CCUS in EMEA
Mitsubishi: leading innovation and deployment in the region
GreenPulse Project: onshore storage network in Spain
First carbon storage at Project Greensand

Stockholm Norvik Port: potential CCS hub

NGK INSULATORS’ honeycomb structures for Direct Air Capture
Better ways to do natural gas treatment while making useful products
Solvent developed at Queen’s University could transform carbon capture
Lloyd’s Register finds technology ready for onboard CO2 capture
That possibility is narrowing rapidly, with energy-related CO₂ emissions continuing to rise in 2022 despite declining costs for clean energy technologies and the dynamic deployment of renewables, electric cars and other solutions.

Declining costs for clean energy technologies and new policies have shaved around 1 °C from projected 2100 warming compared to the pre-Paris baseline. The ambitions that countries have put on the table go a significant way to meeting the 1.5 °C goal. If implemented on time and in full, countries’ net zero pledges would be sufficient to hold warming to around 1.7 °C in 2100.

The key question is therefore what needs to be done now to strengthen near-term action to put the world on a credible pathway consistent with the 1.5 °C goal. Four pillars are key:

• In the energy sector, decarbonising electricity, accelerating energy efficiency and electrification are the critical tools. Capacity additions of renewables need to triple from 2022 levels by 2030, reaching around 1200 GW annually, representing on average 90% of new generation capacity each year. Electric car sales should reach a market share of around 60% by 2030, while zero emissions medium and heavy freight trucks should reach a market share of around 35% by the same year.

• Reducing deforestation to net zero by 2030 – in line with The Glasgow Leaders’ Declaration on Forests and Land Use – provides the largest share of CO₂ emissions reductions from the land-use sector.

• Tackling non-CO₂ emissions is vital to limiting peak warming. Assuming strong action on CO₂, meeting or exceeding commitments like the Kigali Amendment on HFCs and the Global Methane Pledge, and acting on non-CO₂ emissions from agriculture, could make the difference between a scenario which substantially overshoots 1.5 °C, risking triggering irreversible climate tipping points, and one which does not.

• Even in a low overshoot scenario, carbon capture and storage and atmospheric carbon dioxide removal will be required to mitigate and compensate hard-to-abate residual emissions. Projects capturing around 1.2 Gt CO₂ by 2030 need to be implemented, against the roughly 0.3 Gt CO₂ currently planned for 2030.

A credible pathway to the 1.5 °C goal needs strong, immediate action on each of these four pillars, to deliver immediate and rapid emissions reductions; strong contributions from all countries, especially advanced and major economies; and clear policy signals to enable actors to anticipate and achieve change.

Carbon Management

Even if clean technologies outside of carbon management are deployed aggressively, carbon management will be needed to meet climate goals. By 2030, about 1.2 Gt are captured annually across the energy system in the Net Zero Emissions by 2050 (NZE) Scenario. This represents almost a 30-fold increase on 2021 levels. Based on current project pipelines, annual carbon capture is projected to reach about 0.3 Gt by 2030. This implies that the current pipeline of projects would need to grow by four times to reach NZE levels by 2030.

Carbon management technologies are an important strategic tool in strong mitigation scenarios, but by no means a silver bullet. The scale of deployment required in the NZE Scenario is huge, equivalent to ten new CCUS-equipped facilities commissioned each month between now and 2030.
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CCUS in Europe, Middle East and Africa

Mitsubishi Heavy Industries: leading the way on CCUS in the EMEA region

While it’s important not to view carbon dioxide capture, utilization and storage as a silver-bullet solution to the climate crisis, carbon capture technologies can play a crucial role especially in helping hard-to-abate industries decarbonize their operations and in efforts to reach net zero emissions. By Mitsuaki “Mickey” Kato, General Manager at Mitsubishi Heavy Industries EMEA.

Current global capture capacity needs to increase almost 30-fold by 2030 to put us on course for net zero, according to the International Energy Agency (IEA). And while new projects are on an upward trajectory across the EMEA region and other parts of the world, realizing the technology’s full potential depends on it operating at scale — doing so quickly and collaboratively.

CCUS policy and landscape in EMEA

As one of the world’s largest carbon markets, Europe is home to a growing network of carbon capture initiatives. There were 71 existing or planned projects underway at the end of 2022, which could produce a combined capture capacity of around 80 MtCO2 per year by 2030. This includes the development of two secure geological storage sites beneath the North Sea: the Porthos project at the Port of Rotterdam in the Netherlands and Northern Lights. They could provide a total storage capacity of 300 Gt, or almost 80 years of current emissions, according to the IEA.

A key tool in the EU’s policy framework is a carbon pricing system on CO2 emissions within the bloc – the European Union Emissions Trading Scheme (EU ETS). It places a cap on industry emissions, beyond which heavy emitting industries are required to buy emissions allowances. With prices for allowances hovering just below €100 per tonne as of late, and the allocation free allowances being gradually scaled back, the incentives to deploy CCUS in the region are growing.

The value of financial transfers from the EU ETS reached around €751 billion in 2022; funds that can mainly be used to further the EU’s green agenda.

This ETS system is not without its risks, however. While the scheme provides an incentive for companies to find low-carbon alternatives rather than pay a carbon charge, it risks making companies within the bloc less competitive internationally. It could also lead heavy emitters in industries like fuel suppliers to pass additional costs on to customers in the form of higher pump prices.

That said, government incentives and a regulatory framework to help meet climate commitments are an important part of efforts to scale up carbon capture solutions throughout the region.

A funding pot of €1 billion — part of a wider €3 billion fund for low-carbon projects — from the EU’s Innovation Fund has been made available for innovative decarbonization initiatives, including CCUS projects, as part of the REPowEU Plan.

The policy framework must also encourage sufficient investment in new infrastructure for carbon capture, transportation and secure geological storage.

In response to President Joe Biden’s Inflation Reduction Act (IRA) legislation, which builds on the 45Q tax incentive scheme to offer investors significant tax breaks and subsidies for new capture projects based in the US, the EU is creating its own package of incentives to prevent investments leaving Europe for America.

Hubs and clusters

Across the English Channel from mainland Europe, the UK has pioneered several CCUS hub and cluster projects. These are made up of a group of local CO2 emitters that use their proximity to share common CCUS infrastructure to reduce emissions.

The Zero Carbon Humber project in the UK’s North East aims to become one of the world’s first net zero industrial regions, for example, combining oil refining, steelmaking, chemical and cement production. Working together, they can unlock CCUS’ local potential by capturing carbon from both natural gas and biomass-fired power generation and hydrogen production, which will be piped to secure storage sites beneath the North Sea.

As part of the Zero Carbon Humber cluster, Mitsubishi Heavy Industries (MHI) is working with Drax to provide carbon capture services to its bioenergy power station near Selby. Bioenergy with carbon capture and storage (BECCS) power plants can generate stable, reliable, baseload power and heat using biomass as a fuel.

The project aims to permanently remove 8Mt of CO2 per annum from the atmosphere. In doing so Drax Power Station aims to become one of the largest sources of Carbon Dioxide Removals (negative CO2) in the world.

A feasibility study is also in progress to explore ways of utilizing captured CO2 from the plant to produce proteins to manufacture sustainable animal feed, helping to promote the circular economy.

Since leaving the EU, the UK has established its own emissions trading scheme (UK ETS), which mirrors the EU ETC “cap and trade” carbon pricing policy in many respects. A limit is set on the total amount of carbon dioxide that can be emitted, which decreases over time so total emissions fall. Once the cap has been exceeded, per-tonne carbon allowances must be purchased at market prices.

The UK has committed to legally binding carbon reduction targets and aims to become net zero by 2050. To that end, the UK government’s March 2023 budget announced a £20 billion support package to encourage early development carbon capture projects.

The package aims to create 50,000 jobs, attract private sector investment and help capture 20-30 million tonnes of CO2 annually by
2030, as part of wider efforts to support 500,000 new green jobs by 2030.

Responding to the growth in demand and government support for CCUS projects in the UK and across Europe, MHI is increasing its local presence with a rapidly growing dedicated decarbonization team based in London.

**Innovation drives progress**

In what is essentially still a nascent sector, innovation plays a key role in bringing new CCUS projects online across EMEA.

As a leading innovator of CCUS solutions, MHI has pioneered a number of proprietary technologies aimed at capturing and transporting carbon dioxide from power plants and industrial facilities.

A program of tests conducted at the Technology Centre Mongstad in Norway, led to an evolution of our existing proprietary KS-1™ technology Centre Mongstad in Norway, leading to a new capture rate of more than 95%, which exceeds the industry standard of around 90%, although the carbon capture rate increased to 99.8% in tests conducted under specific operating conditions.

The new KS-21™ amine-based solvent provides greater stability against degradation than previous versions, while reducing volatility, environmental impact and operating costs.

The tests confirmed a carbon capture rate more than 95%, which exceeds the industry standard of around 90%, although the carbon capture rate increased to 99.8% in tests conducted under specific operating conditions.

After absorbing carbon dioxide from flue gases, the CO2-rich rich solvent is piped to a regenerator, where steam separates the carbon dioxide, which is more than 99.9%-dry pure. It is then transferred to a compressor ready to be utilized or transported to a secure storage site, with the solvent recycled to begin the process again.

Modular designs, transportation and trade. While heavy industry often prides itself on developing big technologies, big infrastructure and big projects, small can also play an important role.

Alongside the bespoke capture systems built for power stations and large-scale industrial facilities, at MHI we have developed a compact carbon capture system, called “CO2MPACT™”, to reduce costs and shorten manufacturing and installation lead times.

One of the compact CO2 capture systems that has recently started commercial operation in Japan has the capacity to capture 0.3 tonnes per day (tpd) and is based on a highly versatile standardized design requiring an installation space of just five meters in length and two meters wide.

The small size of the systems will also allow carbon capture technologies to be applied to even wider range of industrial applications, including small utilities.

Building upon this, MHI is expanding its lineup of compact CO2 capture systems, ranging up to a CO2 capture capacity of 200 tpd.

Compact CO2 capture systems will help promote the spread of CCUS solutions across the EMEA region, enabling more industrial emitters to implement carbon capture technology in a more affordable way.

While preventing CO2 emissions from industry reaching the atmosphere is a vital component of efforts to combat climate change, the story does not end there. Scaling up CCUS adoption and developing a value chain for CCUS across the EMEA region requires new infrastructure to transport, store, track and monitor the captured CO2.

But investing in new capture projects and infrastructure is not without its risks in an industry that must also build demand for CCUS technology.

That’s why Mitsubishi Shipbuilding is undertaking a conceptual study and construction of a demonstration test ship for the CO2L- BLUE dedicated liquefied CO2 carrier, to provide a cost-effective way to meet the projected increase in demand for transporting liquefied CO2.

While trucks and pipelines can transport captured CO2 over land or to geological storage close to capture sites, specially-designed marine bulk carriers will be essential for long-distance transportation — either to distant storage sites or to be utilized by industrial off-takers.

This is particularly important for countries and regions that have few suitable geological storage sites, for example. For CCUS technologies to be adopted at scale, industries without access to local storage will need to transport captured CO2 in bulk to distant storage sites using specially-adapted marine vessels.

The CCUS landscape will continue to evolve, with more CCUS projects and storage sites coming online, greater volumes of captured CO2 traded to industrial end users, combined with stricter legislative measures such as carbon taxes. This will require greater verification and traceability to track, transport, trade and sequester captured CO2.

In light of this, MHI is developing the CO2NNEXTM Digital Platform together with IBM, to promote the CCUS value chain and increase collaboration between CO2 emitters and offtakers — in effect linking sellers and buyers. The platform increases transparency and accountability of carbon sources to facilitate trading and storage.

Working in partnership with IBM, the platform implements blockchain technology and Internet of Things (IoT) connectivity in a cloud-based solution that can analyze, record and authenticate volumes of captured, stored and traded CO2 in real time.

Smart innovations like CO2NNEXTM could help create a CCUS value chain by turning captured carbon dioxide into a tradable commodity.
Regional CCUS applications

Innovations like these are already at work supporting regional efforts to reach net zero emissions across many of EMEA’s industries. And CCUS solutions can already be applied to many industries, but leading companies like MHI continue to work with different sectors to develop new solutions for applications to various flue gas sources.

We are proud to be part of the UK’s first carbon capture initiative in the cement industry, using MHI’s advanced KM CDR Process™ and the proprietary KS-21™ solvent, for example. This meant producing the preliminary front-end engineering design (pre-FEED) for a carbon capture plant at the Padeswood cement works in Flintshire in Wales, with an annual CO2 capture capacity of 800,000 tonnes. Captured CO2 will be transported to a secure storage site in a spent gas field off the country’s North West coast.

In the steel industry, a multi-year trial of the company’s carbon capture technology is underway as part of a collaboration with ArcelorMittal — the world’s leading global steel and mining concern — at its Gent steel plant in Belgium. A feasibility study is being conducted to support progress to full-scale deployment.

Alongside other power-generating projects, our team is supporting commercial-scale carbon capture operations at Peterhead Carbon Capture Power Station in Aberdeenshire, Scotland, with pre-FEED and FEED for its gas turbine combined cycle (GTCC) power plant and carbon capture plant. This first-of-its-kind project in Scotland could capture up to 1.5 million tonnes of CO2 annually, which would be transported and stored beneath the North Sea.

In the Middle East, MHI is conducting a feasibility study to apply its core carbon capture technologies at Aluminium Bahrain BSC (Alba), an aluminium smelter plant in Bahrain, the largest smelter in the world excluding China. Success here will represent the first commercial application of carbon capture technology in the aluminium sector.

While the number of new projects in development across the EMEA region continues to increase, more is needed to meet climate targets. Policymakers in the EU and other regional powers, together with original equipment manufacturers and private companies across many hard-to-abate sectors, must collaborate to create a framework that encourages investment in new CCUS capacity.

Building on decades of hard-won expertise and development ability, MHI deploys a range of solutions among the CCUS value chain throughout the EMEA region: from advanced carbon capture technologies to long-distance transport.

Innovation, collaboration and expertise are essential components of regional efforts to help EMEA’s energy and industry majors realize their net zero ambitions. That’s why we are continually pushing boundaries to develop new and more effective CCUS solutions.

About the author

Mitsuaki Kato joined Mitsubishi Heavy Industries EMEA (MHI-EMEA) in July 2021 to lead the company’s Decarbonisation Business Department, focusing on business development in the UK and the wider European region. Prior to this role, he was responsible for business development of MHI’s Carbon Capture Plant activities in North America at Mitsubishi Heavy Industries America’s Engineered Systems Division.

