Carbon Capture Journal

CCUS in the U.S.

Texas carbon management Roadmap

Webinar report: project updates from Tenaska, Geostock Sandia and Vault 44.01

ExxonMobil's second project in Louisiana

Mar / Apr 2026 Issue 110

Consortium advances UK integrated CCS shipping facility

Image: Stanlow Terminals Limited

Xodus: Carbon capture needs commerciality, not more policy

How novel nanomaterials make CCUS affordable and scalable

CO2 capture from phosphate fertilizer production

Floating the carbon solution: the role of offshore CO2 injection and storage

Carbon Capture and Storage Ladder – 2026 update

In partnership with Bellona, E3G has updated the 2023 CCS Ladder to provide a structured, evidence-based tool for decision makers to evaluate where CCS delivers most climate value in Europe.

The real debate on CCS is not "yes or no", but where it adds genuine and durable climate value. This 2026 edition deepens the analysis, incorporates new stakeholder feedback, and reflects evolving decarbonisation realities, including the scaling of alternatives like electrification, circularity, and efficiency.

Domien Vangenechten, Programme Lead, EU Industry at E3G, said, "Europe's industrial transformation demands smart choices on CCS. Our CCS Ladder cuts through the noise, highlighting indispensable uses in process-heavy industries while signaling where other solutions like electrification will dominate – ensuring every euro spent maximises climate and competitiveness gains is vital to future-proof Europe's industries."

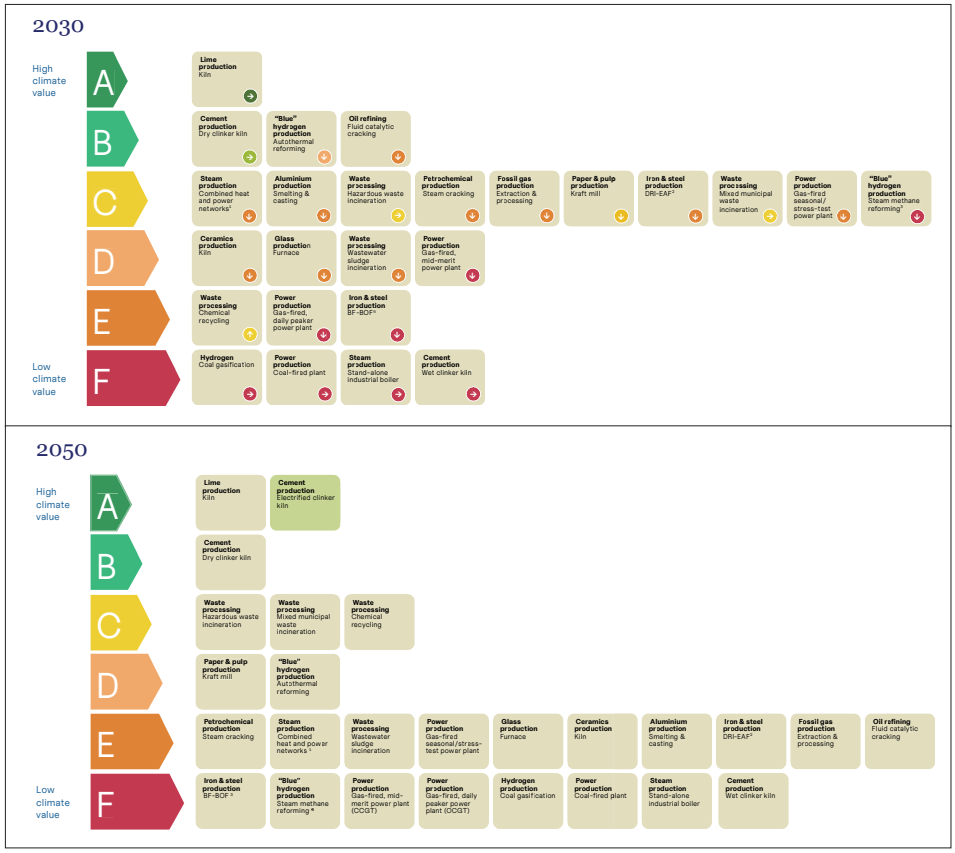
The Ladder assesses CCS applications across key industrial sectors, evaluating their climate value for 2030 and 2050 based on three core criteria:

- competition from alternatives
- mitigation potential
- feasibility

It highlights where CCS is indispensable, where it plays a transitional role, and where its relevance declines as other solutions outperform it.

With limited public funding, infrastructure constraints, and political attention, prioritisation is essential. The Ladder and its underlying analytical framework provide a structured basis to support stakeholders in considering where infrastructure and policy support can deliver most value in a constrained environment.

Georg Kobiela, Policy Lead at Bellona Deutschland, said, "To efficiently deploy public funds and achieve the maximum climate impact, CCS applications must be prioritised based on their climate benefit. Our CCS Ladder offers a conceptual framework for this. Similar transparent and evidence-based frameworks should be applied in the German Carbon Management Strategy – which must now be adopted quickly."



Coloured arrows indicate changes in relative ranking from 2030 to 2050 (up, down or stable. The ladders do not express how much CCS should or will be deployed in any application, nor whether CCS is the only or preferred mitigation lever. All applications assessed have at least some technological and non-technological mitigation alternatives, including those applications with higher rankings

Key insights

High-value applications. CCS remains critical for sectors like lime and to a lesser extent cement production, where process emissions from limestone decomposition have limited viable alternatives. In these areas, its climate value is high and stable through 2050.

Declining value in power. In the power sector, CCS has low and decreasing value, as renewables, storage, and flexibility options deliver deeper emissions cuts at lower costs.

Variable-value sectors. For sectors like waste processing and hydrogen production, the value of CCS varies depending on residual emissions, demand shifts, and system dynamics. Alternatives such as circularity, recycling, and renewable hydrogen show high scaling potential but face economic, infrastructure, and deployment uncertainties.

Dynamic over time. The update shows shifts between 2030 and 2050, emphasising that CCS must complement broader system transformations.

More information

www.e3g.org

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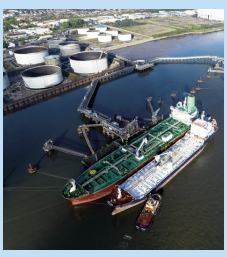

Front cover: A consortium including Stanlow Terminals will explore the feasibility of a new, integrated carbon capture, storage and shipping facility in the UK. (pg. 33)

Back cover: Natural gas produced from East Texas and Louisiana will be gathered and treated at ExxonMobil's NG3 Gillis facility (pg. 9)

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Leaders - CCUS in the U.S.

Projects and policy

Capture and utilisation

Transport and storage

Texas carbon management Roadmap charts path to energy transformation

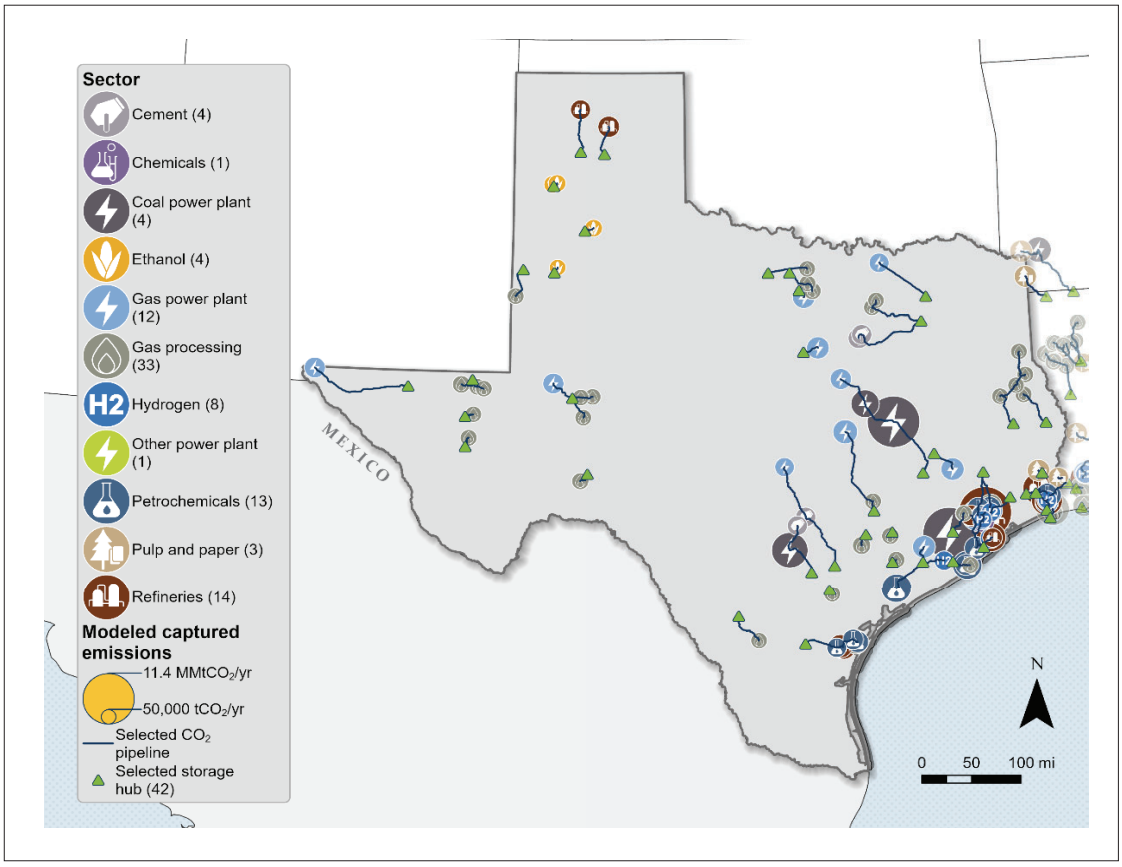
A new Roadmap from the Great Plains Institute with support from the Cynthia and George Mitchell Foundation charts how the state that revolutionised U.S. energy can lead the next transformation.

The Roadmap serves as a reference for understanding Texas's carbon management landscape and provides a clear and practical framework for how Texas can support the deployment of responsible carbon management in the near term.

It outlines Texas's opportunities and challenges and identifies the policy, regulatory, workforce, and infrastructure steps needed to scale projects safely and economically.

It includes a statewide assessment of CO2 sources and storage potential, modeling of near- and longer-term capture and storage scenarios, and analysis of workforce needs, permitting timelines, and investment barriers.

It also recommends actions to strengthen regulatory clarity, enhance community engagement and transparency, and support emerging opportunities such as DAC, hydrogen with carbon capture and storage, and carbon utilisation. The Roadmap is designed to guide planning, investment, and coordinated action across Texas.



Results for the Texas portion of the midcentury deployment scenario. Modeled results show that 97 facilities across Texas, connecting to 42 onshore and offshore storage sites by nearly 1,960 miles of CO2 pipeline, could capture approximately 162 $MMtCO_2$ per year. Transparent items are included in the modeling scenario but reside in other states and facility counts include number of Texas facilities

"Texas stands at an inflection point," says the report. "The same geology that made it the center of American oil and gas—vast underground formations, an unrivaled pipeline network, a workforce that knows how to move molecules at scale—now positions the state to capture a new industry: carbon management."

"The National Petroleum Council projects $15 to $150 billion in investment flowing into Texas carbon capture, transport, and storage by 2050. The question isn't whether this industry is coming. It's whether Texas will take the lead."

Drawing on input from nearly 100 stakeholders—industry leaders, policymakers, environmental advocates, community voices, and technical experts—the Roadmap provides a near-term action plan for coordinated state, policy, industry, and community effort to deploy carbon management technologies responsibly while sustaining economic growth, protecting public health, and supporting Texas's energy workforce.

No other state has this combination:

- Thousands of miles of CO2 and hydrogen pipelines—the largest network in the nation, ready to scale

- 1,655 billion metric tons of geological storage capacity—onshore and offshore formations ideal for permanent CO2 sequestration

- An energy workforce with the engineering talent and operational expertise to deploy new technologies at scale

- Advanced energy leadership—first in wind and solar—growing battery energy storage systems and the potential for accelerating the state's low-carbon transition through advanced nuclear, geothermal, and natural gas with carbon capture, utilization and storage (NG+CCUS)

- Industrial clusters in refining, petrochemicals, and steel are already positioned for carbon capture integration

Federal incentives—including enhanced Section 45Q tax credits—have opened a window of opportunity. Private capital is already flowing. Projects are in development. Texas has already taken important steps, but without positive coordinated state action, Texas risks fragmented permitting, community opposition, workforce shortages, and missed federal funding. Other Gulf Coast states are advancing proactive policies. Texas can either set the standard or watch it be set elsewhere.

The Roadmap recommends immediate priorities:

- Strengthening Texas's competitiveness by modernizing and expanding existing state incentives, commissioning comprehensive economic analyses, and leveraging federal funding opportunities

- Ensuring permitting certainty and regulatory readiness for CO2 storage by supporting Class VI implementation, monitoring RRC staffing and funding needs, clarifying permitting timelines, and exploring long-term liability approaches

- Building public confidence through safety and transparency by expanding access to safety information, monitoring the need for seismic response areas, and aligning with recommended pipeline safety practices

- Supporting coordinated, responsible deployment through improvements in public engagement, better access to project information, and clear expectations for communication with communities

- Preparing Texas's workforce for new energy and industrial opportunities through statewide analyses, regional workforce mapping, new apprenticeship pathways, and reskilling programs

"George Mitchell, the Texas wildcatter who pioneered hydraulic fracturing, helped transform the American energy landscape. That same spirit of innovation now positions Texas to lead in carbon management and other advanced energy technologies."

"The Mitchell Foundation's support for this Roadmap reflects that paradox—and a wager that the ingenuity which unlocked a new era in American energy can do the same for a low-carbon future, with CGMF serving as honest broker in charting the path forward."

TEXAS CARBON MANAGEMENT ROADMAP RECOMMENDATIONS

What steps support safe, economical, and responsible, deployment?

CARBON CAPTURE	Establish a policy council, support continued federal investment in 45Q, modernize and expand state incentives, create state grant and revolving loan programs, commission statewide economic studies, develop a technology-neutral Energy Attribute Certificate framework, integrate into regional water planning, study air quality and health co-benefits, advocate for federal permitting clarity, monitor TCEQ permitting capacity, evaluate natural gas with carbon capture as a clean firm power resource
DIRECT AIR CAPTURE	Conduct feasibility assessments for waste-heat pairing and ensure DAC is eligible for carbon management incentives.
HYDROGEN & CARBON MANAGEMENT	Support federal 45V credit, expand hydrogen eligibility across Texas Emissions Reduction Plan programs, task the Texas Hydrogen Production Policy Council with advancing incentives, convene the Council to support export opportunities, provide public education, strengthen hydrogen safety and emissions standards, and explore produced water opportunities.
CARBON TRANSPORT	Incorporate recommended CO_2 pipeline safety practices and expand public awareness and safety outreach in regions where new CO_2 pipeline development is expected.
CARBON UTILIZATION	Conduct statewide market and policy assessment and support university-industry pilots including CO_2-derived sustainable aviation fuel.
CARBON STORAGE	Participate in training programs, increase RRC funding and staffing for Class VI reviews, clarify Class VI permitting timelines, include undocumented well surveys in applications, monitor Seismic Response Areas, expand induced-seismicity educational resources, and consider a long-term liability transfer framework.
COMMUNITY ENGAGEMENT	Increase communication on permitting, develop a centralized carbon management information hub, define significant public interest in air permitting, establish ongoing communication requirements for capture projects, expand public access to CO_2 pipeline information, increase engagement opportunities in Class VI processes, promote best practices for engagement, and support community benefit agreements and plans.
WORKFORCE DEVELOPMENT	Conduct statewide manufacturing workforce analysis, map regional workforce strengths and gaps, establish carbon management apprenticeship programs, create a workforce advisory council, offer reskilling grants, and leverage the Texas Skills Development Fund.

More information

www.betterenergy.org

www.cgmf.org

Tenaska – CCS as a long-term asset

Tenaska of Omaha sees CCS investments as a long-term asset. It is developing 10 CCS hubs to a standard design, each injecting five mtpa CO2. Bret Estep explained how the company is making it work. By Karl Jeffery.

"We made a decision 3-4 years ago that CCS was going to be a long-dated development asset," said Bret Estep, Vice President, Tenaska Development, based in Omaha, Nebraska.

He was speaking at a Carbon Capture Journal webinar on January 20 about developments with CCS in the US.

"These projects take a long time to do. They are not for the faint of heart or thinly capitalised. But they use limited resources and have decades long value."

In other words, CCS projects make good investments for a company like Tenaska, which has a long-term focus. "Tenaska's basic approach here is building on our own skill set," he said.

Tenaska is an independent power producer which has been in business for about 40 years. It is North America's largest physical gas trader. It is the largest third-party energy manager in the US managing about 15 GW of energy load. It has 800 staff and a $4bn balance sheet.

It operates its own fleet of 8 GW of power generation, mostly gas fired. It has some wind and solar generation. It has a development arm, which Mr Estep is involved with, with wind, solar, batteries, natural gas and CCS projects.

Tenaska is developing CCS projects with a hub and spoke model, rather than a single source, single sink model. It had eleven hubs in development, of which one was sold last year. Five of the remaining ten are in "phase 1." Four have applied for a Class VI injection permits, and the fifth will submit this year.

It is developing projects to a standard design, with targeted 5m metric tonnes CO2 injection per year per project. The hubs are being sited as close to injection sites as possible.

For the sources of CO2, it will start by storing CO2 from its in-development gas power generation, as the "anchor tenant" of the hubs. Tenaska would then become a supplier of low carbon power, not just a CCS company. But it is looking for other emitters, because the more CO2 the hub handles, the more viable the overall project is.

