes known to date: crotonyl-CoA carboxylase/reductase and phosphoenolpyruvate carboxylase. The researchers found these powerful biocatalysts in bacteria. Although each of the carboxylases can capture CO2 more than 10 times faster than RubisCO, the CO2-fixing enzyme in chloroplasts, evolution itself has not brought these capable enzymes together in natural photosynthesis.

Central metabolite

The THETA cycle converts two CO2 molecules into one acetyl-CoA in one cycle. Acetyl-CoA is a central metabolite in almost all cellular metabolism and serves as the building block for a wide array of vital biomolecules, including biofuels, biomaterials, and pharmaceuticals, making it a compound of great interest in biotechnological applications.



Researchers at the Max Planck Institute for Terrestrial Microbiology have designed and constructed a new synthetic CO2-fixation pathway, the so-called THETA cycle

Upon constructing the cycle in test tubes, the researchers could confirm its functionality. Then the training began: through rational and machine learning-guided optimisation over several rounds of experiments, the team was able to improve the acetyl-CoA yield by a factor of 100.

In order to test its in vivo feasibility, incorporation into the living cell should be carried out step by step. To this end, the researchers divided the THETA cycle into three modules, each of which was successfully implemented into the bacterium E. coli. The functionality of these modules was verified through growth-coupled selection and/or isotopic labelling.

"What is special about this cycle is that it contains several intermediates that serve as central metabolites in the bacterium's metabolism. This overlap offers the opportunity to develop a modular approach for its implementation." explained Shanshan Luo, lead author of the study.

"We were able to demonstrate the functionality of the three individual modules in E. coli. However, we have not yet succeeded in closing the entire cycle so that E. coli can grow completely with CO2."

Closing the THETA cycle is still a major challenge, as all of the 17 reactions need to be synchronised with the natural metabolism of E. coli, which naturally involves hundreds to thousands of reactions. However, demonstrating the whole cycle in vivo is not the only goal, the researcher emphasizes. "Our cycle has the potential to become a versatile platform for producing valuable compounds directly from CO2 through extending its output molecule, acetyl-CoA." said Shanshan Luo.

More information

www.mpg.de

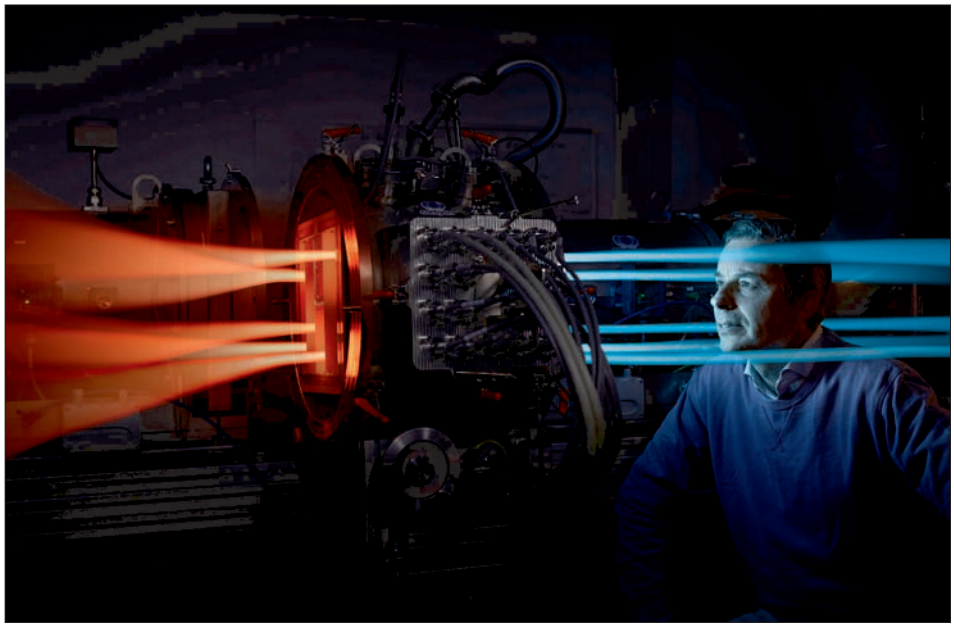
Carbyon develops ultra-fast carbon capture process

Dutch Direct Air Capture company Carbyon has successfully proven that its unique fast-swing process is able to capture CO2 using less than 2,500 kWh/ton.

Carbyon claims it was the world's first to drastically reduce the CAPEX costs of DAC equipment using its fast-swing process. The company now says it has found the missing piece to also sufficiently lower the energy consumption, making this breakthrough a giant leap towards a cost-effective DAC technology below $100/ton.

In its pursuit for a low-cost DAC solution, Carbyon invented an ultra-fast CO2 capturing material. Where conventional materials need hours to capture CO2 from air, Carbyon's can do the same in only a few minutes. In this way, each kilogram of their material captures up to 5 ton of CO2 annually. This allows for compact DAC machine design, resulting in a CAPEX cost below $50/ton.

Initially the fast-swing process suffered from collateral water adsorption, introducing an energy penalty. The recent breakthrough discovery massively reduces water uptake, resulting in an energy demand below 2,500 kWh/ton, while preserving their CAPEX benefits.



Carbyon believes it has found the missing piece of the puzzle: an ultra-fast carbon capture process proven with an energy demand below 2,500 kWh/ton. Photo by Bart van Overbeeke.

Carbyon is the first Direct Air Capture company to merge low CAPEX with low energy demand, thanks to their unique fast-swing process.