Mitsuaki Kato started his career at Mitsubishi Heavy Industries Printing & Packaging Machinery in 2005, followed by roles within MHI Plant Construction as well as MHI’s Infrastructure Business Group’s Chemical Plant Business Department.

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CCUS ZEN in quest to accelerate CCUS in Europe with cluster plans

As part of its mission to accelerate the roll out of CCUS in Europe, CCUS ZEN will this year identify two industrial clusters suitable for deployment of CCUS, one in the Mediterranean and one in the Baltic region.

“The first step will be to identify four promising clusters for each region and from those we are going to pick one from each region for a pre-FEED study. We will do detailed mapping of emissions sources,” explains project coordinator Eirik Falck da Silva of SINTEF. “Some of the harbours might stand out as ideal clusters, drawing on, for instance the example of the Port of Rotterdam.”

To this end, the CCUS ZEN partners gathered earlier this month in Copenhagen for a cluster building workshop which involved networking partners from the Baltic Sea region: energy companies, national energy agencies, industry emitters, industry cluster representatives, storage operators, and members of government and local authorities from the Baltic states.

Private sector partners

The hope is that the cluster plans developed in CCUS ZEN will be advanced and compelling enough that commercial entities and government backers will want to take them further. To ensure CCUS ZEN’s outputs are industrially relevant, CCUS ZEN has two private sector partners, Technip Energies from France, which will help with the plans for the Mediterranean, and Ramboll from Denmark, which will work on the Baltic cluster.

“We need to make sure we produce outputs in a form that can be easily picked up by people who want to take them to the next stage. Technip Energies and Ramboll are perfect for that kind of exercise,” says Dr da Silva. “The ambition of CCUS ZEN is to develop cases that are genuinely so promising that the Commission, national governments, industries look at them and say yes these are our next clusters that could move towards FEED studies and ultimately investment decisions.”

The other key element of CCUS ZEN is knowledge sharing and dissemination. To this end, the project has set up a network of businesses and organisations working in or considering CCUS; it already has more than 50 members.

“This is not an R&D project. Rather, it aims to help people to connect and get to the right information more quickly. We are doing some analysis so the new countries and new developers learn from everything that has happened to date – the UK, Norway and the Netherlands have been working on CCS/CCUS for decades,” says Dr da Silva.

“We are trying to extract that knowledge so that countries that have just started to look at this very recently such as Spain, Italy, Greece, Poland and the Baltic States have a list of recommended actions on how to build clusters and the best way to get a CCUS project started.”

Positive momentum behind CCS/CCUS

The project comes at a time when positive momentum behind CCS/CCUS has increased markedly.

“What feels very different is that we’ve reached a level where interest around CCS/CCUS is broader,” says Dr da Silva. “It’s growing quickly which is very exciting. It’s an industry in its infancy – what’s the best technology, what’s the industrial standard for CO2 transport and export. This is something that’s really growing quickly which is very exciting. It’s an industry in its infancy – what’s the best technology, what’s the industrial standard for CO2 transport and so on – nothing has been decided yet. Everyone with a background in CCUS tends to be very busy these days.”

There is also recognition that CCUS is now more competitive from a financial point of view.

“If you are really going to get your CO2 emissions down and you have a waste-to-energy or a cement plant actually CCS might be the cheapest alternative. So I do feel there is a greater acceptance – it’s not cheap but it might be the cheapest option in more cases than people were willing to accept only five or six years ago. It changed rather quickly,” he says.

Nevertheless, further government or EU incentives are needed to help accelerate CCS/CCUS, notably on carbon taxes, he says.

Carbon price

“It is promising that some countries are talking about a carbon price of €200 a tonne by 2030. At that level CCUS is absolutely in business in many places,” he says. “CO2 emissions are waste going into the atmosphere. If you are allowed simply to dispose of your waste into nature that is always going to be cheaper than separating out the waste and storing it. So you are going to need incentives.”

In parallel, there will be improvements to CCS/CCUS technologies.

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In parallel, there will be improvements to CCS/CCUS technologies.

“Obviously as scientists our ambition is to make it better, more robust, more compact – to keep working on those things. As the designs become more standardised then you will start to see costs creeping down a bit more consistently.”

Another key factor will be to improve the legal framework especially for CO2 storage. This is particularly important for Germany, Europe’s largest economy: it wants to deploy CCS but to transport the captured CO2 to offshore storage in the North Sea rather than storing it onshore.

“We need a legal framework for storage and for cross-border transport and export. This is progressing quite well in some places,” says Dr da Silva. “Today, there can be quite a few rules limiting export of waste products across borders. But, in the case of CCS, it makes perfect sense for CO2 to flow, for example, from Germany into storage in the North Sea.”

More information

www.ccuszen.eu
GreenPulse Project in Spain advances with exploration permit

An important milestone has been achieved for this key project, which will help Southern Europe to meet the European Commission’s objective of becoming climate-neutral by 2050.

GreenPulse is a project promoted by Nexwell Group (nexwell.com) through its venture initiative CarbonCause (co2cause.com) focused on deploying innovative and transformative renewable energy hub solutions by scaling CCS.

This project addresses the European Commission’s shortage in CO2 transport network and storage capacity by setting-up a first-of-its-kind, onshore Demo Project connecting CO2 sources from the Escombreras industrial cluster in Murcia (Spain) surrounding the Port of Cartagena, to the onshore geological storage site “Murcia-Río Segura” in Moratalla municipality, on the Spanish Mediterranean coast.

The initial stage involves achieving a pilot scale where CO2 will be injected and trapped in an underground structure through a secure, cost effective and shared open access transport infrastructure (the Demo Project). The potential source of CO2 will come from a capture plant planned by Holcim in its cement factory located in Carboneras (Almería).

Upon achieving commercial scale and replication, the Demo Project is expected to connect CO2 sources from the Escombreras industrial cluster in Murcia, a major contributor of CO2 emissions in Spain – as well as other Spanish and European regions - to onshore geological storage sites.

This project is particularly important for the region: critically, there are only two commercial scale projects currently operating in Europe, injecting a combined 2 million tonnes (Mt) per year of CO2. Additionally, they are both offshore, as are the additional European North Sea projects currently planned to be operational in the short term.

This reveals a striking lack of CCS projects in Europe, particularly in the South. The existing and planned projects are woefully insufficient to meet the 150 Mt/year of CO2 of atmospheric or biogenic origin by 2050 stated by the European Commission, that would be necessary to meet the European Union’s climate objectives.

On the other hand, offshore projects in the North Sea are not enough for a well-balanced Pan European transport and storage network. GreenPulse promises to be the catalyst to a Mediterranean network to carbon dioxide transportation.

The Escombreras valley: a strategic capture location

GreenPulse is situated close to the industrial Escombreras Valley which hosts a wide array of heavy and hard-to-abate CO2 industrial plants. These include, the fourth largest petroleum refinery in Spain (Repsol Petróleo), natural gas-fired combined-cycle power plants (Naturgy Generación, ENGIE, Iberdrola), cement and petrochemical facilities. This industrial cluster is the third largest source of CO2 emissions in Spain: in 2020, it emitted around 5 million tons per year of CO2 in aggregate.

It hosts a heavy and hard-to-abate CO2 emitting industrial complex, including the fourth largest petroleum refinery in Spain (Repsol Petróleo), natural gas-fired combined-cycle power plants (Naturgy Generación, ENGIE, Iberdrola), cement and petrochemical facilities.

GreenPulse will offer an opportunity for these industries to participate in CO2 mitigation, and a tool to address the reduction of CO2 allowance cap emissions from the EU Emissions Trading System (EU ETS).
The Escombreras Valley is tucked adjacent to key transport infrastructure including:

- The port of Cartagena on the Mediterranean coast (which can play a crucial role as an offloading and processing site)
- The existing network of natural gas pipelines in Murcia, following the Mediterranean coast and connecting with the country center, and with regional pipelines for domestic distribution.
- The planned route for the 2030 H2Med underwater green hydrogen corridor to France.

**Captured CO2 supply for the Demo Project**

Holcim, one of the leading cement manufacturers in Spain, is on a mission to lower the carbon footprint of their operations to build a net-zero future. In this line, Holcim is developing a large-scale carbon capture and utilisation plant through a joint venture – ECCO2.

For the Demo Project, this CO2 from the new carbon capture plant, which would be the first one in Spain, is considered as a source for the pilot phase. This represents an example of the collaboration of different partners across the value chain to shift the paradigm. In this initial phase, the CO2 will be transported by trucks.

During the commercial phase, the different sources of CO2 are projected to be transported by ship to the port of Cartagena and then through a pipeline to the storage site. This will potentially allow the project to be connected by pipeline from the port and Escombreras industrial hub to the storage facility.

**The Moratalla geological storage site**

The Murcia-Río Segura site, located in Moratalla Municipality, contains a suitable underground structure that allows permanent sequestration of CO2 emissions: indeed, the Geological Survey of Spain (IGME-CSIC) classified the Murcia-Río Segura structure as a ‘highly favorable structure’ for CO2 geological storage in their study “ALGECO2”, 2015. Additionally, an initial geological storage feasibility study in December 2022 has yielded a potential of 35 Mt of storage capacity.

To this end, GreenPulse has obtained an exploration and investigation permit granted by the Government of the Murcia Region in March 2023, in compliance with the Directive 2009/31/CE and the Spanish Law 40/2010. The permit paves the way to perform all required characterisation activities to validate the GreenPulse geological storage site.

Upon successful completion GreenPulse fully intends to increase CO2 injection to commercial scale and serve the regional hard-to-abate emissions industry.

**Upscaling and replicability potential of the GreenPulse project**

GreenPulse will analyze different commercial scale CO2 transportation options between the Escombreras region and the Moratalla geological storage site (existing or new pipelines, trucks, and ships). Alternate methods of procurement of CO2 such as Direct Air Capture will also be considered, should such technology scale and provide efficient levels of CO2 in alignment with GreenPulse’s scaling timeline.

Moreover, the project platform has commenced the prefeasibility of additional storage sites in Spain and abroad. This cluster of sites is intended to be integrated into a network to benefit other regions, increase the impact of emissions mitigation and bolster bordercrosser transportation capabilities.

To this end, GreenPulse has identified approximately 300 Mt of storage capacity on sites close to the Mediterranean coast in Spain, which represents a significant opportunity for mitigating greenhouse gas (GHG) emissions.

With an assumed injection rate of 15 Mt/year, roughly 6% of Spain’s annual CO2 emissions can be abated. This level of storage would contribute substantially to the country’s efforts to reduce its carbon footprint and meet the emissions reduction targets set by the EU.

This project is a key one to generating the impact pursued by its CarbonCause platform: to remove CO2 from the atmosphere while enabling a secure energy transition, offering an alternative for industry decarbonization.

In terms of social engagement, GreenPulse has been keen on including a regional research institutions, Universidad Politécnica de Cartagena, to develop local know-how and monitoring of activities. A key element of the trust-building process is the quality of the consortium team that has come together for this project. GreenPulse is comprised of experienced partners in CCS technologies from 6 European countries who tackle the project study areas such as CO2 transport by pipeline and ship, site integrity, containment, leakage risk assessment, well drilling and completion, characterisation and monitoring, public accept ance, communication, and business models.

The team includes recognised leaders in the CCUS industry including: CARBONCAUSE, SINTEF, HOLCIM, Genesis (Technip), Gomez Pardo Foundation, The Spanish Geological Survey (IGME), GESSAL, and ERBS, among others.

**More information**

c02cause.com/GreenPulse
First carbon storage at Project Greensand

Major milestone achieved as Project Greensand initiated the world’s first cross-border offshore CO2 storage intended to mitigate climate change.

The milestone was officially celebrated at an exclusive First Carbon Storage event in Esbjerg, Denmark, in the presence of His Royal Highness Crown Prince Frederik of Denmark, Danish Minister for Energy-, Climate-, and Utilities Mr. Lars Aagaard – and with a pre-recorded address from President of the European Commission Ms. Ursula von der Leyen.

“This is a big moment for Europe’s green transition, and for our clean tech industry,” said Ursula von der Leyen, President of the European Commission.

“The first full value chain, for carbon capture and storage in Europe. You are showing that it can be done. That we can grow our industry through innovation and cooperation, and at the same time, remove carbon emissions from the atmosphere, through ingenuity and cooperation. This is what Europe’s competitive sustainability is all about.”

The invitation only event was attended by representatives from business, policy and industry organisations from across Europe. First Carbon Storage was hosted by Project Greensand led by INEOS and Wintershall Dea.

With first carbon storage Project Greensand demonstrates, for the first time, the feasibility of cross-border offshore CO2 storage across the full value chain - from capture to transport and storage. From when the CO2 is captured in Antwerp, transported by ship to Esbjerg, and finally stored in the depleted Nini West oil field in the North Sea, paving the way for the development of an international CCS value chain.

This marks the culmination of the project’s pilot phase. The Final Investment Decision (FID) for a full-scale project is planned for the first half of 2024.

In February 2023, leading consortium partners INEOS and Wintershall Dea received the necessary storage license from the Danish authorities. At full scale, Project Greensand can store up to 1.5 million tonnes of CO2 per year in 2025/2026. By 2030 it aims to store up to 8 million tonnes of CO2 per year in this area while continuing to make significant contributions to our understanding and growth of carbon storage technology.

The European Commission estimates that the EU will need to store up to 300 million tonnes of CO2 per year by 2050 to meet its climate goals.

“This important milestone firmly demonstrates that CCS is a technology that can deliver on a global scale,” said Sir Jim Ratcliffe, founder and chairman of INEOS.

“The task at hand for the industry and policymakers is now to support the continued development and deployment of CCS as an essential tool to mitigate climate change.”

Project Greensand is a consortium of 23 organisations with expertise in Carbon Capture and Storage, including business, academia, government and start-ups. It is supported by the Danish state through the Energy Technology Development and Demonstration Program (EUDP). CCS is considered a key technology in reaching the Danish 2045 net zero target.

“The Danish subsoil can store a lot more carbon than we ever will capture in Denmark,” said Lars Aagaard, Minister for Climate, Energy and Utilities.

“Therefore, I am extremely pleased that the whole perspective on the Danish subsoil from day one is based on an industrial thinking where these resources should be brought to the market and help other countries meet their climate target on a commercial basis.”