A second customer segment to target is emissions from ethanol producers and other "low cost of capture" industries.

A third segment may be the heavy industry sector including cement, steel, petrochemical and gas processing. Interest from this sector "took a hit" in 2024, with the US administration change, but "I think those are durable long term offers that will happen," he said.

"We expect to see multiple customer announcements this year" - Bret Estep, Vice President, Tenaska Development

It can serve companies producing "blue molecules" (hydrogen and ammonia). "We see some of that developing over time."

A fourth business possibility is direct air capture, paid for by carbon removal credits and tax credits.

Individual clients could typically purchase 500,000 or 1 m tonnes of storage a year. "We expect to see multiple customer announcements this year," he said.

The low carbon power could be sold to large-scale data centre operators, or "hyperscalers." They want power which is low or no carbon and dispatchable (available when they want it), even if the current US administration has different priorities. Tenaska can sign low carbon power purchase agreements.

They do not have many options. One possibility is small modular nuclear reactors, which are not expected to scale until the mid-2030s to 2040s. Another possibility is enhanced geothermal (fracturing the subsurface between two wells). This is "less site constrained than traditional geothermal," but individual projects are smaller, he said. They can use renewables with batteries, which only works in locations with plenty of wind or sunshine.

So, they are turning to a fourth option, combined cycle gas production with carbon capture. Normally, the $85 tax credit alone is not enough to make it financially viable. But if there is additionally a willingness from the data centre operator to pay more for low carbon energy, it can work.

Public acceptance

On public acceptance, Mr Estep notes that there will always be some public opposition to any project, the question is how well you work with it. "If you put cereal milk inside pipelines, someone would be against it," he joked.

"Tenaska has been building energy infrastructure for 40 years now. There is no project we have ever done that has had zero opposition. It is a matter of how you manage those things."

"I get it, landowners are protective of property rights. The best way to accommodate landowners is site your projects well. Do not

do dumb things in the beginning. Then after that you must have a track record, a very good ground game, do what we said we are going to do. Do not make ridiculous claims."

"It is difficult to get this public 'license,' this community buy-in. I do not expect we have an easy road anywhere. I expect we will do the right things and engage those communities."

Public acceptance for pipelines can be particularly hard. The ethanol industry often cannot manage without pipelines, because individual plants may not make CO2 volumes big enough to justify the costs of an onsite CO2 sequestration well. And many ethanol plants are not near good sequestration geology, such as much of the ethanol production in Nebraska,

The Tallgrass Trailblazer project is sending ethanol CO2 in a 392-mile pipeline from Nebraska to Wyoming. There is also Navigator CO2, which had a pipeline project across 5 Midwest states, and Wolf Carbon Solutions, which had a plan in Iowa. Frontier Infrastructure is exploring rail transport of CO2 in southwest Wyoming, he said.

"Needs everybody to be successful"

To get off the ground, the carbon capture industry "needs everybody to be successful," he said. "We are fighting to get these first rounds of projects done. They need to be built very well. People need to own up to commitments they have made."

"Last year was a difficult year for smaller developers. We weeded out some sub-optimal projects. This year we need projects to get done."

The agreement signed in October 2025 by Broadwing Energy for a CCS / gas fired power project in Decatur, Illinois, "was a huge advancement," he said. This project supplies low carbon electricity and steam to Archer Daniels Midland and Google, and should be in commercial operation by 2030.

The CCS industry can seem very slow moving compared to the data centre industry. But the incremental progress which does happen is extremely valuable. "These tiny wins stack up over time," he concluded.

CCS has some big advantages over solar and wind. It is not a 'moonshot' industry, it is "slow infrastructure that's going to be around for decades."

More information

You can watch the full webinar on YouTube at:

https://youtu.be/hXxpvYpPpCI

www.tenaska.com

Geostock Sandia – US CCS market and permits

Geostock Sandia of Houston has drilled eight CO2 wells over the past few years. CEO Sylvain Riba explained which projects are working in the market now, and why it is a "patience game" waiting for permits. By Karl Jeffery.

For now, CCS is "a patience game. We are waiting for permits to happen, to demonstrate examples and success stories," said Sylvain Riba, president and CEO, Geostock Sandia, a CCS storage specialist and consultancy based in Houston.

He was speaking at a Carbon Capture Journal webinar on January 20 about developments with CCS in the US.

The company has drilled around eight wells in the past 3-4 years on behalf of clients, both for injecting and for testing. Testing wells are sometimes required before injection can start.

CCS projects in the US today roughly split into two categories, major hub projects, and small single emitter single storage projects

A typical size for a major hub project is 2.5m tonnes CO2 storage a year, providing a service to other emitting companies. These projects are typically led by very large companies which can finance them.

A typical size for a single emitter project is 100,000 to 200,000 tonnes CO2 a year, which is enough to make it economic. For example, a bioethanol producer, natural gas power plant, or cement manufacturer.

Almost the entire CCS market in the US currently has its projects in the process of approval, he said. It typically takes about 2 years for the US Environmental Protection Agency to approve a permit to drill and inject CO2.

As far as finances, most US investors are focussed on 45Q, the tax credits available when CO2 is injected in the ground, to make the projects viable.

An additional revenue stream is voluntary carbon markets, when companies choose to pay for CO2 to be sequestered (not necessarily their own CO2), to improve the attractiveness of their products. Some ethanol producers are doing this.

Bioethanol production is a particularly good source of CO2, because the chemical process generates a pure CO2 stream which only needs to be dehydrated and compressed before being injected. With CO2 from natural gas combustion flue gas, by comparison, separation is needed.

If the ethanol producer reduces the carbon intensity of the ethanol production process sufficiently, it becomes possible to use it for new markets, such as in making sustainable aviation fuel.

If the CO2 can be injected close to the production site, there is no need to have a hub.

The injection system can be tailored to your needs and production volumes.

Ethanol producers can install injection wells on nearby land, sometimes owned by the ethanol plant itself. This means there is no need to negotiate with landowners.

Geostock Sandia provides support with permitting, geoscience studies, well design, and acts as a general contractor. It has a service to monitor injection throughout the life of the project.

Permits

To get a permit, you need to be able to demonstrate that the well and injection is safe, and the CO2 will stay downhole. US authorities are particularly concerned about the risk that CO2 in the subsurface may contaminate water supplies which will be later used for drinking water. This typically means water at up to 1000 feet deep.

CO2 is injected much deeper than this. There needs to be a buffer zone between the injection and drinking water zones, he said.

EPA is following its "Underground Injection Control" (UIC) philosophy, developed in the 1970s for wastewater injection.

As a permit condition, you will need to monitor the CO2 plume, comparing the model of where CO2 was expected to go with what is actually happening.

You will need to make sure the injected CO2 does not generate "seismicity" (mini earthquakes in the subsurface). If there are any seismic events, the CO2 flow rate needs to be limited.

Typically, companies use small passive seismic monitoring devices, rather than do full 3D seismic surveys for this. "You always must be cost conscious," he said.

You may need to have monitoring wells around the injection site, with sensors in them to record any microseismicity.

CO2 storage "is an industry that's adjacent to the oil and gas industry which has been working in the US for almost a century," Mr Riba concluded.

"It is a proven technology. The US is blessed with sedimentary basins that allow underground injection, let's use them."

Almost the entire CCS market in the US currently has its projects in the process of approval - Sylvain Riba, president and CEO, Geostock Sandia

More information
www.geostocksandia.com

Consultancy buys carbon credits from 1PointFive STRATOS project

Bain & Company purchased 9,000 metric tons of carbon dioxide removal (CDR) credits over three years enabled by Direct Air Capture (DAC).

The Stratos project under construction

The agreement is Bain's first purchase of DAC removal credits as a solution to address residual operational emissions and meet its current net negative commitment.

The CDR credits will be produced from STRATOS, 1PointFive's large-scale DAC facility in Texas that is progressing through start-up activities. The captured carbon dioxide underlying the CDR credits will be stored through durable geologic sequestration.

"Collaborating with Bain & Company reflects our shared commitment to innovation and the importance of accelerating the adoption of Direct Air Capture technology," said Anthony Cottone, President and General Manager of 1PointFive. "We believe this agreement demonstrates continued momentum for the solution while supporting the development of vital domestic infrastructure."

Bain, whose award-winning carbon credit sourcing program includes a diverse set of CDR technologies, has long been a leading supporter of the voluntary carbon market. They have invested in 1.1 million tonnes of high-integrity carbon removal credits over the past five years.

More information
www.1pointfive.com

Vault 44.01 – starting CCS with ethanol

CCS projects are hard, said Scott Rennie of Vault 44.01. For now, it makes sense to focus on the simplest and most cost-effective CCS projects, an ethanol plant with a high purity stream of CO2 that sits near good geology so there is no need for long pipelines. By Karl Jeffery.

The simplest and most cost-effective CCS project could be a bioethanol plant providing a high purity stream of CO2, connecting directly to a CO2 storage site on good geology for CO2 storage, said Scott Rennie, president and CEO, Vault 44.01, based in Sacramento.

He was speaking at a Carbon Capture Journal webinar on January 20 about developments with CCS in the US.

Mr Rennie has been working on CCS projects since 2007, as director of CO2 storage with ConocoPhillips. This long experience has provided an understanding of how hard it can be to get CCS projects running. So, Vault started with a philosophy of looking for the simplest possible project.

Ethanol projects could be a 'gateway' to developing a broader portfolio of CCS projects.

"We would like to work in other industries. If you can think of an industry CCS could apply, we have looked at it. [But] they take longer and are a bit harder to develop."

Vault has eight projects under development in four states in the US Midwest. These are Indiana, Ohio, Michigan and Illinois. It has contracts to eventually sequester 2.7m tonnes CO2 a year. There are a few more projects under development.

So far, Vault has submitted seven license applications for class VI wells, all linked to ethanol plants.

Vault develops CCS projects together with partners, including partners providing capital. Its staff have a background in CO2 storage and oil and gas development. The company manages land acquisition in-house and runs projects in house.

Most of the industries producing emissions, such as ethanol, cement or power, do not have staff with subsurface experience, so may be interested to partner with a company which does. But it can take a long time to explain to them how reservoir engineering works, he said.

The CCS industry needs to get beyond serving ethanol plants if it is going to make a big dent in overall emissions. A typical ethanol plant emits 300k tonnes a year, and the entire US ethanol industry emits 45m tonnes a year.

But total industrial emissions from the US are around 2bn tonnes a year of CO2, with a "dominant portion" being from power generation.

"We're trying to get to decarbonisation of power through multiple mechanisms. That is the end game."

If we wake up a year from now, we are going to see projects under construction, projects permitted. This is a stay the course situation. We are going to see progress – Scott Rennie, president and CEO, Vault 44.01

Policy, regulation, and support

The US CCS business is policy driven, so operators need to keep a close eye on it.

The One Big Beautiful Bill act passed by US Congress in a large part preserved CCS economics as they were prior, including 45Q, keeping the tax credit at $85 / tonne. A lot of clean energy credits were pulled back.

An $85 tax credit means that projects which generate a high purity stream of CO2, and do not involve separating CO2 from a flue gas, can still have "positive economics," so long as they have the right combination of scale and proximity, he said.

Post combustion projects, which require CO2 to be separated from a flue gas, are "generally not in the money at $85." In this case, the $85 provides a "nice baseline" but you want some additional economic uplift to make the project work.

"We've been doing this for 5 years, it is a pretty consistent theme that no investor wants to go and lose money doing a CCS Project," he said.

There were changes made to the Department of Energy funding priorities and about $4bn, which impacted a number of projects in development. This included some early-stage cement projects Vault was working on.

Projects developing Blue Hydrogen driven by the 45V credits included in the 2022 Inflation Reduction Act had their qualification date for projects changed and the near-term deployment of these projects might be smaller than we expected a few years ago.

"There's a few projects that may hit that milestone, but the near-term universe of blue hydrogen projects will be smaller than we expected a year ago," he said.

A major issue for US CCS industry is the timeline for getting CO2 injection permits approved by the Environmental Protection Agency. EPA has said it would like to approve permits in 2 years, but it is looking more like 3 years, which can make things very difficult for CCS investors.

In January 2025 there were about 160 outstanding Class VI permits; as of January 2026 there were 207.

"There's been a lot more permits submitted than permits approved," he said.

EPA has recently developed a pilot program with a goal to approve permits within 18 months, and a few permit applications have been chosen to test it out, he said.

In late 2025 the state of Texas was given "primacy", so it can manage its own permits through the Texas Railroad Commission.

This may make a difference to the 20 CCS projects proposed in Texas. West Virginia and Arizona also got "primacy" in 2025, and more states are expected to follow.

A large part of enabling CCS projects to happen is to get State support, County support, and landowner support to make things happen.

Indiana passed state-wide CCS legislation in 2022. "As we go to 2026, they are still buttoning up elements of that process at the state level," he said.

A challenge with the tax credit system is that if your company is not already paying that amount of tax, it cannot use the tax credit directly.

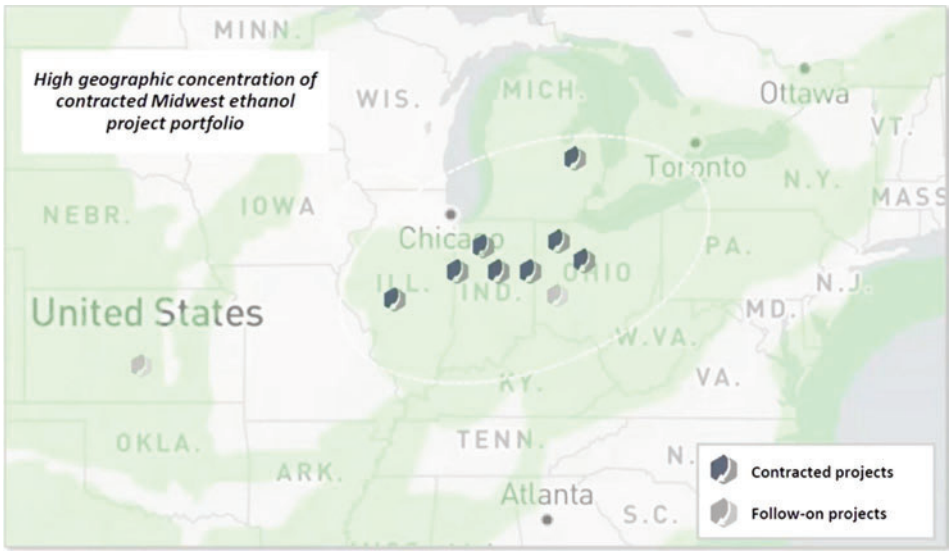
There are financial schemes that can be used to turn the tax credit into direct financing, through a "tax equity partnership structure" or an agreement to transfer the credits to a company which does pay that much tax.

"The process of turning 45Q tax credits into cash is possible, it is a bit of a process, but it can be done."

If CO2 leaks within 3 years, the tax credits can be revoked. Some large CO2 storage companies can handle that risk on their balance sheets, however most companies will choose to insure against it.

"Those policies are really expensive at the moment, but they are placeable," he said.

All of this means that CCS projects are extremely difficult. Mr Rennie's team, many of whom previously worked in the oil and gas industry, have a running joke, "if we want to do something easy, we'll start an oil and gas company."



Vault 44.01 has eight projects under development in four states in the US Midwest. These are in Indiana, Ohio, Michigan and Illinois. It has contracts to eventually sequester 2.7m tonnes CO2 a year and there are a few more projects under development

Projects going ahead

Despite the challenges, Vault believes a number of projects will proceed to commercial operation by 2029. The first group will be projects which do not require CO2 separation from a flue gas, such as ethanol, natural gas processing, and ammonia production.

The Tallgrass Trailblazer CCS project started commercial operation in late 2025, connecting 12-13 ethanol plants in Nebraska with sequestration sites in Wyoming. "My hat off to those guys, they've done a great job," he said.

There could be some Class VI approvals in 2026 enabling a number of ethanol projects to start commercial operation in late 2026 or 2027.

Projects requiring CO2 to be separated from a combustion flue gas will continue to be economically challenged under 45Q, unless there is a reason to pay more for low carbon energy, Mr Rennie said. Data centre customers may be willing to pay more.

CO2 removal is another business opportunity. Some companies have been willing to pay around 200 dollars a tonne to have CO2 taken out of the atmosphere. That price is high enough to "bring certain projects into the market."

And US policy may change with the administration changes in 2029.

Proving the industry

Over the past year, there may have been more negative than positive news about the US CCS industry.

"We've seen a number of market participants struggle and exit markets, seen the number of projects get whittled down," he said.

But that means the remaining projects are typically higher quality, which will help CCS overall build its reputation as an industry that delivers, proving itself to a public which can be sceptical about this new industry.

"If we can establish more sites, establish a track record, that sets us up for a successful growth industry."

"Things are happening. It is a head down, get stuff done and stay out of the news approach, and there's reasons for that."

"If we wake up a year from now, we are going to see projects under construction, projects permitted. This is a stay the course situation. We are going to see progress."

More information

www.vault4401.com

US news

ExxonMobil starts up second CCS project in Louisiana

www.exxonmobil.com

The company is now transporting and storing captured CO2 from the New Generation Gas Gathering (NG3) project in Gillis, Louisiana, its second active commercial CCS operation in the state.

Natural gas produced from East Texas and Louisiana is gathered through the NG3 system for treatment at the NG3 Gillis facility, where up to 1.2 million metric tons per year (MTA) of CO2 is expected to be removed from the natural gas stream before the product is redelivered to Gulf Coast markets, including LNG facilities.

This second active operation in Louisiana joins the start up in July 2025 of transportation and storage of CO2 from CF Industries' Donaldsonville Complex, enabling the production of low-carbon ammonia.