In light of the COP28 event, breakthroughs like these show that Direct Air Capture is becoming a mature solution that can help to meet our climate targets. To limit global warming to 2°C, the IPCC scenarios show that besides the necessary emission reductions, also vast amounts of CO2 need to be removed from the atmosphere. Direct Air Capture is marked as one of the important technologies that can enable fast and durable CO2 removal.

"Our relentless stare-down with Mother Nature's laws of physics finally gave us the insights into how to solve this puzzle," said Hans De Neve, founder and CEO of Carbyon. "This is a major team achievement, 2.500 kWh/ton is a challenging milestone for any DAC technology. Demonstrating this with an all-electric, low-CAPEX technology puts Carbyon in pole position to reach the $100/ton target that the market is looking for. Nothing can stop us now!"

The company is rapidly growing and is currently developing its first engineering-scale machine, that will be validated in the field together with pilot partners. So far, the company has raised $10M and is currently raising a Series A round to finance upcoming activities.

Carbyon was founded in 2019 as a spin-off company from Dutch research institute TNO. The company is located at the High Tech Campus in Eindhoven, the Netherlands, one of the world's leading technology research and innovation centers.

It has a science-heavy team, balanced by the support of experienced business professionals.

The company recently commissioned two newly-designed prototypes in its testing facilities in Eindhoven, enabling the capture of CO2 directly from outside air. The two machines are the first that consolidate all essential functionalities into a complete, cutting-edge direct air capture system.

The machines have been co-created together with Demcon, an experienced high tech systems developer. It was chosen to have 2 exact duplicates in order to double test capacity and validate results. The installations were designed in such a way that different configurations can be applied providing research flexibility.

More information

www.carbyon.com

www.demcon.com

Liquid Wind and industry partners plan additional 10 eMethanol plants

Liquid Wind announces a further strengthening of its partnership with European decarbonisation leaders to include plans of developing and marketing 10 additional eMethanol facilities in the Nordics by 2027.

The Partnership was initially formulated in 2020 among key partners Alfa Laval, Carbon Clean, Siemens Energy and Topsoe. With the shared vision of creating a world that no longer relies on fossil fuels, the collaboration aims to reduce the time, cost, and risk of developing and executing Core eMethanol Plants (CMP).

Building on several years of successful collaboration, as demonstrated by the world-first commercial scale eMethanol facility FlagshipONE, the partners' common mission is to establish 80 standardised, state-of-the-art 100,000 tons eMethanol units by 2030, which are estimated to reduce CO2 emissions by 14 million tons CO2 per annum.

Claes Fredriksson, CEO and founder of Liquid Wind, explained, "The collaboration with our "community partners" has been great for several years, having initially started back in 2018 with a few partners. It is exciting to see our joint efforts intensifying, elevating the degree of both our integration and transparency. Since we began in 2018, numerous developments have taken place within Liquid Wind and also in the market. The coming years will be filled with stimulating and exciting value-generating teamwork."

With this latest expansion in its commitment, the partnership will increase production efficiency to further ramp up design and execution of plants to produce a nominal 100,000 tons eMethanol per year with the aim to develop and market an additional ten Core eMethanol Plants (CMP) before the end of 2027. These units will contribute significantly to the global eMethanol market and future reduction in emissions in hard-to-abate industries such as global shipping.

Julien Gennetier, VP Energy Division at Alfa Laval, commented, "We are very pleased to be a part of this important eFuel project which is an essential building block for the decarbonization of shipping and the overall race to reach net zero. We strongly believe in partnership to win that race and develop the right solution from the start."

An illustration of a proposed Liquid Wind electrofuel facility (Image: Liquid Wind)

The partnership will continue to deliver industry leading ready-to-build eMethanol facilities that are quicker to fabricate, transport, construct, and commission, using partners' innovative technologies and modular solutions. By pooling the partners' technology expertise and capabilities, the partnership aims to unlock new, innovative, and effective fuel solutions for the shipping industry, other hard-to-abate industries, and society at large.

Aniruddha Sharma, Chair and CEO of Carbon Clean, said, "Our continued partnership with Liquid Wind demonstrates the role carbon capture must play in decarbonizing hard-to-abate sectors, such as shipping. Carbon Clean's modular point-source carbon capture technology is the most efficient and cost-effective means of decarbonizing many industries, and it will play a vital role in accelerating eMethanol facilities. I look forward to collaborating with the other industry leaders on many more projects to come – showcasing the U in CCUS as a perfect utilization example."

More information

www.liquidwind.se

www.carbonclean.com

Deep Sky raises funds, signs deals to test and deploy DAC in Canada

Deep Sky is the world's first carbon removal project developer deploying the best carbon capture technology from around the world under one roof.

The company raised a total of $75M CAD in its Series A funding to support gigaton-scale carbon removal in Canada.

The round includes conversion of its $17.7M seed note and $57.5M in new capital co-led by Brightspark Ventures and Whitecap Venture Partners, with major participation from Investissement Québec ($25M), as a mandate of the government of Quebec, OMERS Ventures, and Business Development Bank of Canada (BDC)'s Climate Tech Fund.

The fresh capital will be used to begin planning and construction of its first commercial facility; grow the team; build corresponding carbon removal software for selling carbon credits; and fund its Alpha research facility, the world's first carbon removal research center.

Climeworks

Climeworks and Deep Sky will explore the development of large-scale direct air capture and storage (DAC+S) projects in Canada, with a pathway to remove up to one million tons of CO2 from the air.