More information
www.projectgreensand.com
www.ineos.com
www.wintershalldea.com
Fluxys partners with Wintershall Dea and Heidelberg Materials

Fluxys Belgium and Wintershall Dea will start collaborating on the transport of CO2 by pipeline from Germany to Zeebrugge on the Belgian North Sea coast, while Heidelberg Materials’ cement business in Belgium will gain access to the pipeline network.

CO2 emissions from industrial clusters in southern Germany are to be transported to the German-Belgian border via the planned pipeline network. From there, the CO2 will be transported via the CO2 network in Belgium developed by Fluxys to Zeebrugge on the Belgian North Sea coast, and subsequently to offshore CCS storage locations in the North Sea where Wintershall Dea is involved.

“With Fluxys, we have a strong partner to advance the expansion of the CO2 transport network and thereby create the necessary infrastructure for the capture and storage of CO2 emissions from industry,” said Hugo Dijkgraaf, Wintershall Dea’s Chief Technology Officer and Member of its Executive Board. “In northern Germany, we are already well positioned through our foreseen CO2 hub in Wilhelmshaven. Through our cooperation with Fluxys, we now also want to offer opportunities for the decarbonisation of industrial sites in southern Germany.”

Fluxys is constructing a CO2 hub in Zeebrugge as a collection point for the onward transport of industrial emissions to secure storage sites under the seabed of the North Sea. Wintershall Dea is also planning a CO2 hub – called CO2nnectNow – in Wilhelmshaven on the German North Sea coast.

As part of their cooperation, the two companies are also assessing to jointly develop an offshore transport system, starting from Zeebrugge and Wilhelmshaven, to CO2 storage sites in the North Sea.

“The initiative dovetails perfectly with Fluxys’ strategy to be the essential partner for speeding up the energy transition” said Pascal De Buck, CEO of Fluxys Belgium. “One of our key focus areas is to develop open access CO2 infrastructure to accommodate the carbon capture and storage chain. The CCS chain is essential for industry to decarbonise while maintaining economic activity and employment. Our ambition is to provide the market the capacity required to transport 30 million tonnes of CO2 by 2030.”

Although there are currently still legal hurdles to transporting CO2 to storage sites outside Germany, German policymakers have now come to recognise the potential of CCS. In an evaluation report on the Carbon Dioxide Storage Act, Germany’s Federal Ministry for Economic Affairs and Climate Action recently noted that the country would have to safely store up to 73 million tonnes of CO2 each year under the seabed if it is to achieve net zero by 2045.

Developing a CCS value chain

With a view to achieving its carbon emission reduction goals, Heidelberg Materials’ cement business in Belgium (currently known as CBR) aims to implement the Anthemis project at its Antoing cement plant and is partnering with Fluxys Belgium to create a CO2 value chain.

The partners recently signed a declaration of interest underscoring the cement manufacturer’s desire to have access to and use of the proposed CO2 transmission backbone project.

Heidelberg Materials’ cement business in Belgium is pursuing its CO2 emission reduction goals. Accordingly, the company intends to equip its Antoing site with an innovative hybrid carbon capture unit, a project they have dubbed Anthemis. Once it is up and running, the unit will reduce Antoing’s CO2 emissions by more than 97%. In other words, some 800,000 tonnes of CO2 will be captured annually. As a result, Antoing will become the first cement plant in mainland Western Europe to supply carbon-free cement.

The agreement reached between Heidelberg Materials and Fluxys Belgium aims to accelerate the energy transition of the industrial sector. This important milestone makes a real contribution towards achieving the ambitious climate objectives that Belgium and Europe have set themselves.

“Sustainability is a top priority for Heidelberg Materials. With regard to reducing CO2 emissions, we want to be the industry leader on the path towards carbon neutrality. In order to achieve this goal, we are proud to join forces with a trusted partner like Fluxys Belgium,” said Christophe Streicher, CEO of Heidelberg Materials Benelux.

“Access to the transmission infrastructure that Fluxys Belgium intends to develop from Tournai to Zeebrugge and Ghent will enable our Antoing cement plant to connect to a large-scale CO2 transmission network and to carbon storage sites in the North Sea. With Anthemis, our Antoing production site will become the catalyst for a complete CO2 value chain. At the same time, it should be noted that our group is also a partner in the EU2NSEA project of common interest (PCI), a major cross-border project for the capture and storage of CO2.”

“Heidelberg Materials’ commitment is important for Fluxys as it enables us to actively support the development of a global CO2 transport infrastructure,” said Pascal De Buck.

“The Anthemis facility and its connection to the transmission infrastructure are an integral part of the Fluxys approach, which offers CO2 emitters the possibility of transporting their collected CO2 through pipelines to various export points. Together we are contributing to a more sustainable society through decarbonisation solutions for industry, which are essential for meeting climate change targets and ensuring the long-term viability of the economy.”

More information

www.fluxys.com
www.wintershalldea.com
www.heidelbergmaterials.com
The potential of a European CCS market from a Danish perspective

There is major market potential for CCS in Europe according to a report from Kraka Advisory. CCS can make a contribution to the Danish economy and with its abundant CO2 storage capacity Denmark is a potential trailblazer in the CCS sector.

Financial and employment potential of the CCS sector in Denmark - if Denmark, for instance, achieves a share of 5% of the total European market, this will generate an economic value of between DKK 23 and 50 billion and may also convert into between 4,000 and 9,000 jobs.

There are major differences in the facilities that European countries have available for storing CO2. Countries with abundant access to underground reservoirs in the North Sea, for instance, such as Denmark, Norway and the UK, can store their own CO2 emissions for many years. Other countries, such as Germany and Poland, have considerable storage requirements, but have fewer facilities for storing CO2, while some countries have no capacity at all. This therefore creates a need to establish an international market for trading and transporting CO2.

International cooperation can also help significantly reduce the cost of CCS. This is down to costs being high when storing small amounts of CO2, with the potential of costs being halved in the case of larger volumes. In the short term, Denmark and other countries with good storage facilities are unable to capture sufficient CO2 to achieve the beneficial economy of scale effects. They will only be achieved if the market’s size increases, thereby giving rise to a need to establish a common European infrastructure for transporting and trading in CO2 from several other countries.

The total amount of CO2 which potentially may be stored across EU countries by 2030 is calculated at between approx. 360 and 790 million tonnes of CO2. An annual market potential of this magnitude requires a well-established, reliable transport network and continuous monitoring of storage facilities. Such a system requires international coordination and standardisation, which can obviously be carried out under the auspices of the EU.

According to the report, a European market should be able to attain a total economic value of between DKK 450 and 1,000 billion. The countries participating in a future CCS market can look forward to sharing in the market, but there is uncertainty about the amount which will be assigned to each country.

For example, if Denmark’s share of the market amounts to 5-10 per cent, this will achieve an economic value estimated at between DKK 23 and 100 billion. If the CCS sector grows to such a size, it is also estimated that the number of jobs which can be created directly and indirectly in the CCS industry will range between 4,000 and 17,000.

This is equivalent to Denmark receiving between 18 and 39 million tonnes of CO2. Based on the CCS projects already announced in Denmark, where offshore projects alone in the North Sea will store 13 million tonnes of CO2 from 2030, the report found that a market share of this size could be realistically achieved.

As things stand, Denmark’s facilities in terms of operating as a recipient country for CO2 storage are already good. However, this position will only be consolidated in the future as CO2 emissions decrease and more suitable storage capacity facilities are being continuously mapped.

The political goodwill for CO2 storage already exists in Denmark, which is why Denmark is at the forefront of the effort to create a European market for capturing, transporting and storing CO2.

Large-scale CO2 storage in Denmark may, at the same time, pave the way for investments in the development and application of capture technologies, which many companies would otherwise be reluctant to get involved in if there were no possibilities to store CO2.

More information
www.kraka-advisory.com
Stockholm Norvik Port potential CCS hub

Ports of Stockholm will begin a Feasibility Study to establish a node for captured carbon dioxide at Stockholm Norvik Port, together with leading CCS emitters and actors.

The goal is to increase the possibilities for emission reduction and negative emissions by establishing a regional, sustainable and cost-efficient carbon dioxide infrastructure in eastern Sweden. A solution for transport and handling between facilities that are source of the emissions to the end capture site would be a major contribution to Sweden achieving its environmental goals.

An initial general proof of concept study was designed together with all of the participating stakeholders to clarify the prerequisites and conditions for establishing an interim storage facility at Stockholm Norvik Port. Now Ports of Stockholm is taking the work to the next stage in a more detailed Feasibility Study where the goal is to develop a proposal for a system solution. The study includes risk analyses, business models and permit issues. The project has been named NICE – Norvik Infrastructure CCS East Sweden.

"Stockholm Norvik Port has large potential to become a carbon dioxide hub. The proposed transport solution would be able to handle a significant proportion of the carbon dioxide transport from Sweden, potentially around 9 million tonnes per year, with a potential to become the largest of all similar projects in Sweden," explained Clara Lindblom, Chair of the Board at Ports of Stockholm.

The system would be open to third-party access to be even more cost-efficient and increase the potential for reduced emissions and negative emissions over the longer-term. The work will also inspire others to establish similar regional collaborations with regard to carbon dioxide infrastructure.

"Stockholm Norvik, Sweden’s newest freight port, opened three years ago. With our state-of-the-art facilities and the perfect location in the heart of the Stockholm region, being involved in and enabling a future sustainable transport and infrastructure solution was an obvious choice for us," said Johan Wallén, Chief Commercial Officer at Ports of Stockholm.

The Feasibility Study will function to provide support for future decision-making by Ports of Stockholm and other stakeholders about the possibilities to go further with the planning for a regional carbon dioxide hub at Stockholm Norvik. The Feasibility Study will be carried out in collaboration with Stockholm Exergi, Mälarenergi, Söderenergi, Vattenfall, Heidelberg Materials, Nordkalk and Plagazi.

More information
www.portsofstockholm.com

Webinar: Business opportunities in North America CCUS
Apr 2023
View the recording for free on our website

The webinar is presented by Decarbonfuse, a CCUS technical and commercial advisory firm based in Houston. Featuring:
- FP K Pande, Principal Advisor, Texas Intercontinental Energy Resources and former Chief Engineer with QEP Resources and Director, Reservoir Technology with Anadarko Petroleum Corporation
- Todd Bush, Managing Director, Decarbonfuse, previously Head of North America for Westwood Global Energy, and who also led digital oilfield and environmental for Chevron’s Lower 48 business unit

www.carboncapturejournal.com
Net Zero Industry Act: oil & gas producers finally on the hook for emissions?

On 16 March, the European Commission published several initiatives as part of the Green Deal Industrial Plan (GDIP). The Net-Zero Industry Act brings key elements to the table to ensure Europe follows through on its climate ambition.

Ranging from a welcome acceleration of permitting procedures to a CO2 injection capacity target, it also presents a risk of giving blanket support to technologies that could use a more robust regulatory framework, like hydrogen, to ensure their positive contribution to climate change mitigation.

In short:

- 50 Mt CO2 injection capacity targets set unprecedented responsibility on oil & gas producers but require further clarification to ensure open access;
- Support for access to financing for set of eight Net-Zero Technologies will need input from civil society to work for the climate;
- Hydrogen keeps riding the hype with no conditions set on its efficient use, and a missed opportunity to ensure climate benefits are upheld for its production;
- Public procurement includes sustainability criteria in the bid ranking process but fails to include embodied carbon considerations to promote the use of low-carbon materials.

**Target for CO2 injection capacity: oil and gas producers finally obliged to contribute**

Bellona Europa welcomed the EU-wide target for 50Mt CO2 injection capacity by 2030. The target would come in addition to CO2 storage capacity developed outside the EU territory, meaning EEA states such as Norway and Iceland. This is therefore an ambitious and appropriate target.

In an unprecedented move, the proposal firmly places a responsibility on EU oil and gas producers to contribute to the development of CO2 injection capacity. Notably, by setting in place individual contributions of such entities pro-rata based on their contributions to crude oil and natural gas production.

“While clarifications on open access to CO2 storage for industrial emitters are sorely needed in the proposal, it goes a long way in ensuring that producers of fossil fuels carry their share of the responsibility for the pollution they create,” said Bellona Europa Director, Jonas Helseth.

Clarity on this point is also needed in the legislative text to ensure that we continue to incentivise decarbonisation with renewable energy deployment, in particular for the power sector. Bellona particularly welcomes the framing of CCS in relation to industrial decarbonisation, where alternatives such as direct electrification are not always viable.

**Supporting access to finance through legal certainty and faster permitting**

The proposal sets out measures to reinforce the Net-Zero Technology Ecosystem, with a particular focus on projects facing difficulties in accessing finance within the eight identified “strategic net-zero technologies”.

While recently revised State Aid guidelines will enable EU Member States to support such projects where private capital is insufficient, the proposal importantly acknowledges the role of private capital in the just and green transition.

To facilitate access to finance, several proposed measures promise to de-risk projects, by increasing legal certainty and accelerated permitting procedures. The proposed “Net-Zero Europe Platform” could play a crucial part in identifying and addressing bottlenecks and challenges facing projects within the eight identified technologies.

“While the platform is a welcome development, and in line with Bellona’s call for increased coordination and cooperation, engagement and involvement of civil society in the platform is now lacking but is crucial to safeguard and overcome barriers and challenges facing several of the identified eight technologies, in particular to increasing issues related to public perception.” said Lina Strandvåg Nagell, Senior Manager Projects & EU Policy.

**Public procurement and the missing embodied carbon**

Even though the need for decarbonisation of construction materials, such as cement and steel, is explicitly mentioned in the NZIA proposal, it only covers a part of the issue. For example, CCS is a key element to decarbonise cement as it captures its inevitable process emissions, but the uptake low-carbon cement produced with other technologies (i.e., clinker replacements and alternative materials) should also be promoted.

A way of enabling market access is through public procurement, as it is clearly recognised in the NZIA proposal.

“It is positive that the proposal looks at sustainability criteria for “awarding the contracts or ranking the bids”, but there is no mention that criteria would include embodied carbon considerations,” said Marika Andersen, Senior Project Manager.

“This could be a missed opportunity, to prioritise projects that plan to procure low-carbon materials, and therefore send strong signals to the market.”

Bellona said it would await the next steps of this legislative file, and seek to further clarify and improve the Act.