Two more CCS projects are also lined up to start in 2026. The CO2 contracted for these two active projects accounts for up to 3.2 MTA. ExxonMobil is currently storing the CO2 from both projects in permanent geologic sites through enhanced oil recovery, with plans to transition to dedicated permanent storage.

With its favorable geology and network of industrial and energy infrastructure, Louisiana is uniquely positioned to benefit from CCS to strengthen its core industries, drive economic growth, and reduce emissions. As more CCS projects come online, they'll enhance the state's production of steel, fertilizer, methanol, and power making those products more competitive globally and strengthening U.S. energy security at the same time.

The ability to produce low carbon products through CCS is also attracting companies with large-scale industrial projects such as data centers to Louisiana.

Baker Hughes receives orders to advance Wabash Valley clean ammonia project

www.bakerhughes.com

Baker Hughes will supply essential compression and integrated well construction solutions that support CO2 separation and permanent sequestration.

The project, located in West Terre Haute, Indiana, will repurpose an existing gasification facility into a clean ammonia plant which will be capable of producing 500,000 tons of ammonia per year while capturing 1.67 million tons of CO2, helping to create a more sustainable and reliable domestic fertilizer supply.

Wabash Valley Resources will repurpose an existing gasification facility into a clean ammonia plant which will be capable of producing 500,000 tons of ammonia per year while capturing 1.67 million tons of CO2

"Baker Hughes is a critical sustainability partner for Wabash Valley Resources, providing the advanced technologies that allow us to both open new low-carbon markets and make existing agricultural supply chains more sustainable," said Dan Williams, CEO of Wabash Valley Resources. "Their expertise in well construction, monitoring, and long-term CO2 management enables us to deliver low-carbon ammonia at industrial scale and strengthen America's fertilizer supply chain."

Under the new awards, Baker Hughes will provide compression equipment for Honeywell UOP's hydrogen purification system, along with compressors for ammonia and syngas processing under a separate contract with a different customer, as well as CO2 injection pumps for permanent geological storage.

"Beyond energy, Baker Hughes is helping to transform essential industries such as agriculture to help them expand in a more productive and sustainable manner," said Baker Hughes Chairman and CEO Lorenzo Simonelli. "Wabash Valley Resources' project brings together government, technology partners, industry and global investors to realize world-class industrial innovation so that farms can provide for growing populations."

These latest awards follow a separate well construction contract booked in the third quarter of 2025 to support the site's long-term CO2 storage infrastructure. This includes constructing two CO2 injection wells and four monitoring wells, using advanced completions systems and corrosion-resistant cement to ensure long-term integrity. Monitoring technologies deployed in the wells will support regulatory compliance, environmental protection and full lifecycle CO2 management.

Lapis Carbon Solutions applies for carbon storage licence in Illinois

www.lapiscarbonsolutions.com
www.bigriverresources.com

Alongside its partner Big River Resources it has filed a Class VI application for a new CCS project adjacent to Big River Resources' Galva ethanol facility.

The project will permanently store more than 725,000 metric tons of carbon dioxide per year over 12 years. This positions Big River to materially lower the carbon intensity of its products and compete in the next generation of low-carbon fuels.

"Our partnership with Big River marks an expansion into the Midwest—a market where bespoke carbon solutions are needed now more than ever," said Lapis CEO Reg Manhas. "This shows the expertise of our world-class team to find creative solutions that are customised to the needs of the emitter and of the local community."

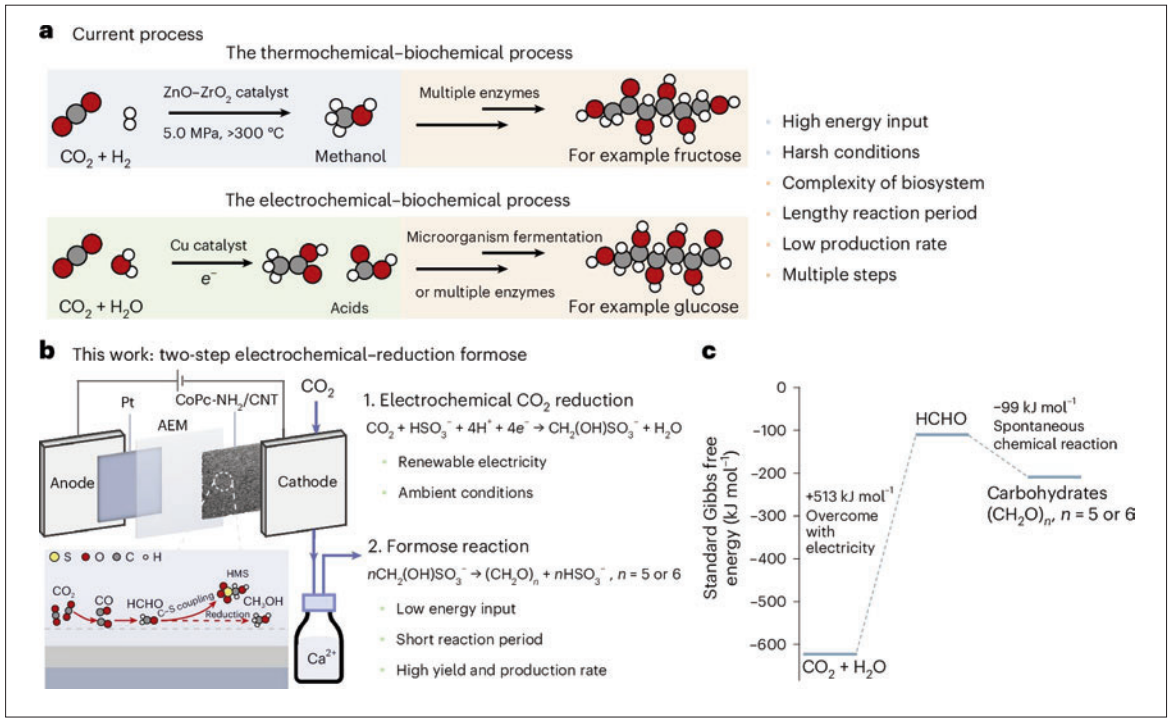
The announcement follows the successful completion of a stratigraphic test well that confirmed favorable geologic conditions for the safe and permanent storage of CO2. The sequestered CO2 will qualify for federal tax credits under section 45Q of the Internal Revenue Code.

Transforming CO2 into carbohydrates with renewable energy

A two-step method developed at Yale University for converting carbon dioxide into carbohydrates has potential applications in agriculture and biotech.

In a new study published in Nature Synthesis, chemists at Yale and the University of California-Berkeley have developed a two-step process that removes carbon dioxide from the air and converts it into carbohydrates, aka sugars.

Previous studies from various research institutes, including Yale, have explored ways to convert CO2 into simple molecules, such as methanol and formate, that can be used as industrial feedstocks for other products and to reduce greenhouse gases.



Comparing different pathways from CO2 to carbohydrates. Figure: Nature Synthesis (2026)

The new study pushes this idea further. It describes a process for using renewable electricity to transform CO2 into long-chain carbohydrates (molecules with five or six carbon atoms), which are considered the molecular building blocks of life.

"We were motivated by the successes and limitations of our own previous work," said Hailiang Wang, a chemistry professor in Yale's Faculty of Arts and Sciences, member of the Yale Energy Sciences Institute and Yale Center for Natural Carbon Capture, and co-corresponding author of the study.

"The products we've made up to now, such as methanol, are very useful, but we wanted to develop conversions for even more complex and valuable products."

In the new study, Wang and his colleagues begin with an electrochemical reaction that, if left uninterrupted, will convert carbon dioxide into methanol. However, the researchers halt the process in mid-reaction — when the molecule is formaldehyde.

At this point, the researchers convert the formaldehyde molecule into a molecule called hydroxymethanesulfonate (HMS), an organosulfur compound that is stable against further reduction.

"Formaldehyde is so reactive, it is challenging to work with," Wang said. "But we've been able to stabilize it."

The HMS can then be converted, in a thermochemical reaction, into carbohydrates, such as synthetic sugars for agricultural feedstocks and sweeteners. In addition to these potential uses in agriculture and food production, the new chemical process may have applications in drug design and biotech, Wang said.

Such applications are all in addition to the environmental benefits of disposing of CO2. The researchers are now planning to refine the results with additional research and are pursuing a patent application for the process.

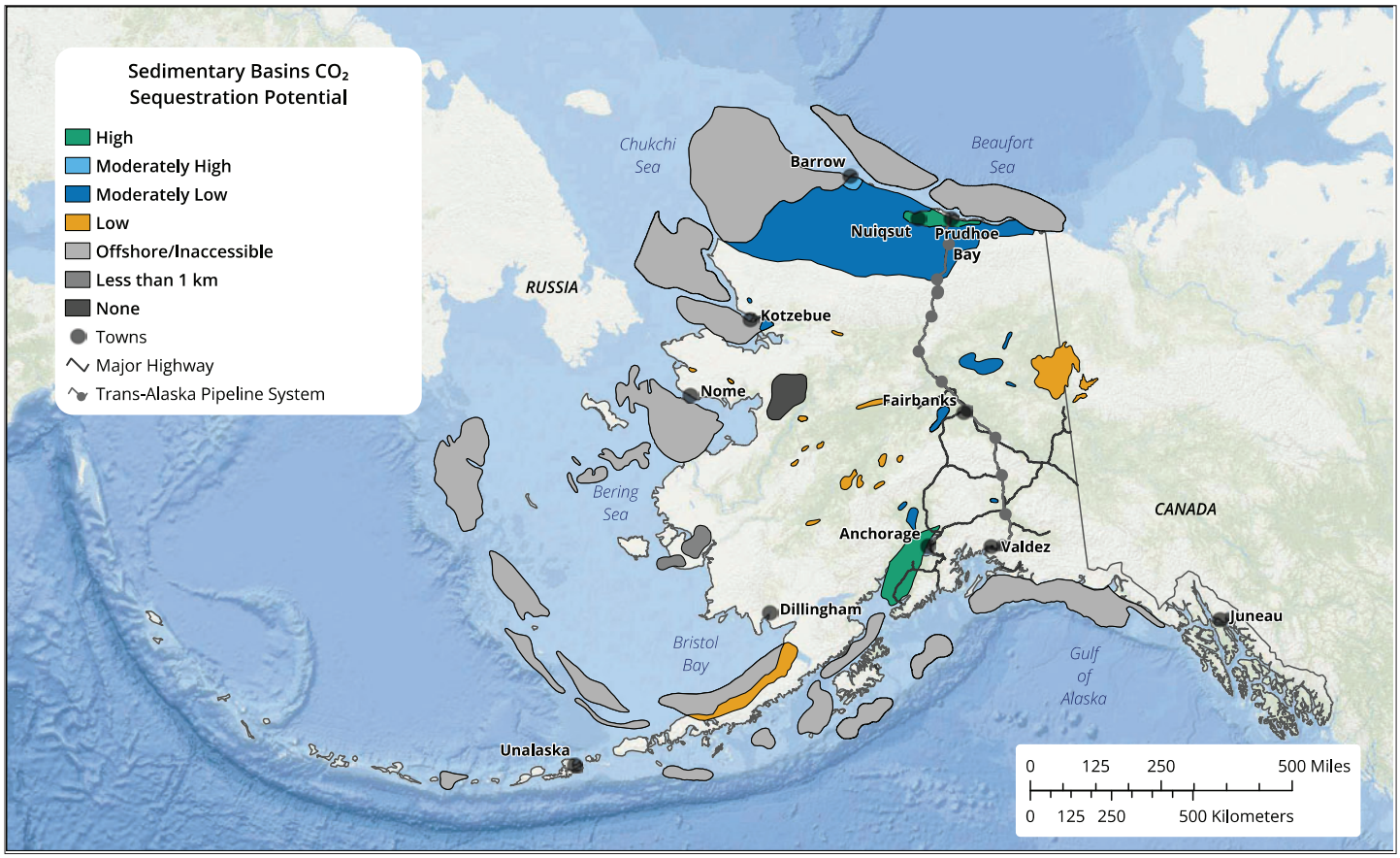
The National Science Foundation, a National Brown Investigator Award, and the Yale Center for Natural Carbon Capture supported the research.

More information

https://wanglab.yale.edu

Alaska launches online CCUS information repository for stakeholders

The Department of Natural Resources has launched the Alaska CCUS Hubsite, a powerful new tool designed to support data availability for resource industry explorers, technical professionals and the public.



The site delivers a centralised, user-friendly platform that brings together decades of geological, technical and regulatory data from across the entire state to inform CCUS opportunities.

The Alaska CCUS Hubsite offers access to well data, seismic surveys, land information and spatial data - making it an essential resource for companies and individuals engaged in carbon storage or oil and gas exploration.

The online tool will aid in site selection, project development and research by consolidating information that was previously scattered across multiple agencies. The database streamlines the process of evaluating subsurface conditions, identifying promising storage reservoirs and understanding the regulatory landscape for new ventures.

"Industry explorers will find the hubsite especially valuable for its depth of technical detail and ease of use," said the developers.

Whether assessing the feasibility of new projects, reviewing historical production data or planning future exploration campaigns, users can quickly access the information they need to make informed decisions.

The platform also supports collaboration between government, academia, and private sector partners, fostering innovation and efficiency in Alaska's resource industries.

"The Alaska CCUS Hubsite is an exciting new resource for explorers and developers," said Commissioner-designee Crowther at the Department of Natural Resources.

"By making critical technical data and regulatory information available in one place, we're helping unlock new opportunities and drive responsible development across the state."

The project was made possible by a grant from the U.S. Department of Energy. The DNR Division of Oil & Gas partnered with the DNR Division of Geological & Geophysical Surveys, the Alaska Oil & Gas Conservation Commission, the Alaska Center for Energy & Power at the University of Alaska, Fairbanks and Alaska Resource Education on this tool.

More information

https://alaska-ccus-hub-soa-dnr.hub.arcgis.com

Carbon capture needs commerciality, not more policy

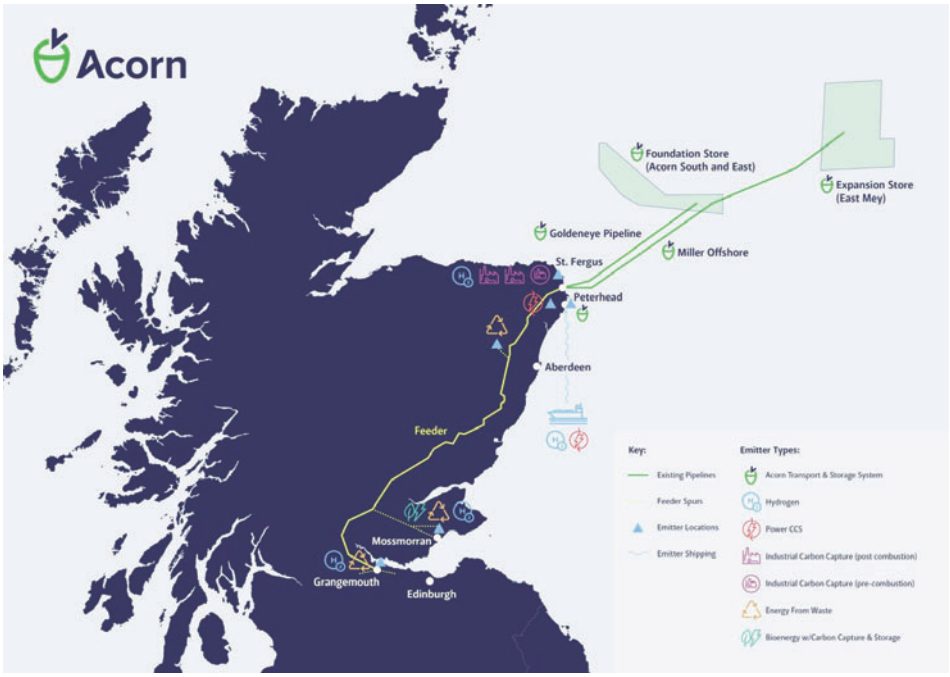
What the CCUS industry lacks is not ambition or engineering capability, but the scale and commercial framework needed to make the likes of Scotland's flagship CCUS project Acorn, now at risk after operator Storegga announced plans to sell off its stake, truly self-sustaining. By James McAreavey, Head of CCUS, Xodus.

The carbon capture, utilisation, and storage (CCUS) industry is gaining momentum across the world with a small, but increasing, number of major projects in construction and having started up.

CCUS is a vital part of decarbonising society and is based on well-established and proven technologies.

As a result, the economics of capturing and storing carbon will improve as the scale of individual projects increases alongside the impact of network effects and optimisation through learning.

Over the next two decades, as capture systems, transport networks and storage hubs mature, costs will come down. The groundwork being laid today is building the backbone for that future system.



Policy and regulation must be partners, not obstacles, if flagship projects like Acorn are to succeed

Commercial footing comes first

To accelerate that trajectory, CCUS needs a credible commercial model. Encouragingly, signs of one are starting to appear.

Voluntary carbon markets linked to energy-intensive industries and data centres are trending towards trading carbon storage at $400 to $500 per tonne, making CCUS a commercially attractive business.

This shows that when carbon abatement is measurable, verifiable and permanent, markets are willing to pay for quality.

With frameworks that properly value "avoided emissions", the CCUS industry can shift from a small number of government supported projects to a fully commercial business, following the tried and tested cost-decline pattern established for energy and chemical industries.

Policy and regulation must be partners, not obstacles

Regulation remains essential, especially in ensuring safety and permanence. But it should enable, not inhibit, the scale-up of CCUS. As our report Forecasting the North Sea CCUS infrastructure to 2050 points out, EU and UK frameworks currently demand near-perfect storage integrity, adding compliance cost and slowing projects.