Canada represents a strategic location for the deployment of Climeworks' DAC+S solution in collaboration with local project developers such as Deep Sky. Its vast territory offers the potential for an abundance of renewable energy, including hydro and wind power, as well as permanent and safe geologic storage of CO2, both of which will be explored by the two parties under the agreement.

Open communication about local needs and expectations is regarded as a key for the collaboration's success. With its Canadian base, ability to build CDR infrastructure and its team's vast subsurface experience, Deep Sky is well-positioned to identify stakeholders across the public and private sectors to engage with potential projects.

The collaboration envisions the development of DAC+S projects with a pathway of removing up to one million tons of CO2, with the target to install the first DAC capacity before 2030. This is a crucial milestone for CDR technologies to reach before further scaling to gigaton capacity.

Airhive

Airhive, a UK-based DAC startup, has partnered to deploy one of the largest Direct Air Capture plants in Canada.

An illustration of Alpha, the world's first carbon removal research centre, which will be located in Montreal

Airhive will deliver and install a modular DAC unit to be operated at Deep Sky's pilot facility in Quebec in 2024. The unit will have the capacity to remove 1,000 tonnes of CO2 per year, making it one of the largest installed end-to-end DAC systems in the world.

Airhive's technology uses a unique fluidisation process. Fluidisation is the process of using a gas or liquid – like air – to make static solid particles behave as "fluid." Airhive uses naturally carbon-absorbing rock minerals and increases their capacity to uptake CO2 by reforming them into small particles with very high surface areas. The particles then get "fluidised," creating a turbulent sandstorm-like cloud in which the particles rapidly collide with the CO2 molecules in the air.

This naturally occurring process normally takes thousands of years, but Airhive makes it happen in minutes - the process removes close to 100% of the CO2 in air passed through its system in less than 0.1 seconds.

Once in operation, the partners will monitor the performance of the DAC unit and collect data on the performance of the unit in terms of carbon dioxide removal (CDR), energy consumption, and more. The partnership aims to validate the technology for commercial deployment in Canada as part of Deep Sky's mission to develop Canada into a world-leading hub for carbon removal. This follows successful demonstrations of Airhive's technology in its London lab and via the ongoing development of an 80 tonne pilot in Teesside, in northern England.

"We have been incredibly impressed by Deep Sky's vision, speed and capability, and we're delighted to be working with them to deliver on their vision," said Rory Brown, Airhive CEO. "At 1,000 tonnes annual capacity, our system will be one of the largest installed end-to-end DAC systems in the world, and a demonstration of our commitment to scaling low-cost, energy efficient DAC as rapidly as our climate needs and deserves."

More information

www.deepskyclimate.com
www.climeworks.com
www.airhive.earth

C-Capture begins CCS trial in the glass industry

The project aims to demonstrate that a low-cost carbon capture solution is a reality for difficult-to-decarbonise industries in the race to net zero.

C-Capture began Europe's first carbon capture trial on a mainstream flat glass manufacturing plant. The trial forms part of the company's national project, 'XLR8 CCS – Accelerating the Deployment of a Low-Cost Carbon Capture Solution for Hard-to-Abate Industries'.

Tom White, CEO, C-Capture, said, "With COP 28 recently drawing to a close, we are proud to announce a significant step on the path to net zero with the successful start of our carbon capture trial in the glass manufacturing industry. Carbon capture is an essential part of the raft of solutions that are urgently needed to tackle climate change. Currently though, barriers such as cost, technology maturity and compatibility within multiple industries, are preventing the widespread adoption of carbon capture."

"Based on a fundamentally different chemistry to other commercially available approaches, our next generation technology is an innovation in the carbon capture sector. It is lower cost and environmentally benign as it does not rely on the use of amines. It is also extremely robust and suitable for use in industries such as glass and cement which are essential to the economy but difficult to decarbonise due to the high level of impurities in their flue gases."

"The advantages of C-Capture's approach mean it has the potential to break through the barriers that are currently preventing the widespread adoption of carbon capture and storage technology – and make a globally significant contribution to tackling climate change."

Beginning with glass production, XLR8 CCS will prove the ability of C-Capture's innovative carbon capture technology to remove carbon dioxide from the flue gas emissions of three industries which are difficult-to-decarbonise but committed to reducing their carbon levels. Carbon capture trials will follow in the cement and energy from waste industries as part of the project which secured £1.7m in funding from the Department of Energy Security and Net Zero's £1 billion Net Zero Innovation Portfolio.

C-Capture's Project Manager, Claudia Hernandez and XLR8 CCS project partners at the CCSCU which has been deployed at Pilkington UK's site in St Helens, UK, to trial C-Capture's carbon capture technology in the glass manufacturing industry

The funding is part of the £20 million Carbon Capture, Usage and Storage Innovation 2.0 programme aimed at accelerating the deployment of next-generation CCUS technology in the UK. Additional private sector contributions support a £2.7 million total for this multi-industry project.

The carbon capture trial is now successfully underway in St Helens, UK, at XLR8 CCS project partner's Pilkington UK glass manufacturing site part of NSG Group. It is the first demonstration of a carbon-capture technology on an industrial flat glass furnace in Europe.

The compatibility of C-Capture's proprietary solvent-based technology will be assessed with a further five carbon capture trials from next year at sites owned by project partners Glass Futures, Heidelberg Materials and Energy Works Hull – in conjunction with leading consulting and engineering company, Wood. Carbon capture solvent compatibility units (CCSCUs) designed and built by C-Capture and Wood will be installed and operated on partners' sites.

Project success will see C-Capture and its project partners well placed for deployment of commercial-scale carbon capture facilities across the three industries by 2030 which could capture millions of tonnes of CO2per year.