**More information**

www.bellona.org
single-market-economy.ec.europa.eu
The changes to Celsio’s project will not have any impact on the completion of Longship as a whole chain for the capture, transportation and storage of CO2. The Norcem and Northern Lights projects have both passed the halfway point in their construction processes and will be in a position to capture and store CO2 from 2025.

EU-Norway Green Alliance to deepen cooperation
c.europa.eu
The EU and Norway have established a Green Alliance to strengthen their joint climate action, environmental protection efforts, and cooperation on the clean energy and industrial transition.

Both sides reiterate their commitment to their respective 2030 targets of at least 55% greenhouse gas emission reductions compared to 1990, and to achieving climate neutrality by 2050. They aim to keep global temperature rise within the 1.5C limit under the Paris Agreement while ensuring energy security, environmental protection and human rights.

The EU and Norway will work closely together to ensure the successful implementation of the Paris Agreement and the historic biodiversity agreement reached at the UN Biodiversity conference COP15.

“Norway is a long-standing and reliable partner to the EU and we share a common vision for building a climate-neutral continent,” said President of the European Commission, Ursula von der Leyen. “We want our societies and economies to prosper together while reducing emissions, protecting nature, decarbonising our energy systems, and greening our industries. This Green Alliance makes our bond even stronger and allows us to design a better future together.”

The EU-Norway Green Alliance, prepared and negotiated under the auspices of Executive Vice-President for the European Green Deal Frans Timmermans, will focus on the following priority areas:

- strengthening efforts to combat climate change including cooperation on climate adaptation, carbon pricing, carbon removals, and carbon capture, transport, utilisation and storage;
- increasing cooperation on environmental issues with a focus on halting and reversing biodiversity loss, forest degradation and deforestation, promoting circular economy and addressing the full life cycle of plastics, the development of global standards for the management of chemicals and waste and sustainable ocean management;
- supporting the green industrial transition and further enhancing political and industrial cooperation through strategic partnerships, such as a future Strategic Partnership on Sustainable Raw Materials and Batteries Value Chains;
- accelerating the clean energy transition with a focus on hydrogen and offshore renewable energy;
- decarbonising the transport sector across all modes of transport, with special regard to zero GHG emission and zero pollution shipping;
- increasing regulatory and business cooperation to set global standards for the innovative environmental solutions required to accelerate the transition to circular and net-zero economies;
- consolidating existing collaboration on research, education, and innovation in the areas of decarbonisation, renewable energy, and bioeconomy;
- working together to promote sustainable finance and investments to set Europe on a pathway to an environmentally sustainable, climate-neutral and climate resilient economy.

A Green Alliance is the most comprehensive form of bilateral engagement established under the European Green Deal, with both parties committing to climate neutrality and to aligning their domestic and international climate policies to pursue this goal. This is only the second agreement of its kind, following the EU-Japan Green Alliance signed in 2021.

The EU and Norway also agree to jointly promote ambitious climate action on the global stage. To this end, the two parties, as leading major donors of climate finance, will cooperate to support developing countries and emerging economies in the process of implementation of their climate and environment policies. To help keep global temperature rise within the 1.5C limit, the agreement confirms that full respect for the precautionary principle is paramount in the Arctic region.
Carbon Centric begins first project outside Norway

**www.carboncentric.no**

The development agreement focuses on deploying CarbonFree’s proprietary SkyCycle™ technology at hard-to-abate industrial sites.

Approximately 10,000 tonnes of CO2 can be captured from the incineration plant annually. The goal is for the capture plant in Reykjanesskóri to be operational in 2025. Carbon Centric will build, own, and operate the capture plant, bringing the total number of announced projects in their portfolio to four.

The project will benefit from Carbon Centric’s standardized carbon capture concept. Kalka will have one of the world’s first full-scale carbon capture plants for waste incineration.

"Iceland is an ideal location for carbon capture due to good energy availability, local storage opportunities and local CO2 use applications. We are happy to collaborate with Kalka to add carbon capture to Iceland’s only waste incinerator," said Fredrik Häger, CEO at Carbon Centric.

Kalka serves an important role for the international airport and surrounding municipalities to handle waste that can’t or shouldn’t be recycled. Today, the plant has enough waste heat to power the carbon capture plant.

By separating the CO2 from the flue gas, the waste heat can be used while turning CO2 into a commodity that can be sold in the use market or permanently stored. Both alternatives can provide a positive climate impact.

"Over the past 3–4 years carbon capture has changed from a footnote to a headline in the waste incineration discussion. Carbon Centric is doing very important work by taking the concept from R&D to commercially viable solutions. Of course it’s very exciting for us to have an opportunity to be early adopters of this technology. There is no doubt in my mind that a few years down the line there will not be an incineration plant in the world that’s not capturing its CO2," said Steinþór Þórðarson, Managing Director at Kalka.

For small and medium sized incinerators, there can be significant barriers to entering the carbon capture market. That is why Carbon Centric offers a standardized and modular capture concept. This way, smaller projects are more viable and allow incinerators to install carbon capture already today.

Aker Carbon Capture to conduct test campaign for Fortum in Denmark

**www.akercarboncapture.com**

Aker Carbon Capture has been awarded a test campaign and feasibility study for Fortum Waste Solutions’ facility in Nyborg.

Fortum’s waste incineration plant is specialized in the safe destruction of hazardous waste and turning it into energy. The planned capture capacity will be around 170,000 tonnes CO2/year.

Aker Carbon Capture is currently delivering a first-of-a-kind modular carbon capture facility at Twence’s waste-to-energy plant in Hengelo, the Netherlands. The company will bring experience from this project to the Fortum decarbonization study.

Fortum Waste Solutions has extensive experience in handling hazardous waste. The Danish company is part of the Fortum’s Nordic Business Area Recycling & Waste, which employs around 1,000 people, covering a network of over 30 offices.

At the facility in Nyborg, the hazardous waste is safely transformed into energy in the form of district heating, which covers around 85% of Nyborg Municipality’s heating demand. A successful recovery of excess heat from the carbon capture process can lead to more district heating, which can replace heat that is produced with natural gas today.

"By selecting Aker Carbon Capture as an experienced partner for our feasibility study and pilot project for capturing and storing CO2, we are in the best hands to develop the optimal solution for Fortum," said Jens Peter Rasmussen, Head of Waste Management Service Denmark, Fortum Recycling & Waste.

"This is the starting point for reaching the first milestone in our carbon capture and storage project, which will make us CO2-neutral by 2030. In the long term this will develop the company to not only detoxify and utilize hazardous waste from industry, but at the same time recycle the derived CO2.

The results from this test campaign can be used towards a large-scale carbon capture plant.

"Different from other test rigs, our Mobile Test Unit is a complete replica of a large Aker Carbon Capture plant and has more than 30,000 operating hours on different flue gases around the world," said Tove Ormevik, Chief Operation and Aftermarket Officer at Aker Carbon Capture.

"We can therefore offer our customers a unique opportunity to test our technology at their site and de-risk the project with results that are fully benchmarking towards a large implementation, prior to a full-scale investment decision."
NGK’s honeycomb structures and DAC

Honeycomb structured ceramics could be very effective for direct air capture, reducing energy costs of air circulation and providing a high surface area. NGK INSULATORS, a manufacturer of honeycomb ceramics for removing pollutants from vehicles, explains more.

NGK’s monolith ceramic honeycomb substrates provide a robust solution for solid sorbent DAC systems to effectively capture and utilize CO2 while minimizing operational energy expenses. NGK INSULATORS, LTD, a company with a 100-year history of producing ceramic materials such as for automotive exhaust gas purification, and a specialist in ceramic honeycomb structures, discovered that their unique and established honeycomb structured carriers are a promising solution to DAC challenges.

NGK’s HONEYCERAM is probably not a household name to many outside the industry. However, it is in fact used in about half of the cars on the road today to purify harmful pollutants such as HC, CO, and NOx in exhaust gas. Indeed, NGK’s honeycomb ceramic carriers are mass-produced in 12 factories in 9 countries worldwide.

NGK has embarked on research and development to apply their honeycomb structure HONEYCERAM to DAC. NGK’s thin-wall honeycomb ceramics have low air resistance and high specific surface area. When passing through the angular honeycomb ceramic, which acts as the contactor, CO2 can be adsorbed and collected by the sorbent applied to the honeycomb structure, play an important role in meeting net zero goals.

Potential Use Case

The advantages of NGK’s ceramic honeycomb include a large specific surface area and low pressure loss, as well as the ability to control thermal capacity, cell structure/pore microstructure, and maintain durability. Furthermore, it is proven reliable technology and has the potential to be extremely cost effective, as it is already a mass-produced product and reusable. NGK’s ceramic honeycomb have been proven to survive in harsh conditions. NGK is confident they can be reused multiple times after the end of the sorbent’s full useful life.

Compared to a packed bed reactor (PBR), honeycombs have the advantage of being much lower pressure loss (1/50th of a PBR) and lower thermal capacity (1/3rd of a PBR), which can reduce the energy required for ventilation and heating.

In addition, the pore structure of honeycombs are controllable, and can be precisely tailored to the physical requirements of each unique sorbent. NGK’s honeycomb ceramics would be suitable for solid sorbent DAC systems.

Collaborative Partnerships

NGK is working on collaborative research and technology evaluations with DAC companies including DAC plant players, research institutions, and startups with novel sorbent technologies.

What are the potential collaboration possibilities with NGK? For example, a company could explore the possibility of incorporating honeycomb ceramics in plant design through collaboration with DAC plant designers, or combine CO2 sorbents and their support materials with development companies. NGK’s core competencies extend beyond our product technology into simulation technology, quick sample lead times, and well established support teams within our North American and European group companies.

“We aim to create new supply chains together with partners for the development of DAC solutions,” Shigeru Kobayashi, President, NGK Insulators stated. “In 2025, NGK together with our partners aim to conduct demonstration experiments with partners and ultimately scale up our technology into DAC plants at the level of several hundred to several thousand tons of CO2 per year.” To accomplish this NGK is showing a proactive attitude towards collaboration with its partners.

About the company

NGK INSULATORS, LTD. (NGK) is a leading company in the field of ceramics. Since its foundation in 1919, NGK has used its unique ceramic technology to provide numerous ground-breaking products that solve societal issues.

As one of the largest manufacturers of ceramic substrates for automotive catalytic converters, NGK has built on this to also develop new products and businesses with ceramics that actively reduce the strain on the global environment.

NGK provides the energy storage system “NAS” batteries – vital tools for sustainable energy infrastructure. It also provides a compact, thin, and high-energy-density lithium-ion rechargeable battery through its “EnerCera” product line, contributing to IoT.

NGK focuses on the two business fields “carbon neutrality” and “digital society” and is aiming to realize 80% of total company sales in these two fields whilst also achieving net-zero CO2 emissions by 2050.

NGK INSULATORS

www.ngk-insulators.com/en/

Hi-DAC@ngk.co.jp
Better ways to do natural gas treatment while making useful products

Natural gas comes out of the ground often containing hydrogen sulphide, CO2, carbon monoxide and carbonyl sulphide (COS). This needs to be removed, a process which results in big CO2 emissions. The authors outline how useful products could be generated instead, with CO2 being sequestered.

By Hadi Z. Alakhdhar, MEng PMP CEM, Saudi Aramco Project Engineer and Graham John Hollingsworth CENG BENG, Aramco Overseas Company, Project Management Consultant

While natural gas is a major fuel, it will be a priority to find ways to enhance the natural gas treatment process, to maximize the return on energy and resources and minimize emissions.

The natural gas treatment process itself could yield valuable products, such as hydrogen, ammonia, sulphur and carbon.

Currently, the natural gas treatment process removes sulphur compounds (hydrogen sulphide and carbonyl sulphide) and sour components (carbon monoxide, carbon dioxide) from the gas and exhaust streams.

The hydrogen sulphide and carbonyl sulphide are thermally oxidised in a process which generates CO2 and SO2 emissions to the atmosphere.

Instead, the hydrogen sulphide could provide a source of hydrogen and sulphur.

Hydrogen from H2S

Several laboratory studies and demonstrators are investigating the feasibility of processes to recover hydrogen and elemental sulphur from hydrogen sulphide in gas treatment. The race is on to achieve an economic commercial process.

Methods being explored include electrolysis, catalysis, plasma microwave, biological, thermal, nuclear thermal, the bunsen reaction with electrolysis, photo catalytic processes. These processes would need to scale up for plant flows and be fit for actual gas stream compositions.

They would need to safely handling all toxic, flammable components such as hydrogen sulphide, carbonyl sulphide and mercaptans.

One approach to commercialization is reported in the use of a nickel selenide (NiSe) nano wire array catalyst on nickel foam (NiSe/NF) in a membrane electrode assembly stack. Although one of the major obstacles to electro catalytic commercial applications is catalyst life. The NiSe nano wires are reported to have only 500 hours of catalyst stability without passivation.

Other researchers have created graphene-encapsulated metal catalyst with up to 1200 hours stable performance in removing H2S impurities in industrial syngas to produce hydrogen.

The combination of renewable electricity
with a H2S rich stream promises to be the most economic H2 production process, with the highest percentage energy return, due to the lowest required electrolysis input energy.

Although if the produced hydrogen is also used for electrical generation, the overall efficiency, from initial electrical input, via gas, back to electrical output, will be low. Electrical transmission, where practical, is preferable as an energy vector.

Hydrogen and ammonia

A hydrogen synthesis plant is currently the predominant, cheapest method of hydrogen production, stripping H2 from natural gas hydrocarbons, via an energy intensive steam reforming process, with the carbon dioxide by-product emitted to atmosphere.

Blue hydrogen is the term for hydrogen also generated by natural gas steam reforming, but making productive use of the CO2 by-product.

Green hydrogen may be produced by water electrolysis utilizing renewable electric energy sources, or via a natural gas pyrolysis process (thermal decomposition at high temperatures).

The pyrolysis process can only be truly green if the required steam heating, to 600 degrees C reaction temperature, is achieved without wasteful emissions. Most likely, the heating will be done through combustion of a fraction of the hydrogen product, minimized via suitable application of heat exchangers to heat the incoming natural gas with the outgoing hydrogen product, and insulation of the process.

Ammonia is by far the easier medium of energy storage and transport compared to hydrogen.

Liquefaction is at -33C, versus -250C for hydrogen. Over a third of hydrogen’s heating value is consumed in liquefaction for transport, compared to around 10% for ammonia.

Saudi Aramco has successfully demonstrated the production and delivery of 40 tonnes of liquid blue ammonia from Saudi Arabia to Japan. The natural gas steam reforming process is employed, supplemented with Carbon Capture/utilisation of CO2 by-product to enhance oil recovery and for methanol production.