We are beginning to see the semblance of a cross-border market happening in the EU, underpinned by government programmes to support emitters who are looking for locations to store their carbon.

The UK and EU currently do not recognise each other's carbon storage sites, despite identical standards. A report authored by Xodus for the CCSA highlights the potential to save around 21% on the cost of transport and storage within the EU, EEA, and UK by enabling cross border transport of carbon.

This is a real business opportunity that not only reduces the costs for emitters and governments across Europe but also assists the UK in funding our own decarbonisation efforts.

While there is currently a barrier for UK storage companies to compete for business with EU emitters, the recent announcement of the UK Government's commitment to conclude EU–UK ETS linkage by the next EU–UK Summit should provide UK businesses a clearer route to market for EU capture projects that look likely to need to use North Sea storage sites.

The real test is not whether CCUS can survive without policy, but whether it can mature into a self-sustaining market where investors have long-term confidence.

Building a market that values carbon properly

Carbon storage remains undervalued. To unlock CCUS at scale, we need either higher and more stable carbon prices, or voluntary markets that consistently reward high-quality, verifiable storage. Short-term incentives like the US 45Q tax credit have proven valuable catalysts, but durable economics will depend on predictable carbon storage values.

Where regulation and funding align, projects move. Norway's Northern Lights is now storing carbon transported from both local and remote emitters, the Porthos project in the Netherlands is under construction, and the UK's HyNet and Northern Endurance Partnership projects are advancing. Others will follow as frameworks mature and costs fall.

CCUS as infrastructure capital

Seen through the right lens, CCUS is a classic infrastructure opportunity, one with high upfront cost but long asset life and stable returns once established. That profile naturally attracts infrastructure investors and sovereign funds looking for long-term, climate-aligned assets.

Private capital will commit at scale when there's a credible pathway for revenue and manageable risk. That means pragmatic regulation, recognising that absolute zero leakage is an aspiration, not a prerequisite, and a clear value signal for stored carbon.

The capital is ready, but investors must have confidence that rules, rewards and returns will endure.

The bottom line

CCUS is at a key crossroads, transitioning from a small number of government-supported projects to a large-scale and wide-spread industry. The cost curve is already starting to bend, spurred on by every project that gets built.

To realise its potential, the focus must shift from subsidising projects to structuring markets, including valuing carbon storage correctly, aligning regulation with scalability and treating CCUS as an essential and effective tool for decarbonisation.

The technology works. The expertise exists. What remains is to create the commercial environment that allows CCUS to stand on its own two feet and grow to the scale required to deliver a decarbonised future.

The capital is ready, but investors must have confidence that rules, rewards and returns will endure - James McAreavey, Head of CCUS, Xodus

More information

www.xodusgroup.com

Isometric updates carbon removal certification for energy-from-waste sector

Two of the UK's largest EfW operators, enfinium and Cory Group, have partnered with Isometric to certify carbon removal from their facilities under the updated protocol. www.isometric.com

According to estimates, EfW has the potential to remove up to 10 million tonnes of carbon dioxide from the atmosphere annually in the UK. Both enfinium and Cory have selected Infinium to certify carbon removal from their projects.

Stacy Kauk, Chief Science Officer at Isometric, said, "Energy-from-waste presents a significant carbon removal opportunity that has, until now, been difficult to rigorously certify. Isometric is changing that by using new approaches that make it possible to certify only the carbon captured from organic waste, so that every certificate represents a tonne of carbon dioxide removed from the atmosphere and real climate benefit."

EfW facilities combust municipal solid waste to generate energy. If these facilities capture carbon dioxide produced from biogenic materials (such as food, wood, and paper) and store it permanently underground, it can be durably removed from the atmosphere.

Without EfW, the biogenic waste would decompose in landfill, releasing carbon dioxide and methane, a greenhouse gas over 80 times more potent than carbon dioxide over a 20-year period. And, without carbon capture, this biogenic carbon dioxide would be released during combustion.

enfinium has selected Isometric to certify carbon removal from its Parc Adfer project. Once operational, the project is forecast to remove up to 120,000 tonnes of carbon dioxide per year.

Cory Group has selected Isometric to certify carbon removal from its Riverside 1 and 2 projects.

The update was developed by Isometric's in-house Science Team, with input from an expert industry group and an independent Science Network of more than 400 scientific experts. It requires rigorous measurement, including radiocarbon analysis to distinguish biogenic carbon from fossil fuel-derived materials in mixed waste streams.

Marsh CCS Report: UK and Europe risk missing out on vital investment

Significant CCS investment opportunities could be lost if governments do not provide stable and credible support, as emerging markets in the Middle East and Asia quickly gain traction for capital investment.

Challenges such as rising costs, regulatory readiness gaps, and policy uncertainty threaten to slow deployment, putting jobs and regional economic growth at risk, warns the report from global insurance broker and risk advisor Marsh Risk.

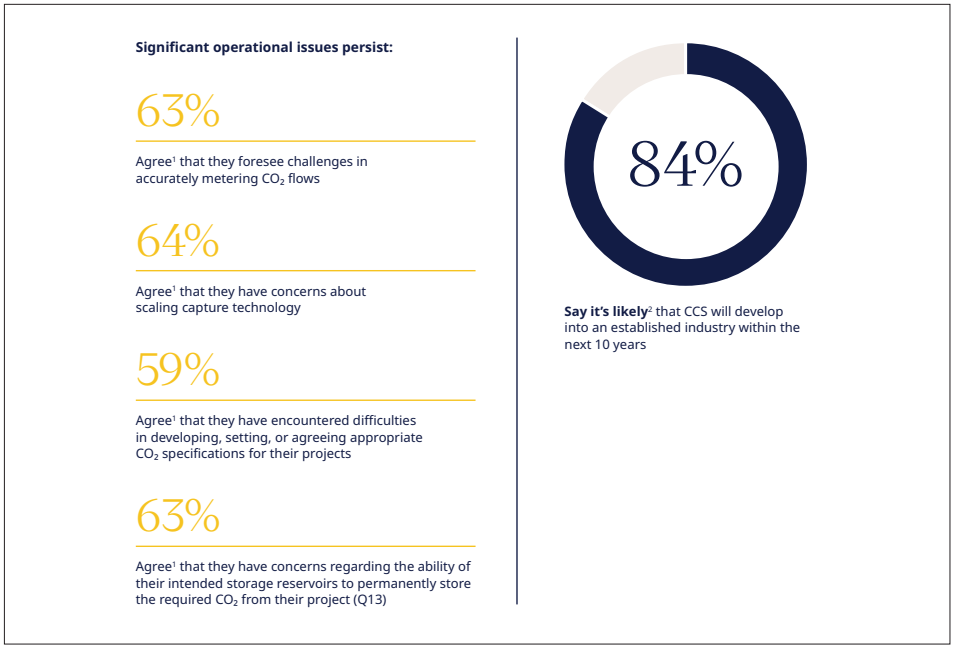
The analysis, CCS at Scale: Aligning Risk and Reality in Carbon Capture and Storage, is based on the views of 504 senior UK-based CCS decision-makers covering the global CCS value chain. According to the findings, Europe is currently the leading region for planned CCS investment, with 62% of industry leaders targeting the area, ahead of North America and the Middle East & North Africa.

However, with the average forecast cost to capture, transport, and store CO2 coming in at $163.45 per tonne – well above current carbon prices – many projects are likely to remain reliant on national subsidies to be commercially viable. Furthermore, 42% of leaders expect costs to rise by 11-15% and 31% anticipate increases of 16-20%, adding even greater pressure to project economics.

The cautious investment approach being taken to CCS projects is reflected through the analysis's findings of a staggered timeline for Final Investment Decisions (FIDs): 26% of FIDs are expected between 2025-27; 35% between 2028-30; 23% between 2031-33; and 12% between 2034-36.

While this could reduce developers' immediate financial exposures, it risks creating a bottleneck towards the end of the decade, putting strain on financing, supply chains, and storage capacity.

Insurance is seen as a key enabler of CCS projects, with nearly two-thirds of leaders relying heavily on insurance to manage risks. However, engagement between risk, insurance, and technical teams remains limited, highlighting the need for better alignment between risk management and project delivery.



The survey revealed an optimistic outlook for the CCS industry. However, despite this widespread enthusiasm, CCS leaders remain acutely aware of the practical challenges and cost concerns that could hinder project execution and scalability

Andrew Herring, Global Chair of Energy and Power, Marsh Risk, said, "Stable policy frameworks, regulatory certainty, and credible risk transfer mechanisms are essential if the global CCS industry is to attract the scale of investment needed to accelerate decarbonisation and support economic growth. For this vision to be realised, governments must commit to multi-year funding programmes, establish clear project pipelines, and invest in essential CO2 transport and storage infrastructure. The insurance industry is playing its part in enabling this vital energy transition industry to grow – governments must also now step up."

The findings show CCS is shifting from mainly US and Eurocentric markets – which enjoy established emissions trading schemes, attractive tax incentives, and streamlined permitting – to a multi-regional investment frontier. For example, the Middle East has scale and cost advantages, particularly through energy megaproject integration, while there is strong government backing in Japan and South Korea, and early hubs around heavy industrial clusters in Singapore. Projects are already planned across Malaysia, Indonesia, and Thailand.

Emerging regions are positioning themselves as the next CCS growth wave: Australia is leading in the Pacific, with projects linked to LNG and hydrogen exports using existing energy infrastructure; and in China, CCS pilots are projected to grow under the 2060 net-zero pledge.

More information

www.marsh.com

Report demonstrates viability and value of CCUS

"Informing the Deployment of Carbon Capture, Utilization, and Storage", developed by the World Business Council for Sustainable Development (WBCSD) and Arup, offers evidence from current deployments, regulatory frameworks and technological advances.

CCUS can be a materially significant contributor to the decarbonisation of hard to abate sectors. offering a viable and practical way to prevent greenhouse gas from entering the atmosphere. It complements decarbonisation through electrification and renewable deployment by offering solutions for industrial applications where these alternatives are not fit for purpose or cost competitive. Yet it remains clouded by myths and misconceptions that risk undermining decision-making and investment.

Key highlights include:

• Clear, science-backed responses to misconceptions about safety, cost, and effectiveness of CCUS.

• A review of CCUS policy mechanisms and the affordability of CCUS today together with key cost reduction variables to improve competitiveness.

• Practical focus areas to enable commercially self-sustaining projects in the next decade.

The resource is designed for industry leaders, investors, policymakers, and NGOs seeking clarity on CCUS's role in achieving net zero.

Cost reduction factor	*Cost reduction variables*	*Description*
Advancements in capture technologies	10-30 £/tonne of CO_2	Drop from £60-80 per tonne to £40-50 per tonne as capture technologies mature.
Shipping	10-25 £/tonne of CO_2	Non-pipeline transport options, such as shipping or rail, provide flexible and scalable alternatives for emitters operating far from major pipeline networks.
Cluster development	10-15 £/tonne of CO_2	Estimated cost reduction range when leveraging shared infrastructure compared to stand alone facilities.
Integration with existing infrastructure	5-10 £/tonne of CO_2	Using existing pipelines or storage facilities, particularly in regions with mature oil and gas infrastructure like the US or North Sea.
Standardization and modularization	5-10 £/tonne of CO_2	Could save within that range, particularly in regions adopting uniform specifications across emitters. Standardizing components like CO_2 compressors and absorbers, as well as modularizing designs reduces custom engineering costs and shortens timelines.
Liquefaction	6.5 £/tonne of CO_2	Assuming electricity costs of £0.10/kWh, liquefaction consumes around 65 KWh of CO_2 with energy costs varying on electricity price.
Energy efficiency improvements	5-8 £/tonne of CO_2	Reducing energy consumption during capture and regeneration could save this much per tonne of CO_2 capture. Process innovations such as heat recovery in capture systems reduce the overall energy demand.
Storage – onsite buffer storage for non-pipeline transport (NPT)	2-4 £/tonne of CO_2	Onsite buffer storage requirements for NPT modes add to CAPEX but are shared across multiple emitters in cluster configurations. Costs for buffer storage vary based on capacity but are estimated to be around this value.
Micro-networks for small emitters	20-30 % per tonne	By forming "micro-networks," smaller emitters can pool resources and share operational costs, reducing barriers to participation in carbon capture services. Dependent on the level of integration and proximity to storage sites.
Flue gas blower	15 % of total OPEX	Positioning blowers downstream of pre-treatment cooling systems reduces their size and power demand, achieving up to 15% OPEX savings.

Cost reduction variables to improve the business case for CCUS

Building the conditions for scale

The next phase of CCUS is a shift from isolated, custommade projects to repeatable systems. The long-term ambition is framed around moving from government supported deployment toward more commercially self sustaining markets as carbon value signals, standards and infrastructure mature.

Six practical focus areas to enable commercially self-sustaining projects in the next decade:

• Network interconnectivity and CCS-as-a-service to connect dispersed emitters to storage via flexible transport options and cross-chain risk sharing.

• Cluster development that designs shared infrastructure for expansion, enabling new emitters to connect over time through strategically located nodes and spur lines.

Market frameworks that provide predictability through carbon pricing, trade and policy mechanisms, with rules that recognize verified storage outcomes.

• CCUS-enabled products where interoperable standards for carbon intensity allow buyers to procure lower-carbon products such as cement and steel with confidence.

• Technology developments focused on integration, operational performance, and cost reduction through learning-by-doing and standardization.

• Value chain development and collaboration covering supply chains, skills, jobs, and public confidence through transparent communication and verifiable outcomes.

More information

www.wbcsd.org

www.arup.com

SMI report recommends dedicated capital fund to accelerate CCS deployment

The Sustainable Markets Initiative (SMI) has published a new report which explores key investment barriers facing carbon capture and storage and how these can be overcome.

The report, "Unlocking Private Capital for Carbon Capture and Storage", sets out a practical roadmap for the finance sector to play a role in accelerating the mobiliaation of private finance for global CCS deployment.

C.S. Venkatakrishnan, Barclays Group Chief Executive and Chair of the Sustainable Markets Initiative's Financial Service Task Force, said, "The technical capability of carbon capture and storage is proven and, in key markets around the world, commercial and policy frameworks are in place to connect supply and demand."

"The foremost remaining challenge, therefore, for accelerated deployment of CCS at scale, is enabling an influx of private capital into the sector. This report proposes practical actions to unlock that investment."

Produced under the SMI Financial Services Task Force (FSTF) "CCS Lighthouse Project"*, the report finds that CCS represents a multi-billion-dollar investment opportunity. However, despite this opportunity, there is a structural financing gap.

As a result, independent capture-side developers often lack access to late-stage development capital and long-term revenue certainty to reach final investment decision (FID). Many early CCS projects have depended heavily on government support, rather than operating on a merchant basis — a model that is not scalable.

To close the financing gap and scale private capital mobilization, the report recommends an integrated, three-part strategy for SMI FSTF member banks and the wider finance sector.

Unlock stalled projects by establishing a pre-FID development capital fund

The financial services sector could explore committing to a multimillion-dollar catalytic development fund to support capture projects approaching FID. Targeting high-impact markets such as the Nordics and the US, the fund could provide flexible instruments, including equity, debt, and guarantees, to de-risk late-stage project costs and crowd in institutional capital. The report identifies over 130 near-term projects globally that could benefit from this funding.

Create bankable revenue streams by aggregating demand and structuring offtake solutions

The financial services sector can bring together coalitions of buyers for CO2 removal credits and low-carbon products and services (e.g. through environmental attribute certificates), pooling demand and offering credit enhancement tools to secure long-term offtake.

By converting voluntary pledges into investment-grade contracts, these coalitions will provide the revenue certainty needed to attract bank and investor finance.

Accelerate learning cycles and investor confidence via a global CCS financing lessons forum

The report calls for a global CCS financing lessons forum, organized by a credible third party, to share best practices on structuring, risk allocation, and policy alignment. The forum could host case studies and peer-to-peer learning to accelerate market maturity, reduce the cost of capital, and shorten the time to FID.

Jennifer Jordan-Saifi, CEO of the Sustainable Markets Initiative, said, "Carbon capture and storage can be a key enabler of the sustainable transition, but it requires confidence, collaboration and capital to move from ambition to action.

By aligning capital, policy, and industrial capability we have the opportunity to progress CCS from a promising technology into a core pillar of transition, which can help deliver lasting, system-wide change."

To get to net zero by 2050, the International Energy Agency (IEA) estimates CCS could deliver up to 8% global emissions reduction from 2022-2050, around ~ 6 GtCO2/yr by 2050, or equivalent to taking every car and van on earth off the road, more than one and a half times over.

These three integrated recommendations will play an important role in supporting the sector. Encouragingly, the study reveals market fundamentals are improving, policy is spreading, carbon prices are expected to rise, and green premiums and decarbonisation credit markets are beginning to emerge.

The project pipeline is expanding rapidly, with operational facilities up 54% year-on-year and 117 projects targeting final investment decision (FID) before 2027 The UK, Nordics, and US Gulf Coast are leading the way, shifting towards more market-based frameworks, and developing regulatory and offtake models that can attract private investment.

David Hatcher - Managing Partner of Baringa, said, "Carbon capture and storage is essential, not an option. It is key to unlocking whole-economy decarbonisation and kick-starting a huge investment opportunity in a rapidly growing asset class."

"This report provides a clear, actionable pathway for the finance sector to help scale CCS deployment globally. At Baringa, we're proud to support this work and work towards helping unlock the capital, confidence, and collaboration needed to accelerate the transition to net-zero."

More information

www.sustainable-markets.org

DNV report shows CCUS supporting GCC energy transition

The report "Oil & Gas Decarbonization in the Gulf Region" looks at how Gulf Cooperation Council (GCC) countries are cutting the emissions intensity of their core oil and gas production while continuing to play a central role in global energy supply.