UK Minister for Energy Efficiency, Lord Callanan, said, "Carbon capture will play an essential role to decarbonise heavy industries and deliver on our ambitious climate goals."

"We've already invested nearly £350 million in the technology, including for this first ever carbon capture trial in the flat glass industry in Europe."

More information

www.c-capture.co.uk

Capture & utilisation news

BlackRock invests $550m in Oxy's STRATOS DAC project

www.1pointfive.com
www.blackrock.com

BlackRock has signed a definitive agreement to form a joint venture with Occidental through its subsidiary 1PointFive that will own STRATOS.

STRATOS is designed to capture up to 500,000 tonnes of CO2 per year. and will be the world's largest Direct Air Capture facility. Construction activities for STRATOS are approximately 30 percent complete and the facility is expected to be commercially operational in mid-2025. The project is expected to employ more than 1,000 people during the construction phase and up to 75 once operational.

"We are excited to partner with BlackRock on this transformative facility that will provide a solution to help the world reach net zero," said Vicki Hollub, President and CEO, Occidental. "This joint venture demonstrates that Direct Air Capture is becoming an investable technology and BlackRock's commitment in STRATOS underscores its importance and potential for the world. We believe that BlackRock's expertise across global markets and industries makes them the ideal partner to help further industrial-scale Direct Air Capture."

STRATOS is expected to provide cost-effective solutions that companies in hard-to-decarbonise industries can use in conjunction with their own emissions reduction programs. To date, 1PointFive has signed CO2 removal credit purchase agreements with customers, including Amazon, Airbus, All Nippon Airways (ANA), TD Bank Group, the Houston Astros, and the Houston Texans.

"BlackRock is proud to partner with global energy leader Occidental to help build the world's largest direct air carbon capture facility in Texas," said Larry Fink, Chairman and CEO, BlackRock. "Occidental's technical expertise brings unprecedented scale to this cutting-edge decarbonisation technology. STRATOS represents an incredible investment opportunity for BlackRock's clients to invest in this unique energy infrastructure project and underscores the critical role of American energy companies in climate technology innovation."

ExxonMobil to build CCS pilot plant with FuelCell Energy

www.fuelcellenergy.com
www.exxonmobil.com

The pilot plant aims to obtain data on performance and operability of the carbonate fuel cell (CFC) technology, jointly developed with FuelCell Energy.

ExxonMobil's affiliate Esso Nederland BV plans to build a pilot plant at its Rotterdam Manufacturing Complex to test a breakthrough technology that could significantly reduce CO2 emissions from key industries.

Additionally, the pilot aims to address potential technical issues that may occur in a commercial environment and better understand the costs of installing and operating a CFC plant for carbon capture.

"The unique advantage of this technology is that it not only captures CO2 but also produces low carbon power, heat, and hydrogen as co-products," said Geoff Richardson, SVP of Commercial and Business Development for ExxonMobil Low Carbon Solutions. "We are excited for the opportunity to pilot this innovation at our own Rotterdam facility."

Esso's Rotterdam integrated manufacturing site will be the first place in the world to pilot this technology. Pending a successful demonstration, ExxonMobil could deploy this technology at its manufacturing sites around the world.

Carbonate fuel cells have a unique ability to capture CO2 emissions from industrial sources before they are released into the atmosphere, while also making valuable co-products. This feature increases the overall efficiency of the capture process and provides additional value streams that reduce the cost of carbon capture and storage.

CFC technology is also modular, potentially enabling carbon capture across a wide range of deployment scales. When the CFC technology is technically ready for broadscale implementation, it could potentially offer economical decarbonization solutions for customers from a wide range of industries and serve the broader goal of working towards a net-zero future.

"FuelCell Energy and ExxonMobil believe that capturing carbon at the source is an efficient way to decarbonize heavy industry," said FuelCell Energy President and Chief Executive Officer Jason Few.

"This technology can capture carbon and produce electricity simultaneously, making it a game-changer in the industry."

The pilot project is co-funded by the European Union under the Emissions Trading System Innovation Fund and by the Netherlands Enterprise Agency by means of a Demonstration Energy and Climate Innovation (DEI+) grant.

Air Liquide to build a world-scale CO2 capture unit in Rotterdam

www.airliquide.com

The company will build, own and operate the carbon capture unit in the industrial basin of Rotterdam using its proprietary Cryocap™ technology.

The new unit will be installed at the Group's hydrogen production plant located in the port of Rotterdam and will be connected to Porthos, one of Europe's largest carbon capture and storage sites aiming at significantly reducing CO2 emissions. Through this project, Air Liquide will be able to supply hydrogen that will be significantly decarbonised to its long-term customers.

Air Liquide will capture the CO2 from its existing world-scale hydrogen plant in the port of Rotterdam, using Cryocap™, a technological solution for CO2 capture using a cryogenic process.The carbon capture unit will be operational in 2026.

The Porthos infrastructure overall will enable to reduce emissions by 2.5 million tons of CO2 per year – equivalent to around 10% of the current Rotterdam industry CO2 emissions.

The European Union has recognised Porthos as a major cross-border infrastructure project, contributing to the achievement of energy and climate policy objectives, and has included Porthos to the list of Project of Common Interest.

Santos, JX and ENEOS to support potential expansion of Moomba Phase 2

Following the passage of legislation through the Australian parliament to facilitate the cross-border transfer of CO2, Santos has announced a new agreement with two major Japanese energy companies to collaborate on CCS.