Also, new green ammonia production facilities are under development in Arabia. The largest renewable hydrogen project in the world will produce up to 600 tons per day of carbon-free hydrogen in the form of green ammonia.

H2 and ammonia from H2S

Hydrogen and ammonia production are ideally situated where H2S rich gas streams and renewable energy are available at scale.

H2S could be sourced from sour natural gas treatment facilities where renewable solar/wind/hydro electricity resource is at hand.

Using membranes to make ammonia

An alternative to the predominant Haber-Bosch Ammonia synthesis process is using membranes, which could reduce energy consumption.

The standard Haber Bosch process requires temperatures of 450-500 °C and pressures up to 200 bar, and energy of 10-15 kWh/kg.

A proposed process is taking hydrogen direct from renewable energy driven electrolyzed water cells at 35barg, eliminating the compression stage. It projects 25 per cent less energy input per tonne of ammonia.

Any membrane electrolysis equipment should require minimal natural gas pre-treatment, and handle feed gas stream containing all component fractions such as CH4, C2H6, H2S, COS, CO, CO2, N2 and Argon.

Some laboratory technology demonstrators for hydrogen sulphide electrolysis use a pure hydrogen sulphide gas feed, with a membrane system converting all the H2S to either hydrogen at the cathode or sulphur at the anode.

Equipment design should make particular consideration of hydrogen sulphide toxicity and flammability, such that operation and failure mechanisms (e.g. membrane rupture), do not result in hazardous occurrences.

The cost of Hydrogen in 2022 using various synthesis methods (From H2S splitting to produce Hydrogen from sour gas, Jul 07 2022 Stephen B. Harrison)
Carbon sequestration critical for Australia says report

Sequestration is a necessary part of any rapid, urgent decarbonisation, and the sequestration industry represents a huge opportunity for Australia if we get it right, according to a new Insights Report released by the Climate Change Authority.

The paper “Reduce, remove and store: The role of carbon sequestration in accelerating Australia’s decarbonisation” contains 23 policy insights as part of a “deep dive” designed to help policymakers, emitters and markets to better understand how sequestration can be scaled-up, accelerated and used responsibly.

“Meeting the Paris Agreement objectives for limiting global warming is only possible with both rapid reductions in global greenhouse gas emissions and the removal of emissions from the atmosphere. The Intergovernmental Panel on Climate Change and International Energy Agency indicate the only technically feasible, cost effective and socially acceptable pathways to net zero by 2050 combine ambitious emissions reductions with carbon dioxide removals at far greater scale than at present,” Mr Brad Archer, CEO of the Climate Change Authority said.

The Intergovernmental Panel on Climate Change estimates that for a 50 per cent chance of limiting global warming to below 1.5°C, around 6 billion tonnes of CO2 would have to be removed per year by 2050 globally, and about 14 billion tonnes per year by 2100.

“The Authority’s Report highlights that more work is required to map and understand just how much of Australia’s sequestration potential can be realised,” said Mr Archer.

“While reducing emissions at source is critical, the extent of the climate challenge means there must be effort directed to sequestration. We need to use all the tools in the toolkit. That includes developing a carefully designed portfolio of approaches, as no single technology can achieve the levels of sequestration likely to be needed.”

In its recent 2023-24 Federal Budget Submission, the oil and gas industry called for a national CCUS roadmap to provide clear policy direction, progress carbon management hubs and promote Australia as a regional CO2 storage leader.

Ms McCulloch said, “Australia has an opportunity to not only accelerate to net zero but also create a new industry and ride the wave of global momentum for CCUS, with around 300 commercial projects in development.

“But government leadership is critical. Governments around the world are rapidly increasing their support for CCUS, with the Inflation Reduction Act in the United States a game changer providing significant financial incentives for large-scale deployment of the technology.”

The recent Safeguard Mechanism policy has only strengthened the case for a greater focus on carbon capture to reduce emissions.”

In its recent 2023-24 Federal Budget Submission, the oil and gas industry called for a national CCUS roadmap to provide clear policy direction, progress carbon management hubs and promote Australia as a regional CO2 storage leader.

More information
www.climatechangeauthority.gov.au
www appea.com.au
Canadian CCUS policy requires further detail to support advancing projects

The International CCS Knowledge Centre has released a comprehensive overview of CCUS investment tax credit to aid investment in carbon capture and storage facilities.

The Government of Canada’s 2023 budget contains additional measures to support the development of large-scale carbon capture, utilization and storage (CCS/CCUS) projects, but Canada’s policy framework still requires key details to spur private-sector investment, according to a new overview of CCUS policy by the International CCS Knowledge Centre.

The Knowledge Centre has delivered a primer on the federal budget released March 28, 2023 that provides a detailed break-down of the government’s proposed investment tax credit that is expected to be in place by October this year, following further public consultation.

The tax credit for CCUS projects is the government’s centrepiece for incentivizing heavy industries to build CCS infrastructure and will cover 50 per cent of the capital cost of CO2 capture projects between 2022 and 2030. The tax credit is higher (60 per cent) for projects that capture CO2 directly from the atmosphere (direct air capture) and it also covers 37.5 per cent of the cost for facilities required to transport, utilization and permanent storage of CO2.

The Knowledge Centre’s aggregation of government policies and updates related to the investment tax credit since it was first proposed in April 2021 found that the government is developing further guidance on what costs will be eligible, labour requirements, the obligation of companies to share knowledge about their CCS projects and report on climate risks, and other technical issues that will impact the value of the tax credit for project developers.

There also remains significant uncertainty regarding how the investment tax credit may affect or complement provincial policies and incentive programs that exist or are in development.

“We are pleased the Government of Canada will provide significant support for CCUS development, and we look forward to the government setting out a clear timeline for when the investment tax credit and other policy tools will be put in place with legislation, which will enable Canadian industries to commit to building these multi-billion-dollar projects,” said James Millar, president and chief executive officer of the International CCS Knowledge Centre.

“The fact is that CCS/CCUS projects must get started immediately if Canada is to achieve its ambitious goals for cutting greenhouse gas emissions at least 40 per cent from 2005 levels by 2030 and reaching net-zero emissions by 2050. We also stand to lose investment dollars, and the important jobs and technical expertise that CCS projects entail to the United States and other jurisdictions where the economics of building projects are clear,” Millar said.

The primer also highlights critical gaps that still exist in Canadian CCS policy, including the lack of long-term certainty on the cost of carbon emissions, and the need for a more robust protocol for sharing the valuable knowledge and lessons generated by major CCS projects in order to lower costs and improve the performance of CCS projects across the country and around the world.

The federal government announced its intention to introduce ‘carbon contracts for difference’ that protect investors from potential changes to federal carbon prices in its 2022 Fall Economic Statement, and plans to launch consultations on broad-based carbon contracts for difference in the coming months. Last week, Natural Resources Canada also began soliciting input on its proposal for CCUS projects with investment tax credit-eligible expenses of $250 million or greater to be required to contribute to public knowledge sharing.

“The government’s draft knowledge sharing requirement calls for companies to provide a report following the completion of project construction, and annual reports regarding the operation of CCUS facilities. This is a good first step, but knowledge sharing should not be a ‘one and done’ exercise,” said Beth (Hardy) Valiaho, the International CCS Knowledge Centre’s vice-president of policy, regulatory and stakeholder relations.

“With large public dollars supporting these projects, we need to ensure there is ongoing curation of lessons learned and collaboration between projects if we are to realize the full value of CCS technology across heavy-emitting industries.”

The publication “CCUS Investment Tax Credit – Primer (Spring 2023)” is now available on the Knowledge Centre’s website.
A comprehensive new report by the Climate Change Committee (CCC) demonstrates the scale of the task in achieving the Government’s 2035 goal, with 25 new recommendations to improve the prospects of delivery.

A decarbonised power system is the central requirement for achieving Net Zero in the UK and the prize for all modern economies. Access to reliable, resilient and plentiful decarbonised electricity – at an affordable price to consumers – is key to a thriving, energy secure economy, less dependent on imported oil and gas.

“The climate risks to the electricity system are currently underplayed. Climate-related impacts will multiply as the UK relies increasingly on electricity for heat and transport needs,” said Baroness Brown, Chair of the Adaptation Committee. “The CCC’s analysis shows that a well-designed decarbonised power system, with a higher degree of weather-dependent generation, can be reliable and resilient. This is not an issue for the future, we need to build in that resilience now, as we scale the electricity system to meet our Net Zero targets.”

The report contains fresh insights on the importance of developing a climate-resilient power system – and detailed modelling to illustrate the requirements of the 2035 power system, using actual historical weather data, stress-tested with an extreme scenario of a prolonged period of low wind.

Alongside Government’s Energy Security Strategy commitments to renewables and nuclear, the report finds there is a need for new low-carbon back-up generation, with hydrogen-based power stations and some continued use of fossil gas, made low-carbon through use of CCS.

Lord Deben, Chairman of the Climate Change Committee, said, “For 15 years, the Climate Change Committee’s main recommendation has been to decarbonise British electricity. The offer of cheap, decarbonised electricity for every consumer and business is now within reach, thanks to pioneering efforts to develop renewables.”

“But it will not happen at current rates of deployment

Delivery and deployment of infrastructure must be achieved at a much greater pace than the present regulatory, planning and consenting regimes can achieve. It requires that barriers to swift deployment of critical infrastructure are removed, and policy gaps remedied. This will open the path to major new investment in renewable generation and infrastructure. The network and storage infrastructure needed to support a decarbonised system will also be very significant, with build required for the transport and storage of electricity, hydrogen and CO2.

It is imperative that resilience to the effects of climate change is built into this asset investment programme from the start. Much of the UK’s Net Zero electricity system is yet to be built and requires significant additional investment to replace many existing generation assets as well as significantly expand the system.

The Climate Change Committee has outlined a comprehensive set of new recommendations to deliver the goal.

Comment from CCSA

Ruth Herbert, Chief Executive of the Carbon Capture and Storage Association (CCSA), commented, “Today’s report from the Climate Change Committee is clear – Carbon Capture, and Storage will be critical to delivering a decarbonised GB electricity system by 2035, alongside 70% renewable generation.

“CCS will provide flexible low-carbon generation, either through gas-fired power stations fitted with CCS or CCS-enabled hydrogen used in power generation. Furthermore, the CCC modelling clearly shows that the majority of hydrogen production between now and 2035 will be CCS-enabled.”

“To achieve this we need to move much much faster – the Government’s CCUS cluster programme needs to confirm now that it will significantly ramp up the number of CCS-enabled flexible power and hydrogen projects to be commissioned this decade. We also need a clear strategy for developing and expanding at pace the critical CCS and hydrogen infrastructure that will be vital for not just the power sector, but also industrial decarbonisation.”

“We are delighted to see the recommendation from the CCC that Government should commit to a long-term cross-sectoral infrastructure strategy, and we look forward to working with our members to drive this forward”.

More information

www.theccc.org.uk
www.ccsassociation.org
Catalytic and electrochemical routes to CO2 conversion

Updated in 2022, the report from the Carbon Dioxide Capture and Conversion (C02CC) Program looks at the current state and future prospects for four different groups of technologies for converting CO2 to products: conventional catalytic methods, biological conversion, electrocatalytic conversion and microbial electrolysish. Technologies for biological conversion of CO2 into fuels and chemicals are at different stages, some methods are mature, others are at early stage. All are characterized by technical challenges and limitations, as well as barriers to commercial-scale implementation. Social acceptability and regulations also will play a role in the viability of these technologies.

Biological conversion

CO2 can be converted by a variety of organisms either under natural conditions (biotic, under atmospheric CO2 concentration) or under industrial conditions (enhanced, using higher concentration of CO2). Microorganisms can be activated by a range of engineered/genetically optimised modifications that increase the CO2 fixation rate.

Catalytic conversion

The electrochemical reduction of CO2, CO2RR, is considered one of the most promising strategies to valorize waste CO2 as a feedstock to produce various value-added chemicals. Electrochemical technologies are likely to be among the closest to commercialisation due to the numerous start-ups and established companies investing in this area.

Key takeaways from the report

• The need to meet Net Zero climate change goals by 2050 has driven interest in CO2 conversion.
• There is considerable breadth in terms of technologies put forward to perform CO2 conversions including electrochemical, biological and conventional catalytic methods. Each has a unique set of challenges, opportunities and suitability.
• The use of conventional catalytic methods is the nearest term opportunity with electrochemical methods likely to come next and biotechnological approaches even further along.
• High operational and production costs are major hurdles for commercialisation of microalgae-based biodiesel that can cost more to produce than fuel from conventional sources, depending on technology used, production scale, kind of biomass and lipid content.
• Despite advancements, a recent study that carried out a detailed techno-economic analysis of microbial electrolysis (MES) found that given the current state-of-the-art MES performance and economic conditions, these systems are non-viable with anode material cost and electricity consumption being the main capital and operating costs.

There are many different technologies in development for reducing the carbon footprint of chemicals and fuels and it is a complex task to understand which is feasible on techno-economic level, how soon it would likely be available and the kinds of hurdles which need to be overcome to achieve commercialisation.

The report is intended to address these questions and to provide a wide range of knowledge on the different technologies available along with a realistic view of their potential for implementation. The report provides a comprehensive review of technologies and routes to CO2 conversion in bulk chemicals, fuels, building blocks for polymer materials, etc., by substituting fossil-based routes.

The cyclic economy model requires cycling of carbon, besides the recovery and reuse of several other goods (metals, plastics, wood, paper, water and so on). CCU has received much less funding than CCS, while its potential for fossil-carbon avoidance is very high. CCU is not for storing carbon, but for substituting fossil-carbon.

The development of hybrid catalysis, integration of chemo- and bio-catalysis, may push the development of new processes for CO2 conversion that can be raised to several Gt/y as shown in Figure 1. The use of conventional catalytic methods is the nearest term opportunity with electrochemical methods likely to come next and biotechnological approaches even further along.

CO2RR can be used to produce different compounds such as carbon monoxide, syngas, formic acid, ethylene, methanol, ethanol, propanol, etc., by a proper selection of electrocatalytic materials, solvent and other operating conditions.

CO2RR could use excess electrical energy from intermittent renewable sources to obtain carbon-based chemicals, storing electric energy as chemical energy ideally, without any additional fossil fuel-based electric power sources.