The report is the second in DNV's Energy Transition Outlook 2026 series on the Middle East, examining the twin strategies shaping the region's energy future: selective decarbonization and structural diversification.

Since 2005, the GCC has produced nearly 18% of global oil and gas, a share expected to increase as investment continues in low-cost, advantaged resources. As global energy demand increasingly shifts toward Asia, the region's location and cost competitiveness strengthen its position as a preferred supplier. At the same time, decarbonisation measures are becoming an integral part of long-term competitiveness

"The global energy transition will not progress at the same pace across regions, nor will it follow a single pathway," said Brice Le Gallo, Vice-president & regional director for Southern Europe, MEA & LATAM, Energy Systems at DNV. "In the Middle-East, oil and gas remain central to economic stability and global energy security. The key challenge is to reduce their emissions footprint while accelerating investment in the technologies needed for a lower-carbon energy system."

Oil and gas production in the GCC continues to expand, alongside a stronger focus on reducing operational emissions. Electrification of assets is being used to cut Scope 2 emissions from pumps, compressors, and offshore facilities, through grid connections, renewable power, and hybrid solutions. These efforts are supported by energy-efficiency measures and the use of digital tools and artificial intelligence to optimize drilling, reservoir management, and asset operations, reducing energy intensity and emissions per barrel produced.

Methane reduction remains one of the most immediate and cost-effective options for lowering emissions. Across the GCC, routine flaring is planned to be phased out by 2030 and leak detection and repair (LDAR) programmes are increasingly standard. National oil companies are also aligning with international methane initiatives, enabling continued production growth while reducing methane intensity in line with national net-zero targets.

GCC countries are realigning domestic energy systems to reduce oil and gas use at home and free up volumes for export and low-carbon fuel production. Growth in renewables, electrification of transport and buildings, and efficiency gains are driving this shift. Investment in downstream industries, petrochemicals, and low-carbon fuels is also changing export profiles, moving beyond crude oil toward higher-value and lower-carbon energy products.

Hydrogen and ammonia feature in DNV's forecast as viable long-term export options. With access to low-cost natural gas, strong solar resources, and established industrial and export infrastructure, the region is well placed to scale both low-carbon hydrogen (produced from natural gas with carbon capture) and renewable hydrogen produced through electrolysis. By 2060, the Middle-East and North Africa region is projected to produce around 19 million tonnes of hydrogen and 13 million tonnes of ammonia per year, exporting about 50% mainly toward Europe and advanced Asian economies.

"Hydrogen, ammonia, and carbon capture are becoming core elements of the GCC's energy export model," said Jan Zschommler, Market Area Manager for the Middle East, Energy Systems at DNV. "As emissions requirements tighten, access to international markets will increasingly depend on carbon intensity. Integrating hydrogen production with renewable power, carbon capture, and existing industrial clusters allows the region to remain competitive while meeting these requirements."

CCUS supports much of this transition. More than 98% of CCUS projects planned or operating in the Middle East and North Africa are located in the GCC, led by national oil companies. In January 2026, the UAE's Supreme Council for Financial and Economic Affairs has introduced Carbon Capture Policy as a further commitment to meeting their carbon reduction targets. Captured CO2 volumes (including CO2 removal) are expected to reach around 250 million tonnes per year by 2060, equivalent to roughly 8% of regional energy-related and industrial emissions.

Carbon dioxide removal will also increase. By 2060, bioenergy with carbon capture (BECCS) and direct air capture (DAC) combined are expected to remove around 81 million tonnes of CO2 per year, helping to offset emissions from sectors that are more difficult to decarbonize.

DNV's Energy Transition Outlook 2026 Oil and gas decarbonisation in the Gulf region report describes a transition shaped by sequencing, with reductions in emissions intensity occurring alongside continued hydrocarbon production and investment across renewables, electrification, hydrogen, methane abatement, digitalisation, and carbon capture.

This perspective is consistent with findings from DNV's 2025 Energy Industry Insights survey, which identifies the Middle East as the world's most optimistic energy region, citing expectations of revenue growth, rapid solar expansion, and continued gas development..

Read together, the Outlook and the survey present a picture of a region approaching the energy transition from a position of confidence and capital strength, balancing decarbonisation efforts with ongoing energy system development.

More information

www.dnv.com/energy-transition-outlook

Carbon Capture: Creating jobs, skills and growth across the UK

As the UK marks National Apprenticeship Week, the CCUS sector is showcasing how apprenticeships are vital to delivering a critical industry, creating local jobs and boosting economic growth.

CCUS is helping UK industries such as cement, refining, and chemicals cut emissions while maintaining production of essential products we all use every day said the Carbon Capture & Storage Association (CCSA).

It is also supporting the development of low-carbon products and delivering reliable power generation. By combining practical training with real-world experience, apprenticeships are building the skilled workforce needed for the low-carbon transition.

However, success depends on addressing skills gaps, an ageing workforce, and training capacity, alongside a strong pipeline of CCUS projects across the UK's industrial heartlands. Getting this right is essential for scaling CCUS.

To meet the growing demand for skilled workers, the sector must scale up apprenticeships, ensure there are enough trainers and mentors, and raise awareness of CCUS careers.

The East Coast Cluster (ECC) is already delivering results. NZT Power – the world's first commercial-scale gas-fired power station with carbon capture and storage – is supporting 175 young people into clean energy careers. The project is investing £1m in local skills programmes, while creating hundreds of jobs in construction and engineering.

Over 75 apprentices are already working on sites connecting to HyNet, with more opportunities to come during construction. The cluster recently featured apprentices from companies leading the sector in a social media careers campaign, inspiring over 300,000 young people to engage in low-carbon skills.

In addition, Encyclis's Protos ERF plant – the UK's first full-scale carbon capture facility linked to an Energy from Waste (EfW) in HyNet – has welcomed four apprentices, combining college study with hands-on experience to develop the next generation of clean-energy talent. They will join a workforce of almost 80 people working across the two facilities when fully operational.

CATCH, which will become a world-leading apprenticeship training base in the Humber if projects like Viking CCS and ECC expansion are deployed, recently took apprentices to No. 10 Downing Street for a National Apprenticeship Week reception. They showcased how CCUS careers are creating opportunities for young people and supporting the UK's low-carbon future.

Emily Hasthorpe, Process Operations Apprentice, said, "During my first year at CATCH, I wrote to the Prime Minister to invite him to visit our site, however I was instead honoured to be invited to Number 10 for National Apprenticeship Week. This provided a valuable opportunity to meet the Prime Minister, engage with representatives from a range of trades and companies, and raise awareness of my training provider, CATCH. I am extremely grateful to CATCH for this once-in-a-lifetime opportunity it has been amazing!"

With major CCUS clusters developing in regions including the North East, North West, Humber, Scotland and South Wales, apprenticeships offer a powerful opportunity to support regional growth. Deploying key projects will also give young people the choice of building their careers in the areas they grew up in, keeping talent in these regions, and supporting long-term careers in areas with strong industrial heritage.

"Working on the NZT Power project has shown me just how important apprenticeships are to delivering the UK's low carbon future. Being part of a world first project so close to home means a huge amount to me and it is creating real opportunities for people in Teesside while building the skills we will need for the years ahead," Nathan McGinley, a civil engineer apprentice at Balfour Beatty currently working on NZT Power.

"Through my apprenticeship, I am gaining hands on experience, learning from experienced engineers and contributing to something that will make a genuine difference. Projects like this prove that young people do not have to leave their communities to build meaningful, future proof careers."

Encyclis's Protos ERF plant has welcomed four apprentices

The sector draws on skills from not only oil and gas, but also power, chemicals, construction, and manufacturing, while creating demand for new roles in carbon capture, transport and storage. Apprenticeships are helping workers reskill and giving young people a route into future-proof careers.

Olivia Powis, CEO of the CCSA, said, "Apprenticeships are essential to making carbon capture a success. The UK already has strong engineering skills, but we need clear career paths, investment in training, and a reliable project pipeline. If we get this right, we can keep jobs and skills in the UK, create good local jobs, and lead the low-carbon transition."

Employers across the sector are already working with training providers, colleges and universities to develop apprenticeship pathways. These programmes combine on-the-job experience with formal learning, ensuring apprentices graduate with skills aligned to real industry needs.

More information

www.ccsassociation.org

Report shows CDR necessary for German climate goals

Germany can reach net-zero by 2045 and potentially become net-negative earlier by rapidly scaling up Carbon Dioxide Removal (CDR) says a report from Carbon Gap and Sweco.

However success depends on political ambition, fast infrastructure deployment, and clear policy support. The study by finds that carbon removal could fully offset a wide range of Germany's residual emissions expected by 2045. It outlines two high-ambition pathways in which the offset can be achieved; one prioritising energy efficiency and another limiting reliance on bioenergy with carbon capture and storage.

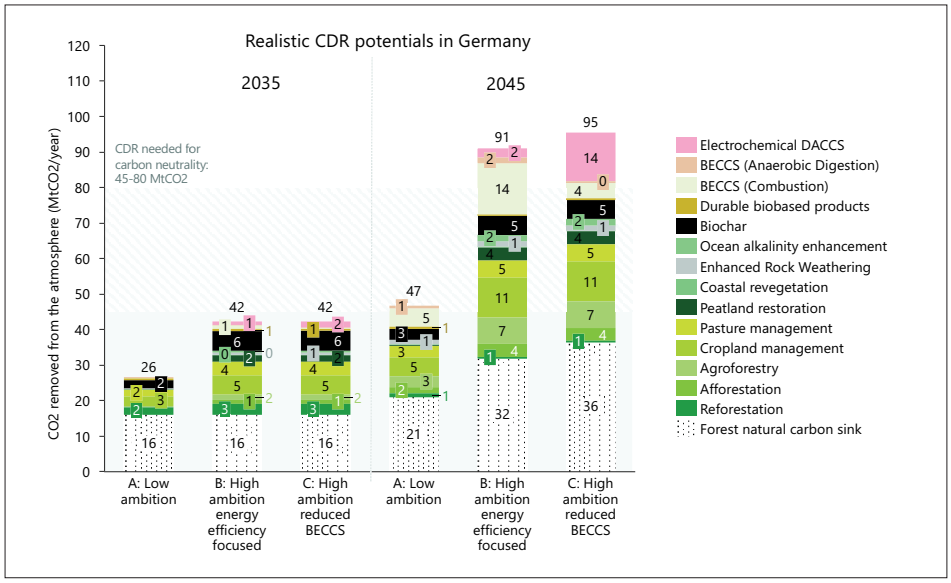
In both cases, a diverse mix of carbon removal methods in Germany could accelerate the achievement of net-negative emissions earlier than planned, depending on the volumes of residual emissions. The main takeaway: Germany needs to scale its carbon removal potential beyond 2050 now and address historical emissions by increasing investment in CDR.

By contrast, a low-ambition pathway delivers only around 47 MtCO2 of removals by 2045, compared to Germany's theoretical maximum CDR potential of ~258 MtCO2/year. The low-ambition pathway does not satisfy the level of residual emissions needed.

The study warns that Germany cannot afford to underinvest in carbon removal; doing so would significantly increase the risk of missing climate targets, particularly given recent volatility in land-based carbon sinks. In contrast, investment and effective policy design could lead to economic growth and position Germany as a leader in carbon removals.

Across all scenarios, the findings show that geological CO2 storage capacity is a main constraint on scaling both BECCS and DACCS. While Germany has significant potential to capture CO2, this potential cannot be realised without rapid expansion of transport and storage infrastructure.

The report stresses that accelerated, large-scale industrial policy interventions are now required. Without coordinated investment in CO2 pipelines, shipping options, and storage sites, Germany risks developing capture technologies that cannot be fully deployed.



Germany's realistic CDR potential for the three scenarios in 2035 and 2045, compared with an expected carbon gap (residual emissions) in 2045

"Germany has a real opportunity to secure its net-zero target with carbon removal, but only if ambition remains high," said Sylvain Delerce, Chief Scientist at Carbon Gap. "Low-ambition pathways are not enough at a time when climate uncertainty is increasing."

Most CDR methods are possible in Germany

The independent assessment finds that most major carbon removal methods – including but not limited to biochar, enhanced weathering, afforestation, and BECCS – are technically possible in Germany. Building a diversified portfolio of nature-based and technological approaches would help distribute risks, reduce pressure on individual resources, such as energy consumption, and provide flexibility for future markets and governance frameworks.

However, such diversification will not happen automatically. It requires strong coordination between the government and industry to ensure that all viable methods are developed.

Public support exists, but uncertainty remains

Interviews with experts and citizens showed broad support for carbon removal, alongside clear concerns. Citizens panels highlighted that Germans are most familiar with nature-based approaches and initially more sceptical of newer technologies, but attitudes towards all methods became more positive after informed discussion.

Despite the support, Germany still lacks a functioning market for carbon removals. Experts and citizens alike point to insufficient policy frameworks and infrastructure investment and stress the need for regulation to prevent greenwashing and ensure genuine sustainability. The analysis finds that public momentum is shaping up; policy and investment must now follow.

More information

https://carbongap.org/deploying-cdr-in-germany

CCSA report highlights EU opportunities from accelerated CCUS roll-out

The new report by the Carbon Capture and Storage Association (CCSA) in collaboration with Deloitte indicates that delays in deploying CCUS technologies risk both climate failure and deindustrialisation. The EU adopted its 2040 climate targets less than two weeks ago - it already risks missing them if CCUS projects won't receive FIDs by the end of 2026.

The report, De-Risking CCUS: A One-Stop Shop for Project Bankability, sets out the scale of the challenge facing Europe's industrial transition and identifies ten priority actions needed to unlock investment and deliver early projects at pace.

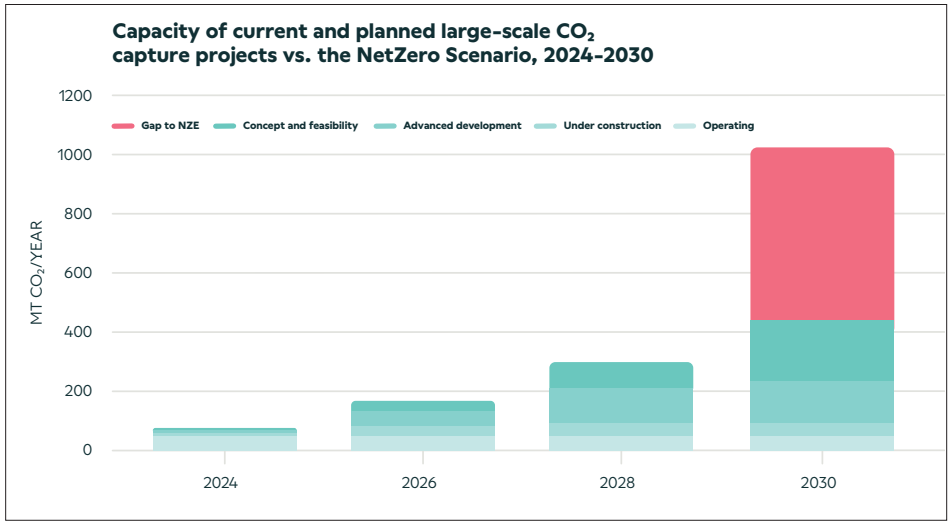
It calls on EU institutions and Member States to act swiftly on funding, regulation and cross-border coordination to ensure that CCUS supports, rather than undermines, Europe's climate and industrial objectives.

According to the European Commission's own Industrial Carbon Management Communication, the EU will need to capture around 280 million tonnes of CO_2 annually by 2040, rising to 450 million tonnes by 2050. Yet today, operational CO_2 storage capacity in the EU stands at just 0.185 Mt per year, far short of the 50 Mt/year injection capacity target by 2030 set under the Net Zero Industry Act (NZIA).

The EU has adopted its 2040 climate targets – setting a legal path to cut greenhouse gas emissions by 90% compared to 1990 levels – only a couple of weeks ago. To reach these crucial targets, CCUS projects need to reach FID this year. What happens in 2026 will invariably affect the EU's decarbonisation path for the next decade.

"Europe has made important strides in advancing CCUS, and the focus must now be on accelerating delivery," said Olivia Powis, CEO, CCSA. "If first-mover projects do not reach Final Investment Decision by 2026, the EU risks missing its 2030 and 2040 targets and losing industrial investment to competing regions."

While more than 950 CCUS projects are in development globally, uncertainty around regulation, risk allocation and financing continues to undermine the bankability of European projects. Fragmented national policies, the absence of clear risk-sharing frameworks, and delays in transport and storage infrastructure are creating decision paralysis across the value chain.



Capacity and planned large-scale CO_2 capture projects versus the NetZero Scenario for 2024-2030 based on IEA data (last updated 25 Apr 2024)

The report highlights that CCUS must be treated as a fully integrated system, spanning capture, transport, storage and supporting infrastructure. Failure in any single segment can stall entire projects, discourage private capital and increase costs for industry. Insights from more advanced markets underscore the urgency.

In the UK, 75% of project developers say they will consider reallocating CCUS investment to other regions if progress stalls, as global competition for clean-tech capital intensifies. The EU cannot afford a similar scenario. Countries that have moved faster have paired public support with clear ownership of early-stage risks, providing invaluable lessons for the EU and its Member States.

To address these challenges, the report proposes a phased, pragmatic roadmap built around ten "no-regret" actions, aimed at de-risking early projects while laying the foundations for a self-sustaining market. The long-term vision is a European CCUS ecosystem based on dense industrial hubs, cross-border CO2 corridors, and strong demand-pull mechanisms where private capital, not subsidies, becomes the main driver.