Santos plans to expand the Moomba CCS project and transform the Cooper Basin into a decarbonisation and low-carbon fuels hub.

The signing of an MoU between Santos, JX Nippon Oil & Gas Exploration Corporation and ENEOS Corporation paves the way for a joint feasibility study that will evaluate the potential to capture, transport and sequester emissions from Japan, supporting expansion of the Moomba CCS project.

The aggregation and management of carbon at Moomba would also support Santos' Energy Solutions low-carbon fuels ambitions and complements current studies with Tokyo Gas and Osaka Gas for potential low-carbon e-methane production in the Cooper Basin. This would facilitate the export of e-methane, made by combining green hydrogen with CO2 obtained from industrial emissions or direct air capture in a circular economy.

The agreement seeks to jointly identify and define commercial and investment opportunities covering the potential importation of up to 5Mtpa of CO2 by 2030, 10Mtpa by 2035 and 20Mtpa by 2040 from Japan to the Moomba CCS project, via either Port Bonython in South Australia or Gladstone in Queensland.

This would potentially provide a large-scale source of CO2 to support Phase 2 of the Moomba CCS project and provide feedstock for future e-methane production. At the same time, this would put South Australia and Santos front and centre in helping Japan to decarbonise its economy.

Santos Chief Executive Officer and Managing Director Kevin Gallagher said the targets set for the study with JX and ENEOS demonstrate the enormous potential of Moomba as a decarbonisation and low-carbon fuels hub, and as an exciting new industry for South Australia.

"If we progress to the next stage, this collaboration could potentially extend the life of the Cooper Basin for another 55 years, keeping it at the centre of a modern Australian energy industry and supporting hundreds of well-paying, skilled and secure jobs for another three generations and beyond."

Santos plans to expand Moomba into a CCS hub for the region

The first phase of the Moomba CCS project is 75 per cent complete with first injection on track for 2024. Moomba CCS is targeting about US$24 per tonne lifecycle breakeven storage costs which will make it one of the lowest-cost CCS projects globally.

The project will have capacity to store up to 1.7 million tonnes of CO2 per year. That's equivalent to delivering – every year – more than 25 per cent of the total emissions reduction achieved in Australia's electricity sector over the past year to March 2023.

"The CO2 target set for 2040 in this study is equivalent to delivering – every year – triple the total emissions reduction achieved in Australia's electricity sector last year. It also equates to around two-thirds of Santos' total annual Scope 3 emissions today or almost four times our current annual Scope 1 and 2 emissions – it's huge," Mr Gallagher said.

"There is surging demand for carbon abatement technologies as our region strives to meet net-zero ambitions. Australia is in a prime position to drive circular economies using its vast carbon storage and renewable energy resources. This combination will make Australia not only a renewable energy superpower, but we can also be a decarbonisation and low-carbon fuels superpower."

Santos said its position in the Cooper Basin with its vast tracts of land, world-class renewable energy resources, strong regulatory framework, depleted oil and gas reservoirs and existing infrastructure, gives an important competitive advantage in pursing this opportunity.

The MoU builds on and complements recent MoUs with APA and ADNOC as Santos seeks to build out a network of CO2 pipeline and other infrastructure supporting a new carbon capture and storage industry in Australia.

More information

www.santos.com

Xodus report: 100 North Sea storage sites needed to meet 2050 CCUS demand

The volume of CO2 injected into the North Sea by 2050 will be equivalent to the natural gas currently being extracted from the basin, according to a new report from global energy consultancy Xodus.

That scale of CO2 storage will require some 100 reservoirs, more than 7,500 kilometres of new pipelines and dozens of onshore emissions capturing and gathering sites.

'Forecasting the North Sea CCUS infrastructure to 2050' was produced in partnership with Subsea7 and is designed to be used as a tool for assessing the relative cost efficiency of CCUS projects and when they would become viable.

Through a detailed analysis, Xodus assessed 560 potential storage sites, existing North Sea gas pipelines and potential new infrastructure to rank the cost efficiency of different CCUS initiatives.

It is hoped that this whitepaper will support CCUS operators and stakeholder to make better informed investment decisions.

Europe is the only leading economic region that has its largest hydrocarbon basin at the heart of its economy. About 40% of European industrial emissions are generated within 500km of the North Sea, a strategic advantage in reducing the cost of developing CCUS projects.

In the coming decade, Xodus forecasts that up to 100% of European CCUS projects will be anchored in the North Sea, though over time this share will reduce. Based on the high-case estimates for emissions reduction, by 2050 the North Sea would retain a 60% market share of a 500 megatonnes per annum (MTPA) market.

Emissions will be imported by vessels and long-distance pipelines but to what extent depends on various factors, including transportation costs, competing storage sites and societal attitudes towards onshore storage.

Steve Swindell, CEO of Xodus said:, If we're to get to net zero in an orderly and timely manner, pioneering technologies like CCUS are a necessity, not an option. Fortunately, the North Sea's world-class oil and gas industry provides the perfect foundation for the rollout of carbon capture, with the potential to repurpose and build around existing infrastructure."

"But the outlook for this crucial technology is somewhat vague with many question marks around timing, volume and prime locations for locking away emissions. Our study analyses many of these uncertainties by examining the infrastructure needed to enable deployment at scale."

There could be eight CCUS projects operational in Europe by the end of the decade, including the Viking cluster in the UK

"We have developed this tool to generate scenario-based forecasts of how Europe's CCUS sector will mature up to 2050, a major asset in helping developers to make educated and accurate investment decisions."