The prospects for electrochemical conversion of CO2 depend on many aspects. In particular, the economic scenario strongly depends on the number of electrons required for the conversion of CO2 to the target product, on thermodynamic and kinetic aspects that affect the energetic efficiency as above mentioned and on the cost of electric energy.

Biological conversion

Technologies for biological conversion of CO2 into CO2RR processes that increase the CO2 fixation rate.
Microbial electrosynthesis (MES)

MES is an electricity-driven bioproduction process carried out in a bioelectrochemical system (BES), where microorganisms catalyze the oxidation and reduction reactions at anodic and cathodic environments, respectively.

BESs are unique devices in which microbial respiration and fermentation coupled with electrodes help in converting chemical energy into electrical energy and the synthesis of value-added chemicals.

In the last decade, the application of the energy recovery from BES has taken a paradigm shift from energy carriers such as H2 and CH4 towards bulk chemicals and biofuels under small applied voltages, renaming it as microbial electrosynthesis.

The spectrum of MES products has grown significantly over the last decade. It started with simple volatile fatty acids (VFAs) like acetic acid but, over the years, has moved on to alcohols and even higher carbon compounds such as biopolymers.

Solar power costs are rapidly decreasing, and the installed capacities are increasing globally. Hence, energy as one of the major cost contributing components of MES will not be an issue in the next few years. Therefore, in future MES studies, such energy sources may already be employed from the early stages of technology development.

Some pilot-scale demonstration plants are currently under preparation and expected to be operational by 2023. Given this pace of development and the current state of the art, a commercial-scale industrial plant can be expected by 2030.

One key area to explore is focusing on niche products that cannot be produced through other CCU technologies, e.g., lactic acid, succinic acid, itaconic acid, etc.

Outlook

CO2 conversion into chemicals, materials and fuels is a promising area that requires continuous public and private funding for developing the catalytic systems and processes; however so far this area has received only limited attention and the cash flow has been very poor, discontinuous, and dispersed without a clear target.

So far, many projects have been performed and developed on capturing carbon dioxide from coal-fired power plants by microalgae and other microorganisms at pilot or industrial scale in various countries. The use and further development of enabling technologies such as metabolic engineering, genetic engineering, and synthetic biology tools will be welcome to increase the production of a wide range of bio-based products from CO2.

An important aspect to consider will also be the production cost reduction by selecting a set of microorganisms able to fix higher amount of CO2. Also design and engineering synthetic metabolic pathways are recommended for future research efforts.

Despite only a decade of research, MES has made rapid strides in terms of product diversity, increased Faradaic efficiency, and first steps towards piloting/upscaling and industrial interest. Even though several challenges remain to be addressed, the research efforts have increased significantly, as evidenced by the large number of projects currently operating in different parts of the world and the number of research teams venturing into this interdisciplinary field.

Figure 1: Perspective use of CO2 that can be converted into chemicals and fuels. Short term: 5-7 y; Medium term: 8-12 y; Long term: 15+ y. Assembled by M. Aresta, 2022

Next articles

This is a series of articles summarising recent key reports from The Catalyst Group Resources Carbon Dioxide Capture and Conversion (CO2CC) Program. Look out for “Advanced Materials for CO2 Capture and Separation” in the next issue.

More information

More information about this report and other services of the CO2CC Program can be found at:
www.catalystgrp.com/tcg-resources/member-programs/co2-capture-conversion-co2cc-program/
Australia’s path to net zero analysed in new study

CCUS to play a key role in decarbonising Australia finds the Net Zero Australia project’s final modelling results of pathways to net zero.

Australia will need to triple the National Electricity Market’s power capacity by 2030 to be on track for net zero by 2050 – requiring a rapid rollout of wind and solar power, transmission, storage, electric vehicles, and heat pumps as the coal fleet is replaced finds the report. All technologies will be required including major expansion of carbon capture and storage.

Net Zero Australia is a partnership of the University of Melbourne, the University of Queensland, Princeton University’s Andlinger Center for Energy and Environment, and Nous Group – and is supported by gifts and grants from various sponsors and has received input from a diverse Advisory Group.

Chair of the Net Zero Australia Steering Committee and University of Melbourne Honorary Emeritus Professor Robin Batterham said Net Zero Australia has set a new benchmark in analysing what it would take for Australia to decarbonise its economy and exports.

“Our results are unprecedented in their detail, rigour and transparency,” Professor Batterham said.

“Our aim is to inform the national debate with better evidence about the diverse preferences of the Australian community.

“This includes reaching net zero with renewables only, or with different mixes of renewables and low-emission uses of fossil fuels, and with different rates of electrification of our energy use. We have even considered whether nuclear energy has a role to play.

“We are not pushing a preferred pathway, rather we are illustrating a range of potential pathways.

“Our assumptions and detailed results are all public so they can be used by governments, businesses, and communities. They include projections for potential energy sources, mapping of possible land use change, and analysis of abatement from farming and other land uses.”

Director of the Melbourne Energy Institute University of Melbourne Professor Michael Brear said the modelling shows Australia will need all viable options to transform its energy system at an unprecedented pace and scale.

“Renewables and electrification, supported by a major expansion of transmission lines and storage, are keys to net zero,” Professor Brear said.

“But we will need an all technology, hands on deck approach. That includes a large increase in permanent carbon storage, deep underground and in vegetation, and a doubling of gas-fired power capacity to support renewables and energy storage.

“Our modelling finds that there would be no role for nuclear energy unless costs fall sharply (to around 30 per cent lower than current international best practice) and renewable energy growth is constrained.”

Associate Professor Simon Smart, Associate Professor in Chemical Engineering at the University of Queensland, said that Australia has a global responsibility and economic incentive to transition coal and liquefied natural gas (LNG) exports to clean commodities.

“Hydrogen made from solar, wind and desalinated water can replace our fossil fuel exports. We can also export large volumes of clean hydrogen with large scale implementation of Carbon Capture and Storage,” Associate Professor Smart said.

“Exporting green metals, particularly iron and steel made in Australia using clean hydrogen, has much lower abatement and infrastructure costs than for exporting clean hydrogen.

“Northern Australia (WA, Queensland, and NT) is particularly prospective for exports, but inland NSW and SA and offshore Victoria and Tasmania can also play major roles.

“Our modelling also suggests that new gas fields may be needed to fulfil export demand for clean hydrogen, particularly if the growth in renewable construction rates hits limits.”

Katherin Domansky, independent Steering Committee member, said that net zero would bring major changes in employment and land use which create large opportunities and challenges.

“Renewable energy has great advantages in providing a sustainable source of energy to Australia and the world,” Ms Domansky said.

“Decarbonisation will provide up to 700,000 direct jobs, mainly in regional and rural Australia.

“However, renewables need much more land area than fossil fuels to produce a given amount of energy. Our renewable resources overlap the lands of First Nations and farming communities, and land with biodiversity value.

“Careful management will be needed to minimise adverse impacts, share benefits with affected communities and achieve a net gain in biodiversity.”

Dr Chris Greig, Senior Research Scientist at Princeton University’s Andlinger Center on Energy and Environment, said that around $7-9 trillion of capital will need to be committed to domestic and export energy and industrial infrastructure by 2060, which is up to six times the business-as-usual amount.

“Additional investment will be needed by households and businesses, to increase the efficiency of their heaters and vehicles, including by converting to heat pumps and electric vehicles,” Dr Greig said.

“The annualised costs of that investment in energy production, transport and use has been estimated at 8-9 per cent of GDP to 2050, which is similar to today’s level.”

More information
www.netzeroaustralia.net.au
In recent years, China has made a significant progress on CCUS development, acquiring the capability to design and demonstrate large-scale CO2 capture, transport, utilisation and storage systems, says the report which can be downloaded from the Global CCS Institute website.

In 2022, the first integrated 1 Mtpa CCUS project, "Qilu Petrochemical - Shengli Oilfield CCUS Project," officially came into operation in August; Baogang Steel Group plans to build an integrated 2 Mtpa scale CCUS demonstration project for the steel industry, and the first phase of the 500,000-ton demonstration project has already started construction; CNOOC, Guangdong Development and Reform Commission, Shell China, and ExxonMobil China signed an MoU to jointly study a large-scale CCUS hub in Daya Bay.

Although most of CCUS technologies have been demonstrated, China’s CCUS development is still lagging behind its carbon neutrality commitment as well as some western countries. Looking forward, the development of CCUS in China still faces challenges such as the lack of market mechanism and insufficient policy incentives.

In the future, it is necessary for China to strengthen CCUS R&D, reduce costs, stimulate market demand, and promote the integration of technology, market and policy.

In response to the new situation, issues & challenges, this Annual Status Report repositioned CCUS under the China’s carbon peaking and carbon neutrality commitment, and reviewed the progress of CCUS technology R&D.

The report also summarized policy development and the challenges facing CCUS further deployment in China and finally, made relevant policy recommendations.

The report aims to provide a reference for policy makers to formulate CCUS-related policies, and support companies to integrate this solution into their decarbonization strategy.

**Challenges and recommendations**

Despite a significant progress, China still has an uphill journey for commercial-scale integrated CCUS projects as it is facing many challenges at this stage, such as high CO2 abatement costs, lack of effective business models, insufficient incentives & regulatory measures, and difficulties in sources-sinks matching. Considering the key role of CCUS in achieving China’s 30/60 goals, it should be further integrated to the country’s carbon neutrality innovation system.

The report puts forward the following five recommendations:

- Incorporate CCUS as an integral part of China’s technology portfolio for achieving the 30/60 goals.
- Build a CCUS technology program oriented to the 30/60 goals, and accelerate the forward-looking deployment of technology R&D and large-scale integration demonstration.
- Develop and improve relevant institutions, regulations, and standards, and promote capacity building.
- Explore incentive mechanisms and facilitate effective business models for CCUS stakeholders.
- Deepen international cooperation and exchange.

**CCUS, a pillar of China’s carbon neutrality goal**

Together with renewable energies, CCUS will be essential to China’s carbon neutrality target. In recent years, with the continuous advancement of international climate governance and the rapid development of technology systems, both the external conditions and inherent needs of CCUS have changed significantly in China.

First, with the increasing international and domestic climate pressure, the need for CCUS development has become more urgent. Second, CCUS application scenarios are changing. To achieve carbon neutrality, near-zero emissions of the fossil energy system and deep decarbonization from industrial processes are not enough; zero- or negative-emissions solutions are also required to reduce existing greenhouse gases (GHGs). Third, low-cost and next-generation CCUS technologies are developing rapidly (1).

In such a context, based on the close tracking of CCUS progress at home in 2022, the report analyzes the demand for CCUS in China under the carbon neutrality goal, summarizes the main trends and challenges faced by CCUS technologies, projects, and policy development, and puts forward corresponding recommendations. The technology and project data of the report is collected by the Administration Center of China’s Agenda 21 (ACCA 21).

As an important part of China’s technology system to achieve carbon neutrality, the application of CCUS is greatly expanded. CCUS is not only an option to achieve net-zero emission of fossil energy, but also a feasible solution for deep decarbonization in hard-to-abate industries such as steel and cement. In addition, negative emission technologies such as BECCS and DAC can also remove GHGs directly from the atmosphere.

With the emergence of new technologies, the CCUS technology system itself is gradually getting enriched, covering CO2 capture, transport, utilization and geological storage technologies. CO2 capture technologies are undergoing the transition from the first generation to the second; meanwhile the third-generation is emerging.
bp buys 40 per cent stake in Viking CCS project www.vikingccs.co.uk

Harbour Energy, which will continue as operator of Viking CCS, and bp have entered into an agreement to develop the CO2 transportation and storage project.

bp has acquired a 40 per cent non-operated share, bringing together two of the most experienced operators in the North Sea. Located close to the heavily industrialised Humber region, Viking CCS has the potential to meet one third of the UK Government’s target to capture and store up to 30 million tonnes of CO2 a year by 2030.

The announcement follows the UK Government’s recent decision to launch Track 2 of its CCS cluster sequencing process, and its recognition that Viking CCS is one of two leading transport and storage system contenders for this process.

Linda Z Cook, CEO of Harbour Energy, commented, “We welcome the UK government’s recent announcement about the launch of Track 2 and the addition of bp as a partner to this transformational project. Viking CCS has the potential to unlock billions of pounds of investment across the full CCS value chain and is crucial for the UK to meet its emissions reduction targets.”

The delivery of the Viking project could be transformational for the region, potentially unlocking up to £7 billion of investment across the full CO2 capture, transport, and storage value chain over the next decade.

Government of Alberta invests in CCS knowledge sharing hub www.ccsknowledge.com

The International CCS Knowledge Centre will establish a national CCS knowledge sharing hub, thanks to foundational support from the Government of Alberta.

The world’s first open-source repository of knowledge and information about the development of carbon capture and storage (CCS/CCUS) projects will be established by the International CCS Knowledge Centre with foundational support from the Government of Alberta.

As a key action item included in Alberta’s Emissions Reduction and Energy Development Plan released April 19, 2023, the Government of Alberta is providing $3 million for the creation of a national CCS knowledge sharing hub that will be an important tool for Canada to meet its ambitious targets for reducing greenhouse gas emissions.

The mandate of the CCS knowledge sharing hub will be to collect and curate best practices and lessons learned from Canadian CCS projects past, present and future – drawing on knowledge from as many projects as possible from initial planning and feasibility studies, through to construction and ongoing operations – to enhance the success of CCS projects and promote continuous learning and improvement in CCS technology.

“Bringing large-scale CCS projects to life at the speed and scale that is required to reach net-zero emissions by 2050 requires unprecedented collaboration between industry, government, academia and other partners,” said James Millar, president and chief executive officer of the International CCS Knowledge Centre.

“The most effective way of reducing risk, lowering costs and improving performance of these multi-billion-dollar infrastructure projects is to share our proven expertise and apply the experience gained across heavy-emitting industries in order to build a sustainable future for all.”

Carbon Capture Coalition Blueprint Releases 2023 Federal Policy Blueprint carboncapturecoalition.org

The roadmap is a list of essential, commonsense policy, regulatory, and implementation related recommendations for the 118th Congress and the administration to adopt as they support the responsible scale-up of the carbon management industry in the remainder of this decade.

A broad and growing group of bipartisan policymakers and a diverse set of stakeholders from industry, energy, and technology companies; energy and industrial labor unions; and conservation, environmental, and energy policy organisations support carbon management as an available and essential tool, among a growing set of solutions, to meet midcentury climate goals, strengthen and expand a high-wage jobs base, and support domestic manufacturing and energy production.