"Scaling carbon capture and storage in Europe requires coordinated action across policy, finance, infrastructure, and industry. This report, developed with the CCSA, builds on extensive engagement across the value chain to identify the conditions needed to unlock first-of-a-kind projects and accelerate deployment. Together, these initiatives offer practical, evidence-based tools to turn Europe's climate ambition into investable, competitive industrial solutions," said Stijn Vercammen, Director, Industrial Transition and Competitiveness, Deloitte.

More information

www.ccsassociation.org/resources/ccsa-europe-market-study

Projects and policy news

EU sets first voluntary standard for permanent carbon removals

https://climate.ec.europa.eu

The Commission has adopted the world's first set of methodologies to certify activities that permanently remove CO2 from the atmosphere including DACCS, Bio-CCS and biochar.

Under the under the carbon removals and carbon farming (CRCF) regulation the EU is setting clear rules and creating new opportunities for climate innovation, investments in carbon removal technologies and addressing greenwashing.

With the certification framework and the governance rules now in place, carbon removal projects using DACCS, BioCCS, and biochar can start applying for EU certification. This marks the transition from rule-setting to action, allowing the first projects to be certified and recognised under the EU's carbon removal framework in the coming months.

The new rules cover three types of permanent carbon removal activities, selected for their technological maturity and potential contribution to the EU's climate objectives:

• Direct air capture with carbon storage (DACCS)

• Biogenic emissions capture with carbon storage (BioCCS)

• Biochar carbon removal (BCR).

Court decision puts Norway on the hook for massive CO2 Storage build-out

https://bellona.org

A ruling by the European Free Trade Association Court that Norway's continental shelf falls under the European Economic Area Agreement could dramatically reshape the country's climate obligations—and trigger a massive expansion of carbon dioxide storage capacity in the North Sea.

Bellona hailed the decision as a historic breakthrough with far-reaching consequences for European climate policy. At the heart of the issue is the EU's Net-Zero Industry Act (NZIA)—specifically its Article 23—which obliges oil and gas producers to help deliver at least 50 million tonnes of annual CO2 injection capacity across the EU by 2030.

Until now, Norway had argued that the country's offshore petroleum activities on the Norwegian continental shelf were not covered by the EEA Agreement. That interpretation allowed Oslo to signal to the European Commission that it had no intention of honoring the NZIA's storage obligations within its offshore oil and gas sector.

Norway, already home to flagship CCS initiatives such as Northern Lights, could face mandatory obligations to develop many millions of tonnes of injection capacity before the end of the decade

The EFTA Court's advisory opinion undercuts that position.

"This is a case we have worked on for more than 15 years," said Bellona's managing director, Sveinung Rotevatn, in a statement. "The Norwegian continental shelf is covered by the EEA Agreement. That means Norway must now incorporate the Net-Zero Industry Act into the EEA framework."

Although the EFTA Court's rulings are formally advisory, this one was requested by the Supreme Court of Norway itself. For Oslo to disregard the opinion would risk significant political and legal friction with Brussels. Bellona's Rotevatn argues that ignoring the ruling could trigger a "deep crisis" in Norway's relationship with the EU— particularly if Norway were perceived as selectively applying internal market legislation.

For European policymakers, the implications are significant. If the NZIA now applies to the Norwegian continental shelf, oil and gas operators active there could face mandatory obligations to develop many millions of tonnes of injection capacity before the end of the decade. With 2030 just four years away, that timeline would require rapid project approvals, investment decisions and infrastructure build-out.

Whether this moment marks the beginning of a genuine European-scale CO2 storage industry, or the start of a prolonged legal confrontation, will depend on how swiftly national authorities act.

DNV launches Industrial Services in shift to broader industrial focus

www.dnv.com/energy/services

The company said the move reflected growing demand from customers navigating increasingly complex energy transition projects, expanding infrastructure investment and more stringent quality and compliance requirements worldwide.

The new name signals a broader industrial focus, spanning traditional energy, renewables, power transmission, hydrogen, carbon capture, rail and industrial manufacturing, and positions the business to support customers across the full asset lifecycle, from fabrication and construction through to operations and in-service performance.

Mohamed Houari, CEO of Industrial Services at DNV, said, "Industrial assets today are larger, more interconnected and more critical to society than ever before. At the same time, regulatory scrutiny and supply chain complexity are increasing."

"Our customers need partners who combine technical expertise with global reach and local presence. DNV's Industrial Services reflects that evolution, we are strengthening our role as a trusted industrial partner helping safeguard performance, manage risk and accelerate delivery of vital energy and infrastructure projects."

Originally rooted in oil and gas inspection, the business has significantly expanded in recent years into offshore wind, power, transmission and distribution, hydrogen and CCS.

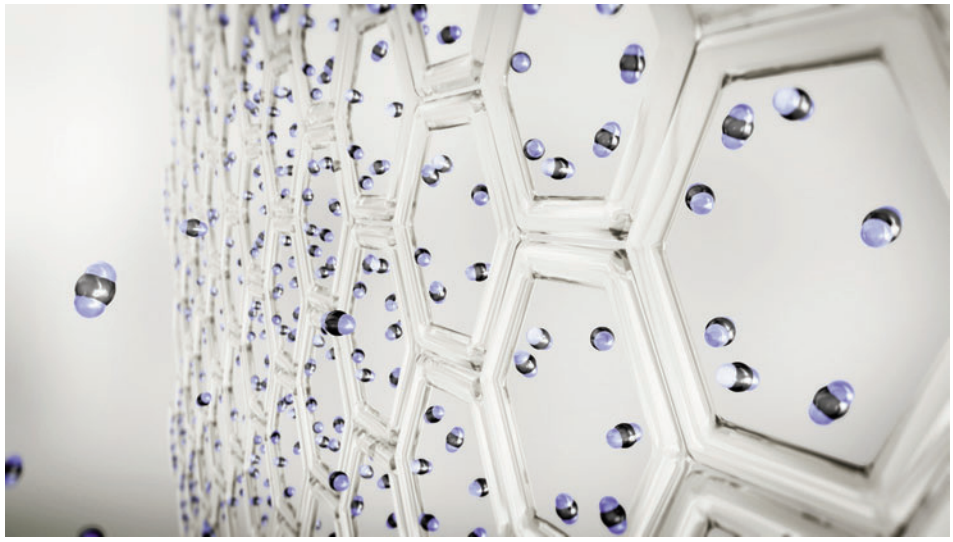
How novel nanomaterials make CCUS affordable and scalable

Across the CCUS value chain, the most stubborn bottleneck is still the very first link: separating CO2 from a mixed gas stream. If we don't fix this problem, CCUS will not play any significant role in decarbonizing our energy system and industries at large. By Magnus Bach, VP of Business Development at Atoco.

The capture phase is estimated to account for roughly 45–65% of the total levelized cost of CCUS, and in DAC it can represent 80–90% of total costs or more. In low-concentration PCC environments like aluminum production or power generation, this translates into capture costs of about $180–$300 per ton, which is simply not economically feasible.

The reality is that today's carbon capture technologies remain well above the cost thresholds required for widespread adoption. High energy demands, complex operations, water use, material degradation, and poor scalability all hinder progress towards large-scale deployment. Especially for DAC and low-concentration PCC environments, we need to rethink the core technologies we are relying upon.

Rather than building on incumbent technologies, we need to introduce a transformative technology to fix the carbon capture problem, thereby enabling a wider adoption of CCUS. The good news is that Nobel Prize-winning science is making exactly that possible.



Nano-engineered reticular materials can make CO2 capture ecnonomically viable, opening a credible path from lab-scale breakthroughs to real-world deployment

Materials with Transformative Potential

"It won't be something big, but actually something pretty small that can transform our planet … If the problem is in the air around us, so is the answer." This quote is from Nobel Laureate Prof. Omar Yaghi, founder of Atoco. What he is referring to are nano-engineered reticular materials. These materials are highly ordered, porous structures formed by linking molecular building blocks with strong bonds.

Their customizable frameworks and high porosity enable precise control over physical, chemical, and mechanical properties. In other words, they can be designed with atomic precision with specific functionalities and applications in mind, in this case carbon capture.

How does this work? Well, these materials such as Metal-Organic Frameworks (MOFs) or Covalent Organic Frameworks (COFs) have an incredibly large internal surface area. Because of their exceptional porosity, a single gram of material—about the size of a sugar cube and appearing as a fine powder to the naked eye—can have an internal surface area comparable to an entire football field.

This is important because all these pores can function as "parking lots" for CO2 molecules. Designed with atomic precision, the material captures nothing but CO2.

The fact that these materials have strong bonds provides stability and allows them to endure extreme temperatures and harsh environments for thousands and thousands of cycles. This level of robustness, together with the large internal surface area and the ability to design these materials at the molecular level with atomic precision makes them a gamechanger for CCUS.

Next Generation of Carbon Capture

So how do these nano-engineered reticular materials make a difference for carbon capture in DAC and low-concentration PCC environments? Let's first look at DAC where costs per ton captured with existing technologies are at levels of up to $1,000. One of the main reasons for these high costs is the need to pre-dry the air stream to protect "the moisture-sensitive materials", currently on the market. With nano-engineered reticular materials, this step can be eliminated entirely.

The reticular materials are completely humidity-resistant and perform reliably, even in the harshest environmental conditions. Another

major cost driver for existing DAC technologies is high energy use due to regeneration temperatures of the existing sorbents of 80 °C to 250 °C. Reticular materials can mitigate this problem as they can regenerate at much lower temperatures, around 40 °C to 60 °C. This is particularly relevant in industrial settings where low-grade waste heat is available in abundance can be leveraged to run the regeneration process.

For many liquid-solvent DAC technologies, water usage is a major constraint. Reticular materials, designed with atomic precision, do not need any water for capture, cooling, or regeneration. Additional advantages of reticular materials include very high levels of durability and modularity, which allows for seamless long-term integration in diverse and challenging settings at low maintenance costs.

For PCC, the core advantages of systems that are leveraging nano-engineered reticular materials are the same as in DAC: lower costs because of lower energy use thanks to resistance to humidity and low regeneration temperatures; high level of modularity and scalability as well as low maintenance costs because of robustness and tunability of the materials.

Another advantage which is particularly relevant for PCC is the resistance of these materials to the very high level of toxicity in a typical flue gas stream in industrial settings such as aluminum production or power generation. Where existing technologies struggle with Nitrogen Oxides (NOx) or Sulfur Oxides (SOx), the performance of systems that are based on nano-engineered reticular materials is not affected by these.

Furthermore, reticular materials show extremely fast kinetics. The adsorption/desorption cycles can be completed in just a few minutes using swing pressure, which further enhances capture efficiency.

From Molecules to Society

Reticular materials have come a long way—from their discovery in the 1990s by Prof. Omar Yaghi to scalable, robust systems that can capture CO2 from air and industrial exhaust. By combining humidity resistance, low-temperature regeneration, high durability, fast kinetics, and tolerance to flue-gas contaminants, these materials remove the main barriers that have prevented wider adoption of carbon capture in DAC and low-concentration PCC environments.

If CCUS is going to play a meaningful role in decarbonizing industry and the energy system at large, capture must become economical across a wide range of applications—not only in ideal conditions. Nano-engineered reticular materials make that achievable, opening a credible path from lab-scale breakthroughs to real-world deployment at the scale climate requires.

More information

https://atoco.com/carbon-capture

Air Liquide and Holcim decarbonising cement in Belgium

The companies will develop a state-of-the-art carbon capture solution for Holcim's near-zero cement plant at Obourg in Belgium.

Under the agreement, Air Liquide will supply the necessary oxygen for Holcim's oxyfuel-ready clinker production line, as well as provide its proprietary Cryocap™ OXY technology to enable the capture of CO2 emissions. The captured CO2 is then intended to be transported via pipelines to a CO2 Export Hub, such as Antwerp@C, for subsequent shipment to permanent offshore storage in the North Sea.

The agreement aims to transform the Obourg plant into a leading large-scale near-zero cement production facility is a significant milestone for the project. The FID remains subject to additional effective partnerships across the value chain, as well as public sector support including for regulation of infrastructure and the provision of derisking mechanisms.

Aiming to capture 1.1 million tons of CO2 per year, the collaboration is part of GO4ZERO, Holcim's investment program that will enable the company to achieve carbon neutrality in Belgium by the end of the decade. The initiative would significantly contribute to the European Union 2050 net zero target.

Holcim's cement plant in Obourg, Belgium

Émilie Mouren-Renouard, member of Air Liquide's Executive Committee, notably in charge of supervising operations in Europe, said, "The transition toward a low-carbon industry is a long-term endeavor that requires steady collaboration and public support in its initial phase."

"For many years, Air Liquide has been committed to decarbonize industrial sectors such as the cement industry, with the development of its visionary and advanced carbon capture technologies. Alongside our partner Holcim, we share the same ambition and this new milestone agreement for the pioneering GO4ZERO project is a powerful signal for Belgium's industrial decarbonisation and energy transition."

CO2 capture from phosphate fertilizer production

CO2 capture technologies are critical for reducing the high carbon footprint of conventional phosphate fertilizers and essential to maintaining international competitiveness in a carbon constrained world. By Stephen B. Harrison, sbh4 consulting.

Diammonium phosphate (DAP) is the most common phosphate fertilizer. It is popular because it is safe to handle, can be applied conveniently as granules and introduces both nitrogen and phosphorus to the soil. High volume commodity crops such as wheat, maize and rice all benefit from DAP.

OCP is the world's largest producer of phosphate fertilizers with 31% global market share. Jorf Lasfar is the world's largest integrated fertilizer complex in the world, from which OCP exports phosphate fertilizers worldwide.

In addition to leading world production of DAP, OCP is leading the world in CO2 capture and utilisation to decarbonise phosphate processing.

Phosphate fertilizer production and phosphogypsum waste

Geogenic CO2

DAP is produced where phosphate rock is mined. This rock is rich in a phosphorus-bearing mineral, fluorapatite. In addition to CO2 emissions from the heat and energy requirements of DAP production, geogenic CO2 is produced during DAP production because the fluorapatite mineral is contaminated with calcite (calcium carbonate, or limestone).

Prior to DAP production, the ore is beneficiated to remove sand, clay, and as much calcite as possible. The beneficiated fluorapatite ore is mixed with sulphuric acid, to yield phosphogypsum as a solid waste material and phosphoric acid. The phosphoric acid is reacted with ammonia, then granulated and sieved to produce DAP.

High quality ores, such those found in Morocco and Jordan contain between 10 and 15% calcite. In other main phosphate rock mining locations such as Florida and Saudi Arabia, the calcite content can be up to 20%.

However only about half of the calcite is separated from the fluorapatite and the calcite is mixed with the sulphuric acid, along with the fluorapatite. During the reaction between calcite and sulphuric acid, CO2 is released.

The flue gas from the chamber where the rock is mixed with sulphuric acid mixing is hot, moist and contains hydrogen fluoride (HF), which is released from the fluorapatite ore. The off-gas is scrubbed with water to remove the HF. The resultant gas mixture is hot, moist CO2-rich, and is generally vented to atmosphere.

If the calcite content of the beneficiated ore is reduced to 6%, as would be the case in Morocco, approximately 0.05 tonnes of geogenic CO2 per tonne of DAP produced. For Saudi Arabian DAP production, the geogenic CO2 emissions liberated during the production of phosphoric acid are close to 0.1 tonnes of CO2 per tonne of DAP.

To partially decarbonise DAP production, recover and separation of the geogenic CO2 from moist flue gas can easily be achieved using cooling and condensation. The resultant dry, pure CO2 can then be liquefied for rail or sea shipment, or compressed for pipeline transmission at low marginal cost.

Utilisation and sequestration of CO2

The idea to capture CO2 from phosphate fertilizer production will be implemented from 2027 by OCP Nutricrops in partnership with OCP Green Water and INNOVX at OCP's Jorf Lasfar industrial platform in Morocco.

The initiative is part of OCP Group's decarbonization roadmap, which aims to achieve carbon neutrality across scope 1, 2 and 3 emissions by 2040. It also addresses international competitiveness by reducing the CO2 intensity of DAP which is important when exporting to the EU where the Carbon Border Adjustment Mechanism will impose tariffs on carbon-intensive imports starting in 2026.

The captured CO2 will be used by OCP

Green Water for pH adjustment and re-mineralisation of drinking water in support of a local reverse osmosis desalination plant. This will support Morocco's goal to meet 100% of the nation's water needs through unconventional resources by 2027.

INNOVX will develop a plant to use captured CO2 and waste phosphogypsum to produce ammonium sulphate fertilizer. The Merseberg Process is one of the pathways to achieve this. It reacts aqueous ammonia with CO2 to produce ammonium carbonate.

Phosphogypsum is reacted with ammonium carbonate to yield calcium carbonate and the target product ammonium sulphate. Calcium carbonate is a recognised permanent sink for CO2, so this pathway sequesters CO2 gas emissions from the DAP process and enables integrated production of ammonium sulphate.

Ammonium sulphate was the first commercially available nitrogen fertilizer. However, it was displaced in many markets by ammonia and urea due to their higher nitrogen content. However, it is still used extensively in Brazil, which imports about 4 million tonnes per year, mostly from China.

CO2 capture from ammonia production

For each tonne of DAP, 0.2 tonnes of ammonia are required to react with the phosphoric acid. Grey ammonia production releases about 1.8 tonnes of CO2 per tonne of ammonia. Thus, 0.36 tonnes of CO2 is released from the ammonia required to produce one tonne of DAP.

Comparing the CO2 emissions from ammonia production to the geogenic CO2 emissions for the Moroccan and Saudi Arabian cases above, this is about 3.5 to 7 times more than the amount of CO2 released from phosphoric acid production. To achieve deep decarbonisation of DAP production, capture of CO2 from ammonia production is also essential.