By the end of the decade, Xodus expects there to be eight operational CCUS projects in Europe, including Northern Lights in Norway, and the Viking and Acorn clusters in the UK. All carbon stores will be situated near or linked to high emitting regions, offering a decarbonisation solution for vast swathes of heavy industry.

Developments will likely be supported by direct government subsidies, alongside contracts tied to the ETS and UKTS emissions schemes.

James McAreavey, Head of CCUS at Xodus said, "It will require a Herculean effort to deliver CCUS projects at the scale Europe needs, but the enormous benefits of doing so are obvious. There is the chance to make the most of existing synergies with the offshore oil and gas industry and reuse miles of existing pipelines that may otherwise need to be removed from the North Sea."

"As the transition progresses, it is inevitable that CCUS projects will be competing for seabed area with other low carbon technologies, but that could drive collaboration between industries and lead to the creation of a basin-wide integrated energy system."

Xodus' work also finds that, with the right approach, between 50% and 70% of North Sea CO2 storage could re-use infrastructure, delivering significant cost savings and environmental benefits.

But this hinges on a strategic national and cross border infrastructure build-out strategy to ensure key infrastructure is kept in place.

More information

www.xodusgroup.com

Northern Lights value chain provides 97% net CO2 abatement

Northern Lights has conducted a study to assess the estimated carbon footprint of its CO2 transport and storage value chain throughout all phases of its lifecycle, from construction to decommissioning.

The study found that Northern Lights will have a net abatement of 97.4% of the stored CO2. This assessment is based on the first developments of Northern Lights with a minimum injection of 5 million tonnes CO2 per annum through 25 years.

The study demonstrates that the Northern Lights CCS value chain is a viable concept and an efficient climate solution that contributes to net reduction of greenhouse gas emissions from hard-to-abate industries.

Key findings:

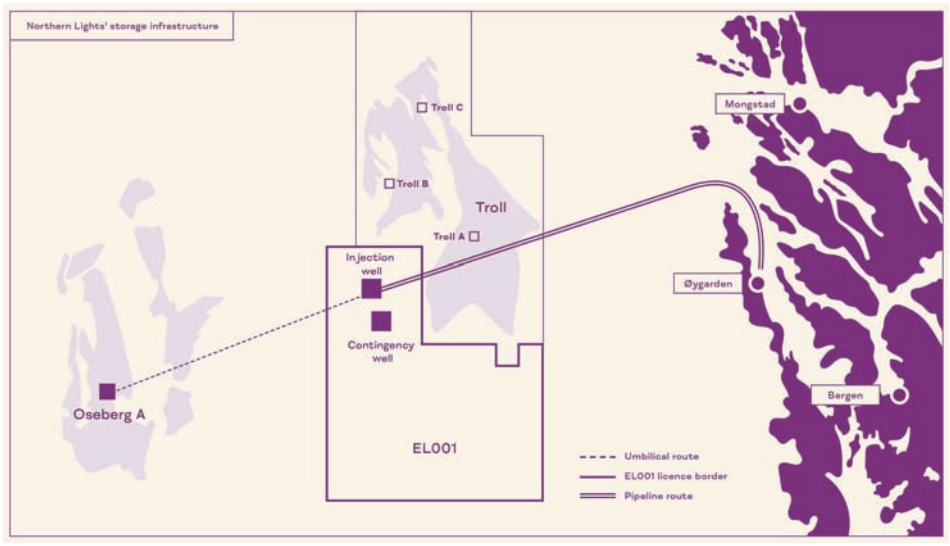
- Northern Lights will store 127.8 million tonnes CO2 over the lifetime of its first development phases.
- The estimated lifecycle emissions are 3.3 million tonnes throughout the value chain.
- Northern Lights will have a net greenhouse gas reduction of 124.5 million tonnes CO2.
- This gives an estimated net abatement of 97.4% of the total amount of CO2 injected.

The lifecycle emissions of 2.6% from the Northern Lights value chain are largely related to the operations of CO2 transport, more specifically the ship fuel consumption.

Northern Lights has already implemented solutions such as LNG fuel, wind-assisted rotor sails, and air lubrication which reduces the carbon footprint compared to conventional ships, and said it is continuously working to assess further climate mitigating solutions.

Background

In December 2020 the Norwegian government committed funding to the development of a full-scale carbon capture and storage project named Longship. To materialize this project, 3 companies (Equinor, Shell and TotalEnergies) established a joint venture, the Northern Lights JV, to oversee the transport and storage part of the chain.



The main objective of Northern Lights JV is to enable the decarbonisation of European industry by providing a service of CO2 transport and storage

The carbon footprint assessment of the Northern Lights value chain was performed to (1) take stock of the current situation and (2) identify further measures to reduce the carbon footprint of the value chain. Calculating the net GHG emissions per tonne of CO2 stored is key to demonstrate that the Northern Lights CCS value chain is a viable concept effectively contributing to GHG emissions mitigation.

The assessment was performed following ISO 14040 / 14044 standards. As of March 2023, the Northern Lights infrastructure to transport and store CO2 is still under construction and planning. As such, this study relies on currently available data and best estimates. Two development phases of the chain are envisaged (1.5 and 3.5MtCO2 stored per year).

The results of assessment have shown that over the project lifetime (from construction to post closure of the storage site) for both phases of the development, a total of 3.32 MtCO2e are expected to be emitted for a total of 127.8 MtCO2 stored. In other words, 0.026 CO2e are emitted per tonne of CO2 stored. 91% of the emissions from the chain development and operation are coming from the transport part of the value chain, i.e. shipping.