"Thanks to robust and sustained bipartisan congressional support, the United States now provides the most forward-looking policies in the world for the deployment of carbon management technologies,” said the CCC. “However, there is still much work to be done to ensure the historic investments made in carbon management throughout the past several years translate to widescale project deployment.”

The blueprint contains a comprehensive set of pragmatic recommendations needed to rapidly deploy these technologies, including:

- Ensuring that the recently enacted supportive policy ecosystem for carbon management is properly implemented at the federal level.
- Coordinated federal actions to implement policies and mechanisms to further ensure benefits from project development flow to affected communities and workers.
- Enacting demand-side policies to incentivize commercial production of products and services sourced from the broad array of carbon management industries.
- Providing federal resources for the development of less commercially mature and next generation carbon management technologies.
- Complimentary Policies to existing laws and programs to strengthen the available portfolio of federal policy support.
- Enabling the appropriate transport and storage of CO2 by swift and coordinated federal action.
- Building upon the portfolio of supportive federal policies enacted over the course of the last few years, the 118th Congress now has the opportunity to reinforce and grow the role of American leadership in the development and deployment of these technologies throughout the remainder of this decade through a number of targeted near-term actions.

These include providing resources for next generation technology deployment; ensuring investment certainty and business model flexibility by providing further small-scale adjustments to the 45Q tax credit; as well as a targeted agenda of coordinated policy and regulatory actions to ensure that CO2 transport and storage infrastructure can scale rapidly and responsibly to meet the anticipated demand.
Solvent developed at Queen’s University could transform carbon capture

A new solvent developed by researchers at Queen’s University Belfast can separate gases efficiently and could reduce the cost of carbon capture.

Separating mixtures of gases into the pure components is critical. It allows for the capture of carbon dioxide from fossil fuel power stations and other energy intensive industries. Once captured, it can then be injected back into the ground.

However, the current processes that are used to do this require large amounts of energy and therefore have their own colossal carbon footprint. In fact, around 16 per cent of the US energy is used in chemical separation processes – the emissions from which are equivalent to several million cars on the road.

The process developed by Queen’s University researchers centres around a new type of solvent - porous liquid. It is much more energy efficient and it’s predicted that it could save around 30 per cent in energy compared to the current process.

The research has been published in Materials Today. The project is supported by the Centre for Advanced Sustainable Energy (CASE), which is funded through Invest NI’s Competence Centre Programme. The Programme brings together business and academia and aims to transform the sustainable energy sector through business focused research.

Professor Stuart James from the School of Chemistry and Chemical Engineering at Queen’s, explained how he and his colleagues developed the solvent.

He said, “Porous liquids, as a new concept, came about after a chance conversation between myself and Professor David Rooney who is a chemical engineer at Queen’s.”

“David pointed out that porous solids have amazing abilities to separate chemical mixtures, but being solids they cannot be pumped through pipes, which limits the ways in which they can be applied.”

“Our conversation gave me the inspiration to invent a new class of materials which are porous but can also flow through pipes.”

The “porous liquids”, which have been developed by Professor James and his team are able to dissolve very large amounts of gas and can selectively dissolve one gas from a gas mixture.

Recent collaborative work funded by CASE Competence Centre suggests that porous liquids could also be very economical and effective for the production of biomethane from biogas, which is a significant resource derived from Northern Ireland’s agricultural waste.

Professor James explained, “This could really transform current processes. Using porous liquids, biomethane could be produced economically and effectively from biogas and this could be added to the gas grid, as an alternative to natural gas. The good news is that in the future this could potentially be used in homes and businesses.”

In 2017, a spin-out company, Porous Liquid Technologies Ltd. (PLT) was founded in a joint venture between Queen’s and the University of Liverpool to develop and commercialise porous liquids.

Professor James added, “Through PLT, we are now pioneering the use of porous liquids in various clean-fuel production processes, including biomethane, blue hydrogen and post-combustion carbon capture.”

“We are now forming partnerships with established companies in these fields in order to implement our technology. For advancing the biogas work, a project is underway to demonstrate the technology on a biogas production site. The project is supported by the Centre for Advanced Sustainable Energy (CASE).”

“CASE is funded through Invest NI’s Competence Centre Programme. Commercial partners on the project are PLT, Clariant (an international chemicals company) and United Renewables (a renewable energy developer and operator with biogas sites in Northern Ireland). For other applications, pilot projects are being planned before large scale roll-out and first industrial demonstrations are expected within the next three to five years.”

More information
www.qub.ac.uk
In a proof-of-concept work, the researchers infused regular cement with environmentally friendly biochar, a type of charcoal made from organic waste, that had been strengthened beforehand with concrete wastewater. The biochar was able to suck up to 23% of its weight in carbon dioxide from the air while still reaching a strength comparable to ordinary cement.

The research could significantly reduce carbon emissions of the concrete industry, which is one of the most energy- and carbon-intensive of all manufacturing industries. The work, led by doctoral student Zhipeng Li, is reported in the journal, Materials Letters.

“We’re very excited that this will contribute to the mission of zero-carbon built environment,” said Xianming Shi, professor in the WSU Department of Civil and Environmental Engineering and the corresponding author on the paper.

More than 4 billion tons of concrete are produced every year globally. Making ordinary cement requires high temperature and combustion of fuels. The limestone used in its production also goes through decomposition which produces carbon dioxide, so that cement production is thought to be responsible for about 8% of total carbon emissions by human activities worldwide.

Researchers have tried adding biochar as a substitute in cement to make it more environmentally friendly and reduce its carbon footprint, but adding even 3% of biochar dramatically reduced the strength of the concrete. After treating biochar in the concrete washout wastewater, the WSU researchers were able to add up to 30% biochar to their cement mixture. The paste made of the biochar-amended cement was able to reach a compressive strength after 28 days comparable to that of ordinary cement of about 4,000 pounds per square inch.

“We’re committed to finding novel ways to divert waste streams to beneficial uses in concrete; once we identify those waste streams, the next step is to see how we can wave the magic wand of chemistry and turn them into a resource,” said Shi. “The trick is really in the interfacial engineering – how you engineer the interfaces in the concrete.”

The caustic concrete washout water is a sometimes problematic waste material from concrete production. The wastewater is very alkaline but also serves as a valuable source of calcium, said Shi. The researchers used the calcium to induce the formation of calcite, which benefits the biochar and eventually the concrete incorporating the biochar.

“Most other researchers were only able to add up to 3% biochar to replace cement, but we’re demonstrating the use of much higher dosages of biochar because we’ve figured out how to engineer the surface of the biochar,” he said.

The synergy between the highly alkaline wastewater that contains a lot of calcium and the highly porous biochar meant that calcium carbonate precipitated onto or into the biochar, strengthening it and allowing for the capture of carbon dioxide from the air. A concrete made of the material would be expected to continue sequestering carbon dioxide for the lifetime of the concrete, typically 30 years in pavement or 75 years in a bridge.

In order to commercialize this technology, the researchers have been working with the Office of Commercialization to protect the intellectual property and have filed a provisional patent application on their carbon-negative concrete work. They recently received a seed grant from the Washington Research Foundation to produce more data for a variety of use cases. They are also actively seeking industry partners from the building and construction sector to scale up production for field demonstrations and licensing this WSU technology.

“Graduate student Zhipeng Li and Professor Xianming Shi managed to add up to 30% biochar to the concrete mix without reducing its strength”

More information

www.wsu.edu
Capture & Utilisation

Path to net-zero carbon capture and storage may lead to ocean

Lehigh Engineering researcher Arup SenGupta has developed a novel way to capture carbon dioxide from the air and store it in the “infinite sink” of the ocean.

The approach uses an innovative copper-containing polymeric filter and essentially converts CO2 into sodium bicarbonate (aka baking soda) that can be released harmlessly into the ocean. This new hybrid material, or filter, is called DeCarbonHIX (i.e., decarbonization through hybrid ion exchange material), and is described in a paper recently published in the journal Science Advances.

The research, which demonstrated a 300 percent increase in the amount of carbon captured compared with existing direct air capture methods, has garnered international attention from media outlets and professional organizations like the American Chemical Society. SenGupta himself has been fielding interest in the technology from companies based in Brazil, Ireland, and the Middle East.

The climate crisis is an international problem,” says SenGupta, who is a professor of chemical and biomolecular engineering and civil and environmental engineering in Lehigh’s P.C. Rossin College of Engineering and Applied Science. “And I believe we have a responsibility to build direct air capture technology in a way that it can be implemented by people and countries around the world. Anyone who can operate a cell phone should be able to operate this process. This is not technology for making money. It’s for saving the world.”

The work is yet another extension of SenGupta’s personal and professional commitment to developing technologies that benefit humanity, and in particular, marginalized communities around the world. His research on water science and technology has included drinking water treatment methodologies, desalination, municipal wastewater reuse, and resource recovery. He invented the first reusable, arsenic-selective hybrid anion exchanger nanomaterial (HAIX-Nano), and as a result, more than two million people around the world now drink arsenic-safe water. Two of his patents have been recognized as “Patents for Humanity” by the US patent and Trademark Office.

His invention of DeCarbonHIX was the outcome of an ongoing CO2-driven wastewater desalination project funded by the Bureau of Reclamation under the jurisdiction of the U.S. Department of the Interior. SenGupta and his students were on the lookout for a reliable supply of CO2 even in remote places. That quest led the way to the field of direct air capture, or DAC, and the creation of DeCarbonHIX. This subject was the dissertation topic for environmental engineering student Hao Chen ’23 PhD, who successfully defended his PhD in March and will receive his doctorate in May.

Capturing carbon at lower concentrations

The most abundant of the greenhouse gasses contributing to global warming is carbon dioxide. In 2021, global emissions of CO2 rose by 6 percent from the previous year—to 36.3 gigatons, according to the International Energy Agency. Just one gigaton (equal to 1 billion tons) is the equivalent of the mass of all land mammals on earth.

Emissions from greenhouse gases have increased global temperatures by approximately 1.1 degrees Celsius above pre-industrial levels, according to the Intergovernmental Panel on Climate Change. In its 2021 working group report, the IPCC estimates the average yearly temperature over the next 20 years is expected to rise by at least 1.5 degrees Celsius. The warmer the earth gets, the greater the fallout in terms of rising sea levels, extreme storm events, and ecological disruption, all of which have repercussions on global health, security, and stability.

“The worst part of this crisis is that people who are marginalized, who are poor, will suffer 10 times more than those who contributed to this situation,” says SenGupta.

There are three ways to reduce CO2, he says. The first—government action—can reduce emissions, but that won’t address what’s already in the air.

“The second way is removing it from point sources, places like chimneys and stacks where carbon dioxide is being emitted in huge
amounts,” he says. “The good thing about that is you can remove it at very high concentrations, but it only targets emissions from specific sources.”

The newest method is called direct air capture, which, he says, “allows you to remove CO2 from anywhere, even your own backyard.”

With DAC, chemical processes remove CO2 from the atmosphere, after which it’s typically stored underground. However, says SenGupta, the technology is limited by its capacity. It can’t capture enough CO2 to overcome the energy cost of running the process.

“If you’re capturing carbon dioxide from a chimney at a plant, the amount of CO2 in the air can be upwards of 100,000 parts per million,” he says. “At that concentration, it’s easy to remove. But generally speaking, the CO2 level in the air is around 400 parts per million. That’s very high from a climate change point of view, but for removal purposes, we consider that ultra-dilute. Current filter materials just can’t collect enough of it.”

Another challenge with DAC involves storage. After the CO2 is captured, it’s dissolved, put under pressure, liquified, and typically stored miles underground. A DAC operation must then be located in an area with enough geological storage—and stability. A country like Japan, for instance, can’t pump CO2 underground because the area is prone to earthquakes.

Seeing a solution in seawater

SenGupta has developed a DAC method that overcomes both the capture problem and the issue of storage.

For the capture problem, he developed DeCarbonHIX—a mechanically strong, chemically stable sorbent (a material used to absorb liquids or gasses)—that contains copper. “The copper changes an intrinsic property of the parent polymer material and enhances the capturing capacity by 300 percent,” he says. “We showed that for direct air capture from air with 400 parts per million of CO2, we achieve capacity, meaning capacity is no longer a function of how much carbon dioxide is in the air. The filter will get saturated completely at any concentration, which means you can perform DAC in your backyard, in the middle of the desert, or in the middle of the ocean.”

The ocean is actually SenGupta’s solution to the storage problem. His DAC process starts with air blowing through the filter to capture CO2. Once the filter is saturated with gas molecules (determined by measuring the amount of gas going into the filter versus coming out of it), seawater is passed through the filter. The seawater converts the carbon dioxide to sodium bicarbonate (you likely know it as baking soda, but lose the visual as we’re talking about a dissolved solution here). The dissolved sodium bicarbonate is then released directly into the ocean, what Sengupta calls “an infinite sink.”

“And it has no adverse impact on the ocean whatsoever,” says SenGupta. “It doesn’t change the salinity at all.”

In fact, he says, the sodium bicarbonate, which is slightly alkaline, may improve the health of the ocean. That’s because elevated levels of CO2 in the atmosphere have gradually reduced the pH of the ocean, causing acidification. More acidic waters harm the growth and reproduction of marine life like corals and plankton and can create catastrophic collapses in the food chain.

“Sodium bicarbonate may reverse that lowering of pH,” he says.

It’s worth noting, he says, that like existing DAC processes, DeCarbonHIX can also be desorbed with hot water or steam, and pure CO2 can be recovered, compressed, and stored underground in geological storage.

“In reality, this new filter material offers a dual mode of desorption and sequestration.”

Adding renewables into the mix

The third part of SenGupta’s innovative method involves conditioning the filter, essentially restoring it to the state in which it can begin capturing CO2 again. (Cleaning it, in other words.) The process requires passing a diluted solution of sodium hydroxide through the filter.

“Now the question is, where will this sodium hydroxide come from? In many places, it’s likely already a waste material, but sodium hydroxide can also be made using seawater, and the energy required to make it can come from renewable sources like solar and wind. If the goal is to remove CO2, you should be emitting as little CO2 in the process as possible. The goal is net zero direct air capture.”

SenGupta envisions an offshore platform of sorts that hosts the entire operation. As the air blows, the filter would capture carbon dioxide until it’s saturated, at which point seawater would convert the gas to a sodium bicarbonate solution, and sodium hydroxide created from seawater would restore the filter to operational status. Energy from waves, wind, and/or the sun would power it all. Such platforms would be spread far and wide in a universal attempt to capture 100 million tons of CO2 in five to seven years.