When ammonia is made from steam methane reforming of natural gas, CO2 leaving the reformer in the syngas must be removed to enable the catalytic Haber Bosch ammonia synthesis reaction to take place. This is normally achieved using an amine solvent based CO2 capture process.

The active ammonia catalyst is iron. All molecules containing oxygen, such as water, carbon monoxide or CO2 must be removed from the syngas before it is fed to the ammonia synthesis loop. Otherwise, the catalyst is oxidised and becomes ineffective. Therefore, every natural gas-fed ammonia plant already has a CO2 capture facility.

In some facilities, about 60% of the captured CO2 is combined with ammonia to make urea. However, the residual 40% of the CO2 from the SMR and ammonia plants that do not utilise captured CO2 for urea production can sequester the captured CO2 to reduce the CO2 intensity of DAP and nitrogen fertilizer production with only a small incremental cost for CO2 sequestration.

Process integration to avoid fossil CO2 emissions

In addition to ore beneficiation, phosphoric acid production and DAP granulation, the end-to-end process at a fully integrated facility, such as Jorf Lasfar includes on-site production of sulphuric acid from elemental sulphur powder, which is imported by ship from refineries in Europe and the Middle East.

OCP Group's third integrated fertilizer production plant, Jorf Fertilizers Company 3 (JFC 3), has been fully operational since 2017 and can produce 1 million tonnes per year of granulated phosphate fertilizers.

JFC 3 includes a sulfuric acid line with a capacity of 1.4 million tonnes per year, as well as a phosphoric acid line of 0.45 million tonnes per year. The chemical reactions involved in the production of these acids are exothermic and at JFC 3 the resultant heat is used to generate 62 MW of electricity on a thermal power plant.

This process integration makes the JFC 3 unit independent in terms of energy consumption and reduces the requirement to burn fossil fuels for electricity generation.

Sulphuric acid circularity and CO2 mineralisation

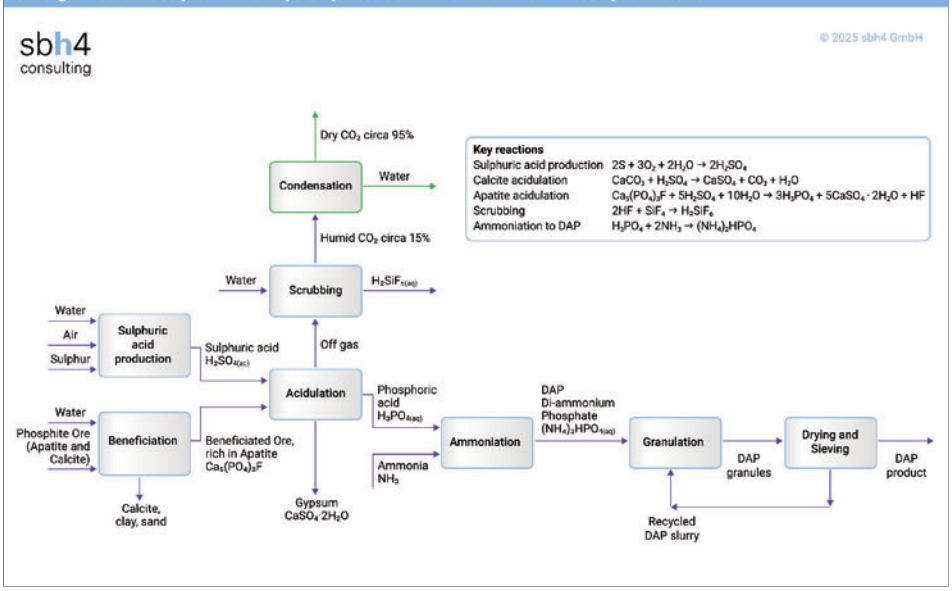
Phosphogypsum is the white solid waste material that is generated during phosphoric acid production. Phosphogypsum heaps are common close to phosphoric acid and phosphate fertilizer plants.

Through calcination of phosphogypsum using high temperature heat, this waste can be converted to lime (CaO), sulphur dioxide (SO2) , oxygen and water. The SO2 gas can be converted to sulphuric acid to introduce circularity to the DAP production process.

Lime can be used for cement and steel production. Also it is used in the pulp and paper industry and for pH modification of soils. Alternatively, the lime can be used to mineralise CO2 from DAP production to produce calcium carbonate which is insoluble and recognised as a permanent CO2 storage.

Putting theory into practice, Ma'aden Phosphate is collaborating with thyssenkrupp Uhde to recycle Phosphogypsum at Ras Al Khair in Saudi Arabia.

Geogenic CO2 capture from phosphoric acid and DAP fertilizer production



More information

https://sbh4.de

Frontier selects Leilac to develop zero carbon lime solution

Leilac, a subsidiary of Calix, has been awarded an R&D grant to support the production of zero carbon lime on behalf of Frontier buyers Stripe, Shopify, and Google.

The Leilac technology produces zero-carbon lime with electric heating and by capturing the CO2 released unavoidably from the raw material during calcination. The lime product has near-zero associated carbon emissions, a necessary enabler for scaling lime-dependent carbon removal methods like ocean alkalinity enhancement (OAE).

Frontier was founded by Stripe, Google, Shopify, and McKinsey Sustainability. Its members have committed to purchase over US$1 billion of permanent carbon removal by 2030.

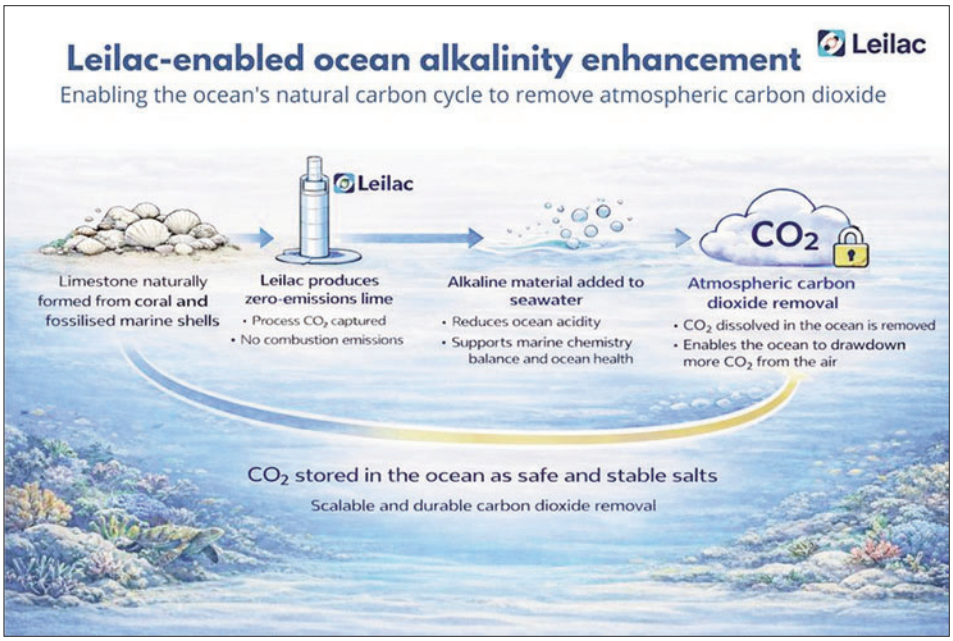
Leilac CEO, Daniel Rennie said Leilac looked forward to working with Frontier to help restore ocean health and mitigate climate change. “Ocean alkalinity enhancement has enormous potential to simultaneously improve ocean health and remove legacy and hard-to-abate carbon dioxide emissions from the atmosphere at the gigatonne scale."

“We look forward to working with Frontier, building on the solutions we are developing to reduce the cost and carbon emissions from cement and lime production. By enabling flexible electric heating and efficient capture of unavoidable process carbon dioxide, Leilac’s patented technology aims to produce the materials needed to seize this opportunity at the lowest possible cost.”

Initially, Leilac will produce OAE materials for testing and conduct an engineering study that aims to develop the lowest cost solutions for producing zero carbon lime for OAE.

The ocean stores approximately 25% of global carbon emissions, making it the world’s largest carbon sink. The absorption of atmospheric carbon dioxide, however, makes the ocean more acidic, harming marine life and limiting the ability of the ocean to absorb more carbon dioxide.

OAE involves adding alkaline substances, like lime and magnesia, to seawater. The OAE material converts the carbon dioxide dissolved in seawater into safe neutral salts, which are already common in the ocean and known to be stable for several thousand years. This process reduces the ocean’s local acidity, helping to improve conditions for marine ecosystems and enabling the ocean to absorb more carbon dioxide from the air, resulting in safe, long-term and verifiable atmospheric carbon dioxide removal.



Visual showing the integration of Leilac technology within an Ocean Alkalinity Enhancement pathway

The U.S. National Oceanic and Atmospheric Administration estimates OAE has the potential to remove 1-15+ billion tons of carbon dioxide annually, supporting the level of carbon dioxide removal required to meet global climate goals.

Quantifying Ocean Alkalinity Enhancement credits

Isometric recently issued the world’s first verified Ocean Alkalinity Enhancement (OAE) carbon dioxide removal credits to Planetary. These credits are an important step towards scaling marine carbon removal pathways responsibly.

In this project, alkaline feedstock was added to an existing outfall at the Tufts Cove power generation station, which discharges into a tidal channel. The alkaline feedstock primarily consisted of magnesium oxide (MgO) and magnesium carbonate (MgCO3).

The CO2 uptake attributable to the project was determined by comparing the cumulative air-sea CO2 flux between two simulations: one representing baseline conditions and one representing the OAE project.

More information

https://calix.global/leilac
https://webflow.isometric.com

C4Capture trial for aluminium begins decisive tests in 2026

Fives, Aluminium Dunkerque, Trimet and Rio Tinto announced a key milestone in their collaboration for developing a CO2 capture solution dedicated to the aluminium industry: the start-up of the trials under real conditions.

After the conception, ordering and installation of prototypes between 2024 and 2025, the C4Capture consortium partners met on 14th of January 2026 at the Aluminium Dunkerque site to start the pilot tests in real condition.

These trials, which will take place throughout the year in both Dunkerque and Saint-Jean-de-Maurienne, will mark a decisive step in confirming the technical and economic feasibility of the solution and guiding strategic decisions for the industrial phases.

They have the ambitious goal of contributing to a 50% reduction in direct CO2 emissions (excluding energy) from Aluminium Dunkerque primary aluminium production by 2030.

The project will test CO2 capture on an aluminium plant in real-world conditions. Image: Aluminium Dunkerque

The project faced several major challenges with the development of an innovative CO2 pre-concentration system using mini hoods, aimed at achieving levels close to gas industry standards, as well as a testing system based on amine absorption technology adapted to the specific characteristics of gases produced by aluminium electrolysis pots.

This project is supported by the French Government as part of the France 2030 plan and was selected as a winner of the DEMIBaC call for projects (which stands for demonstration and industrial adoption of low-carbon production solutions), led by ADEME (the French Agency for Ecological Transition).

Aluminium is a key element for decarbonisation: It plays a central role in lightweighting vehicles and its share in automotive applications is expected to rise by 13% between 2014 and 2050. It also supports growing demand driven by electrification and the replacement of single-use plastics.Its exceptional recyclability also makes it a cornerstone of the circular economy.

As a reminder, primary aluminium production accounts for 2% of the global emissions of greenhouse gases, with an average of 16,1t CO2 emitted per tonne produced. The French producers are already well below this average (4t CO2/t) but are now aiming for net zero emissions.

Working in partnership ensures the development of solutions that meet real-world needs and are immediately tested in actual operating conditions. The combination of experts in each technology has resulted in the following prototypes:

- Aluminium Dunkerque and Trimet at Saint-Jean-de-Maurienne have combined their expertise to help develop this technology at their respective sites.
- Rio Tinto, one of the world's largest aluminium producers, has expertise in the electrolysis process.
- Fives brings over 60 years of experience in capturing and treating gas emissions from primary aluminium production.

More information

www.fivesgroup.com

www.aluminiumdunkerque.com

Capture & utilisation news

Holcim invests in Capsol to scale its carbon capture technology

www.holcim.co.uk

www.capsoltechnologies.com

The investment in Capsol's Hot Potassium Carbonate (HPC) technology for carbon capture will support Holcim's decarbonisation roadmap.

Capsol's post-combustion carbon capture and heat recovery system delivers superior efficiency with a proven and safe hot potassium carbonate solvent (HPC). HPC technology is a mature, energy-efficient chemical absorption process used to remove CO2 from gas streams, that is widely applicable in post-combustion carbon capture. Holcim said it aims to apply Capsol's technology to further advance its decarbonisation roadmap and drive profitable growth.

Ram Muthu, Head of Operational Excellence, Holcim, said, "By combining Holcim's expertise in cement manufacturing and on-site carbon capture with Capsol's safe and efficient technology, we have an additional lever to advance decarbonization and drive profitable growth. Through this strategic investment, we are one step closer to producing near-zero cement at scale to meet growing customer demand."

The investment broadens Holcim's range of decarbonisation technologies. Holcim is assessing more than 500 startups annually through Holcim MAQER Ventures, its corporate venture capital unit. Holcim has made 19 investments to date through Holcim MAQER Ventures, and is constantly working towards scaling groundbreaking decarbonization technologies in the built environment.

Immaterial receives further investment to develop CO2 capture technology

https://immaterial.com

An additional investment by Japanese Utility JERA Co, Inc and new investment by global Chemical company UBE Corporation Japan takes the Series A2 round total to £14.5M.

Immaterial is the only company in the world that can produce MOFs in monolith form: macroscopic, ultra-dense crystals of MOFs that are thermally and chemically stable and preserve their ultra-high storage performance.

Immaterial is a Cambridge, UK based company which has developed a proprietary technology platform to apply monolithic metal-organic frameworks (m-MOFs) to reduce the financial cost of industrial decarbonisation by bringing to market bespoke advanced materials which are optimised to a specific use case, manufactured at scale through proprietary methods, and combined with novel process engineering. These systems have the potential to reduce the footprint, capex and opex of industrial decarbonisation process systems across multiple applications, making these solutions economic within the existing incentive mechanisms.

The Immaterial proprietary technology platform can be applied to existing metal–organic framework (MOFs) compositions to deliver an augmented volumetric effluent effect because of the monolithic form. Demonstrated pilot use cases include among others point source carbon capture, intermittent hydrogen storage, water harvesting and HVAC energy reduction solutions.

The capital raised will accelerate the company's commercialisation plans through pilot projects for carbon capture that demonstrate the impact of the technology platform with partners and customers in Europe and the U.S., while building on the momentum from the successful pilot project already concluded in Europe.

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

First deployment for CarbonQuest CCS on natural gas compression engines

www.carbonquest.com

www.captivatetechnology.com

www.tourmalineoil.com

Tourmaline Oil will install CarbonQuest distributed carbon capture (DCCS™) technology on a natural gas compressor at the Tourmaline Banshee facility outside Edson, Alberta.

CarbonQuest partnered with Canada based Cielo Carbon Solutions and New Zealand's Captivate Technology. For the first time, Captivate Technology's MOF will be integrated into a CarbonQuest system to optimise the carbon capture process and improve energy efficiency. Once captured, the CO2 will likely be transported a short distance by pipeline for permanent underground sequestration in Alberta.

"Our distributed carbon capture technology for medium-sized applications is ideally suited for natural gas compressors found at gas processing facilities," said Shane Johnson, CEO of CarbonQuest. "The integration of Captivate's MOF in this project and Cielo's Canadian presence is a great opportunity to expand our North American footprint."

Half of the $4,100,000 funding for the project is provided by the Alberta government, reaffirming its commitment to pioneering carbon capture and sequestration projects. "Sequestering carbon in Alberta is the right approach, one that promotes both economic prosperity with environmental stewardship, and we hope to see more CO2 injection wells developed in Canada," said Johnathon Sipos, CEO of Cielo Carbon Solutions.

"This project tests our proprietary metal-organic framework (MOF) in a commercial setting," said Shane Telfer, Chief Executive Officer of Captivate Technology, "enabling us to demonstrate how advanced adsorbent materials can revolutionize carbon capture processes. This is the first step in our cooperation with CarbonQuest to develop MOF-based carbon capture projects."

Canada Nickel and University of Texas complete nickel decarbonisation pilot

An in-situ carbon injection pilot has successfully stored 12 tonnes of CO2 at the Crawford Nickel Project demonstrating a further permanent CO2 storage pathway.

The pilot was conducted in collaboration with the U.S. Department of Energy's Advanced Research Projects Agency (DOE ARPA-E) funded team, led by Dr. Estibalitz Ukar, Research Associate Professor at the University of Texas at Austin.

"This achievement marks another critical milestone toward realising a Zero-Carbon Industrial Cluster in the Timmins region. By successfully demonstrating a third pathway for using our ultramafic deposits to capture and store carbon – in addition to the IPT Carbonation and NetCarb processes – we are expanding the tools available for large-scale decarbonization," said Mark Selby, CEO of Canada Nickel.

"The direct injection approach, which is implemented prior to mining, has the potential to lower future mining costs by pre-conditioning and fracturing the rock mass, making it less energy intensive to blast and process during crushing and grinding. The results also leverage portions of ultramafic deposits that lack economically recoverable minerals, turning them into valuable assets for environmental carbon removal."

Dr. Ukar added, "The Crawford in-situ mineralisation field test shows that carbon capture doesn't have to be an add-on to mining--it can be built in from the very beginning. What we demonstrated at Crawford represents more than an experiment at a single site, it's a scalable model for how mining can contribute to global decarbonisation. In-situ mineralization allows us to permanently store CO2 while simultaneously reducing mining energy requirements, creating both environmental and economic value."