The result highlights the viability of the Northern Lights JV value chain in effectively storing more CO2 than it emits. To further improve the carbon footprint of the value chain, Northern Lights JV is currently studying additional mitigation options and compensation mechanisms.

Northern Lights has recently been awarded €131 million under the Connecting Europ- Facility funding scheme. It has also chartered its fourth ship, making it the world's largest dedicated CO2 shipping fleet.

See the infographic on the back page.

More information

www.norlights.com

Transport and storage news

Dutch large scale CO2 storage project L10CCS reaches FEED phase

www.neptuneenergy.com

The project is one of the large stores to be connected to the Aramis CO2 transport and storage initiative in the Dutch part of the North Sea.

Neptune Energy and its partners EBN, Tenaz Energy and ExxonMobil Netherlands CCS have successfully progressed the L10CCS project from the Concept Select phase, which includes various technical and economic assessments, into this next Define/FEED phase.

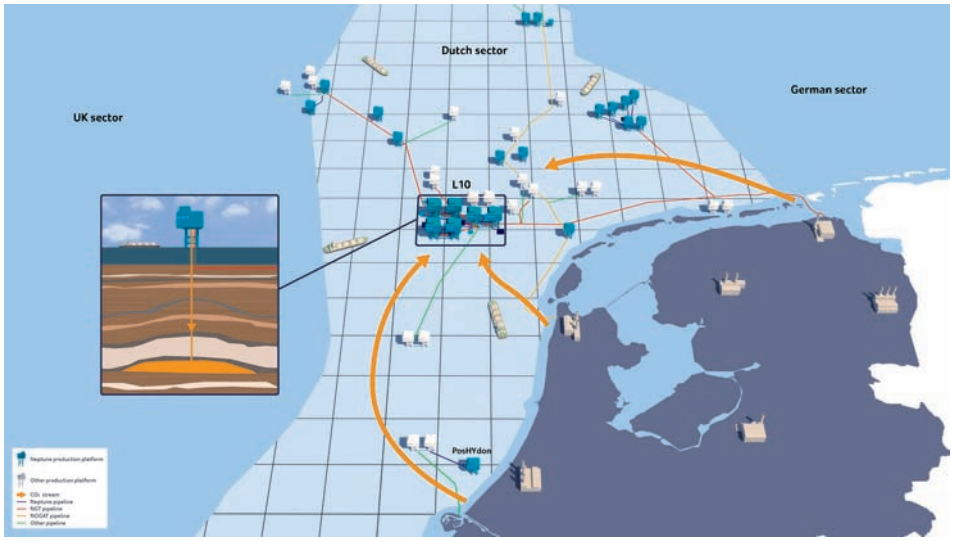
L10CCS seeks to store 5Mton CO2 annually, equivalent to a third of the total CO2 emissions from Dutch domestic vehicles in one year. All partners have signed up to a FEED Cooperation Agreement and Neptune has awarded the Facilities FEED contract to Petrofac, with the contract having kicked off last month.

Lex de Groot, Managing Director of Neptune Energy in the Netherlands, the operator of L10CCS, said, "CCS is expected to account for nearly 15% of the cumulative reduction in CO2 emissions in the EU, according to the IEA Sustainable Development Scenario.

"Without CO2 storage it would not be possible to meet the climate goals. To create a well-functioning CCS market, both emitters and storage providers need CO2 transport. The region around L10 has a potential storage capacity up to 120-150 MT, so will play a crucial role in helping achieve climate goals and open up possibilities for many emitters that need safe CO2 storage in the North Sea at low costs."

The storage licence application for L10CCS was submitted in the second quarter of 2023. The project is awaiting award of the licence by the Dutch Ministry of Economic Affairs & Climate Policy. Talks with emitters, looking for a safe place to store their carbon in depleted gas fields under the North Sea, are ongoing and necessary contractual arrangements will be progressed during this project phase.

Completion of the technical FEED scopes is anticipated during the second half of 2024, with a view to progressing towards a project



Final Investment Decision (FID) shortly thereafter in 2025. The timeline of L10CCS is fully aligned with the Aramis project timeline and is planned to be connected and operational as of day 1 of the opening of this CO2 transport system, now planned in 2028.

Improving the assessment of CO2 storage sites

www.liverpool.ac.uk

www.ukccsrc.ac.uk

A University of Liverpool researcher has been awarded £30k funding for a new project that aims to improve our knowledge of fault behaviour for CO2 storage site assessment.

Dr Emma Michie, a lecturer in Geology with the Department of Earth, Ocean and Ecological Sciences, has secured a nine month Flexible Funding grant from the UK Carbon Capture and Storage Research Community Network (UKCCSRC).

The project will draw on Dr Michie's background knowledge in structural geology to increase our knowledge and confidence in assessing the validity of CO2 storage sites, by analysing surface samples from the Central and Northern Apennines, Italy, and subsurface samples from Norwegian North Sea.

She said, "I am delighted to receive this funding to help improve our knowledge of fault behaviour for CO2 storage site assessment. As part of this funding, I have just returned from a successful fieldtrip to Italy examining outcrop analogues. I look forward to diving into the analysis of the samples I collected during this trip."

The project is one of 13 projects supported by the UKCCSRC, an organisation that supports, strengthens and integrates the UK carbon capture and storage community.

Professor Jon Gibbins, UKCCSRC Director, said, "This UKCCSRC Flexible Funding round will be tackling a wide range of projects suggested by the needs of the UK's growing CCS deployment sector."