“Scale is important here,” he says. “And it’s a scale that we’ve never dealt with before in the history of human civilization. I’ve only done this in the lab.”

It will be a huge engineering challenge to build the technology to the level of true global impact, and it will require expertise and partnership across a range of disciplines—and of course, funding.

“This is obviously not magic,” he says. “There will be many problems to solve along the way. But I believe it has the potential to be a very economical process.”

More information

www.lehigh.edu
Capture & Utilisation

Carbonaide raises EUR 1.8 million to make manufacturing concrete carbon negative
www.carbonaide.com

The company is building the world’s first industrial pilot production line that can make carbon-negative concrete using industrial side streams and CCUS technology.

Carbonaide, a spin-out company from VTT Technical Research Centre of Finland that enables the manufacturing of carbon-negative concrete, has raised EUR 1.8 million in seed funding led by Lakan Betoni and Vantaa Energy. The round was completed with public loans and in-kind contributions from Business Finland and other Finnish concrete companies and strategic investors.

The company will use the funding to integrate its CO2 curing technology into an automated production line of its precast concrete factory in Hollola, Finland. With its factory-sized pilot unit and fully operational value chain, Carbonaide can mineralize up to five tons of CO2 per day and increase production by 100-fold of its carbon-negative concrete products.

The concrete industry is responsible for 8% of global CO2 emissions, with most of the emissions originating from ordinary Portland cement manufacturing: one tonne of ordinary Portland cement creates 800–900 kilograms of CO2 emissions.

With legislation increasingly tightening around construction material emissions, industrially feasible technologies to reduce the CO2 emissions of concrete are severely needed.

Carbonaide’s solution is based on an effective carbonation method, which binds carbon dioxide into precast concrete using an automated system at atmospheric pressure. The technology can halve the CO2 emissions of traditional Portland cement concrete by reducing the required cement content and mineralizing CO2 into concrete.

When industrial side streams, such as industry slags, green liquor dregs, and bio-ash, are used in the binding process instead of normal cement, the result is concrete with a negative carbon footprint. In the process, CO2 is permanently stored and removed from the carbon cycle.

“We have demonstrated in the pilot unit that our technology is capable of reducing the CO2 emissions of conventional concrete by 45%. Last autumn, we demonstrated lowering our products’ carbon footprint to ~60 kg/m3 by replacing Portland cement with slag. Our first pilot unit had limited capacity, so we’re grateful to our investors for the chance to upscale our technology to a factory-sized pilot and demonstrate the technology full-scale,” said Tapio Vehmas, CEO of Carbonaide.

Artificial photosynthesis produces food from CO2 more efficiently than plants
www.tum.de

Researchers at the Technical University of Munich (TUM) have successfully developed a method for the synthetic manufacture of nutritional protein using a type of artificial photosynthesis.

A group led by Prof. Volker Sieber at the TUM Campus Straubing for Biotechnology and Sustainability (TUMCS) has succeeded in producing the amino acid L-alanine, an essential building block in proteins, from the environmentally harmful gas CO2. Their indirect biotechnological process involves methanol as an intermediate.

Until now, protein for animal feed has been typically produced in the southern hemisphere with large-scale agricultural space requirements and negative consequences for biodiversity.

The CO2, which is removed from the atmosphere, is first turned into methanol using green electricity and hydrogen. The new method converts this intermediate into L-alanine in a multi-stage process using synthetic enzymes; the method is extremely effective and generates very high yields. L-alanine is one of the most important components of protein, which is essential to the nutrition of both humans and animals.

Prof. Sieber, of the TUM Professorship for Chemistry of Biogenic Resources, explained, “Compared to growing plants, this method requires far less space to create the same amount of L-alanine, when the energy used comes from solar or wind power sources. The more efficient use of space means a kind of artificial photosynthesis can be used to produce the same amount of foodstuffs on significantly fewer acres. This paves the way for a smaller ecological footprint in agriculture.”

The manufacture of L-alanine is only the first step for the scientists. “We also want to produce other amino acids from CO2 using renewable energy and to further increase efficiency in the realization process,” says co-author Vivian Willers, who developed the process as a doctoral candidate at the TUM Campus Straubing. The researchers add that the project is a good example of how bioeconomy and hydrogen economy in combination can make it possible to achieve more sustainability.

MOF Technologies rebrands to Nuada
www.nuadaco2.com

The UK-based company’s technology efficiently captures CO2 directly from industrial sources, cutting the energy penalty and costs associated with CO2 capture.

The new name is an ode to the company’s Celtic origins and is inspired by the ancient mythical king, Nuada, whose name means "to capture".

Nuada said its technology can play a significant role in the transition to a low carbon economy, providing emitters with an efficient and economical solution to decarbonise their operations, especially hard-to-abate industries, where carbon capture is essential to reaching Net Zero targets.

Nuada said it has positioned itself as a "vertically integrated pure-play carbon capture company". The Company’s technology is currently being deployed in the field at pilot plant-scale by industry leaders in the energy and cement manufacturing sectors.

Dr. Conor Hamill, Co-CEO at Nuada commented, “We are excited to introduce Nuada as the new face of our company. This brand direction and new website signify the start of a new era of redefining carbon capture, where the adoption barriers of energy intensity and high cost are removed.”

He added that: "Our team is dedicated to creating innovative scalable solutions that not only efficiently capture carbon emissions from diverse sources but that can be seamlessly retrofitted to existing industrial installations."
Lloyd's Register finds technology ready for onboard CO2 capture

New report indicates adoption of Onboard Carbon Capture Systems (OCCUS) is dependent on the economic feasibility for maritime supply chain stakeholders.

The Lloyd’s Register (LR) Maritime Decarbonisation Hub’s Zero-Carbon Fuel Monitor has found that although technology readiness is high, the formation of viable economic cases for each player in the supply chain is needed to scale up adoption of Onboard Carbon Capture Utilisation and Storage (OCCUS).

The research has found that technology readiness for OCCUS is significantly higher than its investment and community readiness, largely due to the development and usage of carbon capture technology outside of the maritime industry.

To see the potential benefits of OCCUS adoption, the readiness assessment highlights that regulations will need to be updated to address the practical challenges, including carbon accounting and how OCCUS aligns with MARPOL regulations. There is also a need for significant infrastructure scaling and investment for onboard and offloading solutions to drive adoption. Additionally, safety and operational factors surrounding offloading of liquified CO2 as a result of the carbon capture process need to be considered.

Outlining the need for an increase in investment readiness for OCCUS, the report concludes that evidence is required to validate the real-world performance of onboard capture technology, to ensure adopters can be assured of the technology’s emission reduction credentials.

The research suggests the solutions could play a significant role in the shipping industry’s journey towards zero carbon emissions, with OCCUS considered as a mid-term ‘step’ for ship operators and owners. OCCUS technology has potential for existing vessels where conversion to zero carbon fuel is cost prohibitive, thus increasing the lifetime of an asset.

Charles Haskell, Director, LR Maritime Decarbonisation Hub, said, “The maritime industry needs decarbonisation solutions that reduce emissions in the short to mid-term, and carbon capture can be a transitional tool for operators and owners to do this. LR Maritime Decarbonisation Hub’s research emphasises the need to focus on providing demonstrable evidence that OCCUS systems can help owners in meeting interim emissions regulations with existing vessels.”

“The research also underlines the need for maritime supply chain stakeholders to come together, to ensure that the required infrastructure is developed and implemented to allow the industry to use the solutions which score high on technology readiness.”

The publication of the research follows the announcement that LR has been selected by the Global Centre for Maritime Decarbonisation (GCMD) to carry out an industry first concept study into offloading liquefied CO2 as part of the carbon capture process, addressing the requirement for infrastructure and safety as part of the OCCUS process.

LR has also been involved in a number of other carbon capture projects, including the Approval in Principle for Value Maritime’s Filtree system and Rotoboost’s pre-combustion carbon capture solution.

More information
www.lr.org
At the launch ceremony, participants from related organizations including the Ministry of Economy, Trade and Industry, NEDO (the New Energy and Industrial Technology Development Organization) and the ship owner, Sanyu Kisen were on hand to offer their congratulation for the safe launch of the ship.

Mitsubishi Shipbuilding is in charge of all aspects from the ship design through construction, which is underway. Following outfitting and sea trials, the ship is scheduled to be handed over in the latter half of fiscal 2023.

This demonstration test ship hull will be equipped with the liquefied CO2 tank system researched and developed by the Engineering Advancement Association of Japan (ENAA). After completion, the demonstration test ship will be engaged in liquefied CO2 transportation for the CCUS R&D and Demonstration Related Project, the Large-scale CCUS Demonstration in Tomakomai, the Demonstration Project on CO2 Transportation, the R&D and Demonstration Project for the Marine Transportation of CO2 (the “Demonstration Projects”) which have been conducted by NEDO since June 2021.

ENAA, Kawasaki Kisen Kaisha, Ltd. (“K” LINE), NGL, and Ochanomizu University will accelerate their research and development of the LCO2 transportation technology and contribute to the reduction of the cost of CCUS technology and realization of LCO2 safe large-scale long-distance transportation.

ENAA has been engaged in research and development towards the operation of a demonstration ship equipped with a liquefied carbon dioxide ship tank system, and it will continue to be responsible for the planning, analysis and supervision of the demonstration test.

“K” LINE carried out a risk assessment of the demonstration test ship in the safety evaluation in 2022 and will contribute to the development of an operation manual for the demonstration vessel.

NGL is proceeding with the planning of the management and operation of the demonstration vessel. In addition, NGL is conducting a case study of its own LPG vessel in preparation for the measurement of data related to the temperature, pressure, flow, etc. of the CO2 on the demonstration vessel.

Ochanomizu University is conducting fundamental research on the control of the state of carbon dioxide (phase changes) and provide the information necessary for safe transportation studies.

More information
www.kline.co.jp
www.mhi.com
TÜV SÜD to build world’s first traceable CO2 calibration facility

Following a successful bid for £950K funding from Horizon Europe, TÜV SÜD National Engineering Laboratory will build the first UK national standard liquid / dense phase CO2 calibration facility.

The 3.5-year project, called “A European Network of Research Infrastructures for CO2 Transport and Injection” (ENCASE), will involve 20 partners from across Europe and be coordinated by the Institute for Energy Technology (IFE) in Norway.

The TÜV SÜD focus will be on building a facility to run accurate R&D tests with CO2-rich mixtures for flow measurement and sampling systems. This will provide the necessary traceability and research capabilities which will ensure accurate fiscal flow measurement across the CCUS chain.

This research project is a first of its kind and holds significant importance in achieving net zero and reaching sustainability targets, as accurate measurement of transported and stored CO2 is essential for the deployment of CCUS.

The project is part of the EU’s Horizon Europe initiative which funds research and innovation that responds to challenges like climate change and improves European research infrastructures and standards.

Following the project’s kick-off meeting on 3 March 2023 in Oslo, Gabriele Chinello, Head of Carbon Capture, Usage and Storage (CCUS) at TÜV SÜD National Engineering Laboratory, expressed his excitement about the project and its potential benefits.

I’m looking forward to seeing the impact that this research will have on the measurement and monitoring of CO2 for Carbon Capture Utilisation and Storage. Thanks to the funding and collaborations that are now available, the project is poised to make a significant contribution to the fight against climate change and help pave the way for a more sustainable future.”

The new facility will be built at TÜV SÜD National Engineering Laboratory in East Kilbride, Scotland.

NETL data portal to aid completion of permit applications for carbon storage

donor://www.tuvsud.com

An NETL project team developed the Class VI Data Support Tool Geodatabase using data from the Carbon Storage Open Database, the Energy Data eXchange (EDX), the U.S. Geological Survey and other sources. The geodatabase is free and publicly available. It is hosted on EDX, NETL’s virtual data collaboration and curation platform for data-driven technology development.

Class VI wells are used to inject CO2 into deep geologic formations solely for the purpose of permanently storing the greenhouse gas. The U.S. Environmental Protection Agency tailored Class VI program rules as a part of its Underground Injection Control Program to ensure these wells are appropriately sited, constructed, tested, monitored, funded and closed once injection activities are completed. Most projects are intended to store captured CO2 deep underground in saline geologic formations.

“Class VI well permits have the potential to revolutionize the way we think about permanently storing CO2,” said Paige Morkner, a research scientist. “We’ve developed this tool to help make that possible.”

Those preparing Class VI permit applications can now use the geodatabase to query, explore and download spatial data for the entire United States. Once downloaded, the data can be queried for use on a state-by-state basis using software such as Eris and ArcGIS.

Morkner and her colleagues fast-tracked the development of the new tool. The Inflation Reduction Act of 2022, which was signed into law last August and increased federal tax incentives for carbon management projects, is driving industry and developers to jump-start subsurface sequestration activities.

NETL’s new geodatabase provides developers with technology to visualize subsurface data from the CO2 reservoir to the surface so they can safely and permanently sequester CO2, a critical component of the Biden Administration’s goal to achieve a 100% carbon emissions-free electricity sector in the United States by 2035 and a net-zero clean energy economy by 2050.

Upgrades to the geodatabase are planned. By December, the geodatabase will be integrated into a data visualization dashboard tool, which will enable users to interact with the data in a virtual environment and easily pull relevant spatial data and information into maps for a Class VI permit application without having to download the data to their local computer.

“Our data support work is a valuable step forward. It will enable operators, researchers and other carbon storage community members to quickly find and query publicly available spatial data used to produce some of the narratives and maps necessary to complete the site characterization process needed to file a Pre-Construction Class VI permit application with the EPA,” Morkner said.

Samskip carbon capture system stores CO2 in batteries

Samskip has recently embarked on a new innovative project that will reduce CO2 emissions for its vessels and make it available to other industries.

Samskip’s Carbon Capture and Utilization system is a clever and sustainable application that in real-time captures 30% of the CO2 emissions generated by combustion engines and stores it in portable batteries.

These batteries can then be delivered to businesses that use CO2 such as agricultural clients and greenhouses who currently use gas powered machinery to create CO2 needed to stimulate growth of their products.

The captured CO2 can then immediately be used bypassing the need for the gas-powered machinery in turn reducing the use of natural gas.

Samskip has recently embarked on a new project to use CO2 captured from the atmosphere to reduce emissions from its vessels and will make it available to other industries.

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