Petrofac wins FEED for Netherlands Aramis CCS project

www.aramis-ccs.com

www.petrofac.com

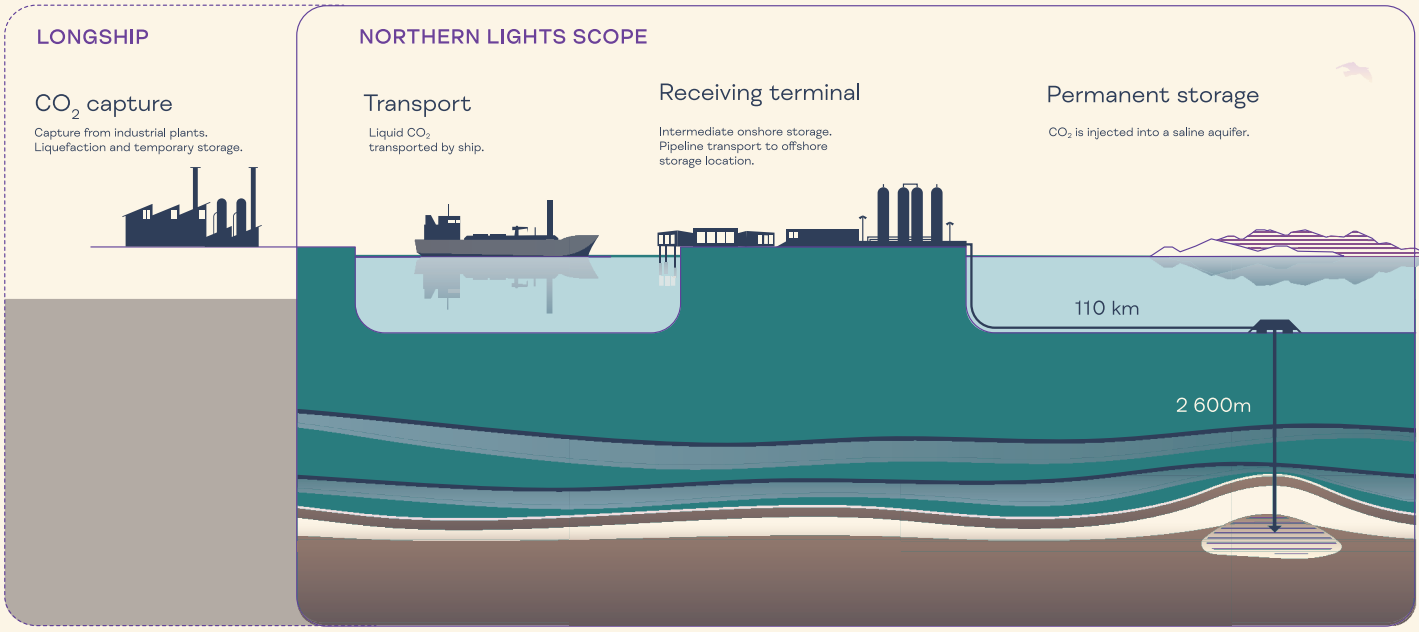
Petrofac has begun a multi-million-dollar front-end-engineering design (FEED) for the Netherlands' flagship carbon transport and storage system, Aramis.

Aramis, a joint development by TotalEnergies, Shell, Energie Beheer Nederland (EBN) and Gasunie, offers a route to decarbonisation for hard-to-abate industries across the Netherlands, Belgium, and France. It seeks to capture carbon dioxide from industrial clusters, transporting it for permanent storage in depleted offshore gas fields under the North Sea.

The captured CO2 will be carried via onshore pipeline or ship to a collection hub in the Port of Rotterdam. Following temporary storage and compression, the CO2 will be carried by pipeline designed to transport up to 22 million tonnes of CO2 annually, to several offshore facilities.

Carbon footprint of the Northern Lights JV CO2 transport and storage value chain

Northern Lights

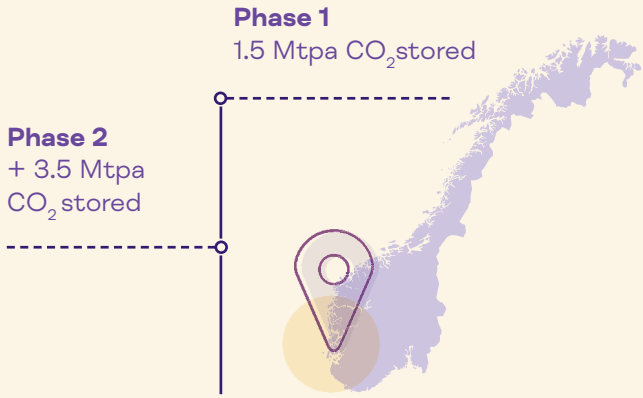


CARBON FOOTPRINT OF THE VALUE CHAIN

127.8	3.3	97.4%
Mt CO_2 Stored over project lifetime	Mt CO_2 Lifecycle emissions of the value chain	Net abatement potential

About the project

In December 2020 the Norwegian government committed funding to the development of a full-scale CCS project named Longship, which aims to capture CO_2 from industrial sources in the Oslo-fjord region, transport it to Øygarden onshore terminal, and inject for permanent storage in a deep saline aquifer in the North Sea. Northern Lights JV was established to oversee the transport and storage part of the value chain. Northern Lights JV will deliver CO_2 transport and storage services to other companies across Europe.



About the methodology

The study was performed according to the ISO standards 14040 and 14044, accounting for all the emissions of greenhouse gases induced directly or indirectly during the entire lifecycle of Northern Lights activities. For each activity, the design, procurement, construction, operation, decommissioning, postinjection and post closure phases are assessed.