After nearly two years of planning, laboratory experiments, and deployment of an extensive monitoring network, the CO2 injection field test was conducted between mid-November and mid-December 2025. All data collected to date indicate that the field test proceeded as planned and was a success: approximately 12 tonnes of injected CO2 remained dissolved at depth, with no surface leakage detected.

Starting on November 20, 2025, the pilot project conducted short-duration injection trials over a 12-day period, until December 1st. From December 2nd until December 18th, CO2-saturated water was injected continuously at a constant CO2 delivery rate injected into a single injection well drilled to a depth of 396m. The well was cased to 350m, establishing an injection interval between 350m and 396m. The trials confirmed that the injected CO2 remained fully dissolved within the water column, with no upward migration of CO2 gas observed.

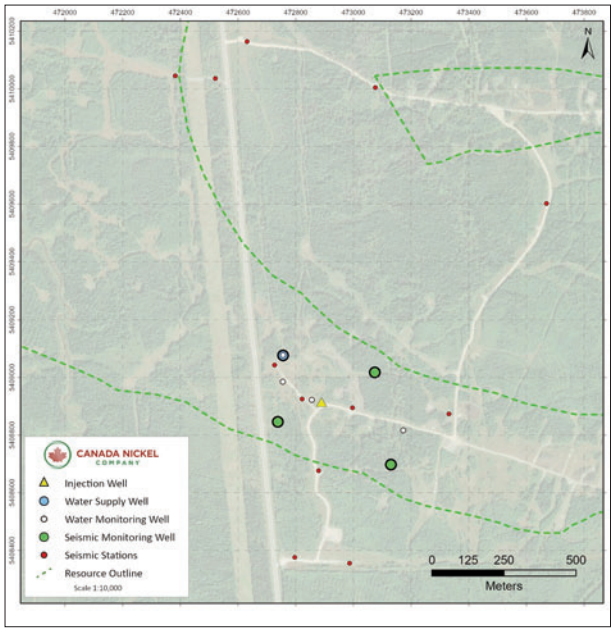


Figure 1. Location of drillholes and stations for the Carbon sequestration test at Crawford. (CNW Group/Canada Nickel Company Inc.)

The water used to dissolve carbon dioxide was sourced from an onsite well. The well configuration for the test consisted of an injection well (IN), a water supply well (SW), four water monitoring wells, 12 surface seismic monitoring stations, and three seismic monitoring boreholes (Fig. 1).

Seismicity and potential CO2 gas leakage was continuously monitored throughout the field test. No significant seismic events (M>1) were detected, and no CO2 was observed emerging from monitoring wells or through the silty sedimentary cover. Preliminary chemical analyses indicate that, at the time of writing, the injected CO2-rich water had not reached the monitoring wells, as predicted by reactive transport modelling. No surface leakage was detected, providing a strong indication that, as expected, all injected CO2 remained at depth.

In the coming months, monitoring of seismicity, water chemistry through regular sampling, and potential CO2 gas leakage will continue. Monitoring wells will be re-entered and sampled in the spring, following several months of reaction, and prior to ground thaw, to ensure access to the site. The area is also being monitored using InSAR satellite measurements. Monitoring will continue for several months as the team tracks seismicity and water chemistry to continue understanding and documenting subsurface fluid flow and reaction processes.

The initiative is independent of Canada Nickel's In-Process Tailings (IPT) Carbonation and NetCarb Programs (processes in which CO2 is injected and stored in waste rock and tailings) and represents a key step in expanding the Company's carbon capture and storage capabilities.

Results from this study will help guide future post-mining carbon sequestration strategies, further strengthening Canada Nickel's vision for a Zero-Carbon Industrial Cluster in the Timmins Region.

More information

www.canadanickel.com

Floating the carbon solution: the role of offshore CO2 injection and storage

Offshore storage is emerging as a strategic component of the carbon value chain, and ABS is already working to foster the collaborative networks needed to convert concept into deployment. By Michael Kei, ABS Vice President, Technology.

Interest in carbon capture and storage is accelerating as industries adapt to evolving regulatory expectations, customer requirements, and competitive pressures. For energy intensive industries such as cement, steel, chemicals, and refining, scalable CO2 management solutions are increasingly viewed as key enablers for continued market access and long-term operational resilience.

The Northern Lights project will use LCO2 carriers to transport CO2 from source to store

Capturing CO2 at land-based facilities and transporting it to offshore locations for permanent geological storage is increasingly viewed as one of the most viable pathways to compliance and risk reduction. While the technology is proven, the diverse stakeholders across this highly integrated ecosystem are still seeking consensus on a workable economic and regulatory model. This is where Floating Storage and Injection Units (FSIUs) could play a pivotal role.

Anatomy of the offshore carbon value chain

There are three main parts to an offshore CCS value chain: the land-based industrial emitter where the CO2 is captured, the CO2 transport provider (typically a specialized liquefied CO2 carrier) and the offshore storage operator. Each faces distinct challenges spanning regulation, technology, financing and risk allocation. Any misalignment, be it incompatible CO2 specifications or transport bottlenecks, can delay or derail projects. Closer collaboration across this chain is essential to ensure compatibility and coordination.

An FSIU – either a newbuild or converted existing offshore asset - receives liquefied CO2 from specialized carriers, stores and conditions it onboard, and ensures continuous injection into subsea wells for permanent storage in depleted oil and gas reservoirs or saline aquifers.

Unlike fixed offshore platforms or long subsea pipelines from shore, floating facilities have the flexibility to be deployed incrementally and relocated as early-stage CCS markets continue to evolve.

Northern Lights: A proof point for scale

The Northern Lights project in the Norwegian North Sea illustrates how CCS value chains can mature when commercial alignment, government support and industrial demand converge.

Equinor, Shell and TotalEnergies have taken final investment decision on phase two of the project, which has been underpinned by substantial government support - the Norwegian government covered about 80% of the cost for Phase 1 while Phase 2 has received €131 million from the EU funding program, Connecting Europe Facility (CEF).

Other projects are now approaching FID, including APOLLO CO2, which has been awarded €169.3 million in funding under the EU's 5th Innovation Fund Large-Scale Projects Call. The project, a collaboration between the Greek natural gas system operator DESFA and ECOLOG, aims to create the first large-scale CCS hub in Greece by 2030, with a first phase capturing 3 to 5 million tons

of CO2 from industries in the Attica region, with the possibility of scaling up to 10 million tons.

Meanwhile, EnEarth, a subsidiary of UK oil and gas group Energean, is developing the Prinos Carbon Storage Project, also backed by EU funding, while Malaysian energy giant Petronas was recently awarded the first Offshore Assessment Permit for CCS for the Duyong field, located offshore Peninsular Malaysia.

These developments underscore several lessons relevant to floating injection concepts: customer commitment is decisive, public-private partnerships reduce risk and catalyse investment, and scalable infrastructure unlocks further demand.

MODEC's Floating Storage and Injection Unit (LCO_2FSIU) was awarded approval in Principle (AiP) from ABS last year. It is able to receive, temporarily store and ultimately inject carbon dioxide

Floating solutions may offer a complementary pathway, particularly where onshore infrastructure faces permitting constraints or where storage sites are remote.

Why offshore, and why floating?

Offshore storage offers several advantages over onshore alternatives. Regulatory and environmental constraints are often less complex, public acceptance risks are reduced, and mature hydrocarbon basins offer significant subsurface capacity and existing skills and knowhow to support the project. Floating injection facilities add another layer of flexibility, acting not only as injection hubs but also as processing and transfer platforms.

FSIUs can support regions where pipeline transport is not feasible or economical, enabling ship-based CCS networks to emerge. Their mobility allows operators to match infrastructure investment with market development, reducing upfront capital risk.

The impurities barrier: why standardisation matters

Despite its promise, offshore CCS - floating or otherwise - faces substantial challenges. Regulatory frameworks remain fragmented, long-term liability is not uniformly defined, and economic models are still evolving. Storage operators must identify and mitigate operational risks while assuring regulators and the public of safe, permanent containment.

One of the most pressing technical barriers, however, is the issue of CO2 impurities.

Today's LCO2 carrier fleet is largely built to customized specifications, which increases costs, limits fleet scalability and creates bottlenecks across the value chain. This customization is driven by uncertainty over impurity compositions and their impacts on materials, safety and operability.

Standardisation could be transformative. By defining acceptable impurity "envelopes," designers and operators could move toward speculative newbuilding of CO2 carriers and associated floating infrastructure.

Classification societies such as ABS are actively working with industry and academic partners - including Texas A&M University and Sintef, one of Europe's largest independent research organisations - to close knowledge gaps around impurity behaviour and materials compatibility.

Solving this challenge could unlock significant pent-up demand for offshore storage solutions.

ABS: a catalyst for action

As an independent and trusted third party, ABS is uniquely positioned to help convene stakeholders, educate the market and foster alignment across the offshore CCS ecosystem.

While not a solutions provider, ABS plays a critical role in nurturing the conversations and collaborations from which safe, commercially viable and scalable solutions can emerge.

Floating offshore CO2 injection facilities will not solve climate change alone but as part of an integrated carbon value chain, they may prove to be one of the most adaptable tools available.

The conversation is moving quickly. The question is whether the industry can move together.

More information

https://ww2.eagle.org

UK and European partners advance carbon shipping in the North Sea

Two MoUs were signed by port and infrastructure partners to study the potential of CCS shipping corridors between Northern Europe and the UK, as well as sharing experience and understanding of this new but crucial energy transition area.

Associated British Ports (ABP), LBC Tank Terminals (LBC), North Sea Port and the Port of Esbjerg have signed two significant MoUs. The first between ABP and LBC and North Sea Port and a second between ABP and the Port of Esbjerg set the stage for collaborative efforts to develop shipping routes for captured carbon dioxide, enabling hard-to-abate sectors to cut emissions while supporting and growing jobs.

The North Sea's geological capacity for permanent carbon storage makes it a natural hub for this emerging market. By connecting emitters of CO2 with storage operators, via shipping routes, ABP and their partners aim to deliver scalable solutions that accelerate the energy transition.

The two MoUs will focus on:

• Designing port infrastructure for CO2 handling, storage and shipping.

• Building a robust value chain for CO2 transport between ABP's Humber ports and leading European ports and infrastructure asset owners.

• Driving innovation and efficiencies in CCUS related transportation.

The UK has world leading geological capacity for storing captured carbon and ABP has already achieved planning approval for a CCS handling terminal at the Port of Immingham, linked to the Viking CCS cluster.

Henrik Pedersen, Chief Executive Officer of ABP, said, "Ports have always been gateways for energy. Today, they are at the forefront of the energy transition. This agreement is about building the infrastructure and partnerships needed to decarbonise industry and create new opportunities for sustainable growth. It paves the way for the UK to utilise its world leading geological assets to provide near term options for emissions reductions across Europe and realise significant export potential for the UK."

"This is not just about reducing emissions – it's about creating a new market for carbon shipping that will help Europe meet its climate goals and secure industrial competitiveness and the jobs that rely on it at pace."

The Viking CCS project represents the most mature project in ABP's current portfolio of CCS solutions. The project involves receiving captured CO2 via ABP's?Immingham Green Energy Terminal (IGET) for secure and permanent storage in depleted gas reservoirs in the Southern North Sea. IGET recently achieved full planning permission, via a Development Consent Order.

This initiative is central to establishing a world-leading CCS industry in the Humber region, the UK's most industrialised area and largest emitter of CO2. By repurposing existing pipeline infrastructure and developing new import terminals like IGET the project provides a competitive, low-cost solution for industrial decarbonisation, both within the UK and internationally, via shipped CO2.

LBC's operational expertise and strategic infrastructure make it ideally positioned for the seamless supply chain for captured CO2, including temporary storage, processing, and shipment.

Radboud Gordon, Group Business Development Director New Energies, LBC Tank Terminals, said, "Signing this MoU is about moving from vision to tangible progress. By combining LBC's operational expertise in safe and sustainable storage with the port capabilities of ABP and North Sea Port, we can design an efficient, scalable shipping corridor that connects European emitters to UK storage at pace, supporting a competitive, cross-border CO2 market."

North Sea Port comprises a wide variety of industries, all looking into different decarbonisation routes, amongst others CCS. Therefore North Sea Port is actively supporting CCS projects through its central location, infrastructure and logistics capabilities and has ambitions to play a bigger role. The port area in Vlissingen is a strategic location to both receive captured CO2 from diverse off-grid locations and transship it onto ships for transport and storage offshore.

Cas König, CEO, North Sea Port said, "Our sustainability ambition is clear: a net zero port by 2050. To this end, we are creating connecting infrastructure with our partners. CO2 transport by ship is an additional and flexible means in the chain of industrial decarbonisation. By signing this MoU with ABP and LBC, we are taking a practical step to investigate a cross-border CO2 corridor that connects emitters to certified storage in the North Sea. Leveraging our shared port infrastructure and maritime expertise, we aim to cut costs, accelerate deployment, and ensure the energy transition strengthens – not weakens – Europe's industrial competitiveness."

The Port of Esbjerg is central to the Greensand CCS project, which aims to establish the EU's first full CCS value chain. Construction began in May 2025 on a CO2 transit terminal at Esbjerg, featuring six large tanks (each ~1,000 tonnes capacity) for liquefied CO2. This terminal will serve as a logistics hub for captured CO2 from Danish biogas plants, which will be shipped to the Danish North Sea for permanent storage.

Dennis Jul Pedersen, CEO of Port of Esbjerg, said, "Europe is at the beginning of a new reality where CCS will play an increasingly important role in supporting investment and jobs in critical industrial and energy sectors. Collaboration is key to unlocking the potential of carbon shipping. By partnering with ABP, Esbjerg aims to create scalable solutions that support Europe's decarbonisation ambitions and strengthen the role of ports in the green transition."

More information

www.abports.co.uk

Transport and storage news

Stanlow Refineries, Spirit Energy and Progressive Energy join forces to advance CO2 infrastructure

www.stanlowterminals.co.uk

Stanlow Terminals Limited (STL) has entered into a collaboration agreement to explore the feasibility of a new, integrated carbon capture, storage and shipping facility in the UK.

The agreement intends to assess the joint business case and development planning feasibility of a CO2 shipping import terminal, based at STL's Tranmere Terminal, within the Port of Liverpool, and at the Stanlow Manufacturing Complex, part of Essar Energy Transition.

Mike Gaynon, CEO of Stanlow Terminals Limited, commented, "We're delighted to be working alongside Spirit Energy and Progressive Energy on this important collaboration. It brings together the right partners with the right expertise to open up new opportunities for CO2 movement and storage and drives forward Stanlow's broader decarbonisation ambitions."

The partnership will also assess the opportunity to transport CO2 volumes received via the new STL shipping import terminal(s) to Spirit Energy's Morecambe Net Zero (MNZ) carbon store in the East Irish Sea.

The vision is to transform the Stanlow manufacturing complex into a decarbonised energy hub supporting long-term, sustainable jobs and industrial innovation across the region. It further supports Essar Energy Transition's US$3billion investment into its decarbonisation programme, aiming to become one of Europe's leading low-carbon fuels producers.

Ontario's carbon storage regulatory framework comes into effect

www.ontario.ca

Applications are now open for geological storage projects that could help industries cut emissions and save nearly $1 billion.

Ontario is ready to accept applications for commercial-scale geologic carbon storage projects as part of a government plan to protect Ontario by unlocking new opportunities to attract investment and build a more competitive, resilient and self-reliant economy. The technology has the potential to help energy-intensive industries cut greenhouse gas emissions by five to seven million tonnes annually, the State said.

"Carbon storage is a tried and trusted technology in Canada and around the world and Ontario is ready to take a safe and responsible approach to unlocking this new opportunity for workers and businesses," said Mike Harris, Minister of Natural Resources. "Our government is moving forward with strong environmental protections and clear rules that protect our environment while also protecting our economic advantage."

Ontario has undertaken years of extensive research and consultation to develop the regulatory framework for geologic carbon storage projects. The Geologic Carbon Storage Act, 2026 will provide clarity for industry operators to guide the safe, responsible management of carbon storage projects.

European Commission affirms EnEarth Prinos CO2 storage project

www.enearth.earth/what-we-do

The Directorate-General for Climate Action (DG CLIMA) has given a 'positive Opinion' after reviewing plans to store carbon dioxide in the Prinos reservoir in the Mediterranean Sea.

The EC's Opinion confirms that the technical work submitted by EnEarth meets EU requirements and demonstrates that the Prinos site is suitable for the safe, long-term storage of CO2.

The assessment recognises the quality and strength of the geological and technical studies EnEarth has prepared. It also supports EnEarth's understanding of the reservoir's dynamic behaviour and the systematic monitoring procedures it will put in place.

Prinos is expected to store 3 million tonnes of CO2 per year at full capacity

Nikolas Rigas, managing director of EnEarth, said, "This positive Opinion from the European Commission is a strong vote of confidence in the Prinos carbon storage project, and in the quality of the work of the EnEarth team."

"It confirms what we already know – that Prinos is a safe storage site and a vital player in decarbonising hard-to-abate industry in Europe and Greece, and helping our country meet its goal of reducing emissions by 80 per cent by 2040."

While the Opinion is not legally binding, it represents an important milestone in the permitting process and supports the ongoing review by the Hellenic Hydrocarbon and Energy Resources Management Company (HEREMA), which will make the final decision on granting the storage permit.

EnEarth submitted its permit application to HEREMA in July 2024, supported by technical evidence, including dozens of studies assessing safety and suitability of the site, proof of Energean Group's technical capability and competence, and detailed descriptions of construction activities.

The first phase of the project is expected to store 1 million tonnes of CO2 per year, increasing to up to 3 million tonnes of CO2 annually at full capacity.

ExxonMobil starts second commercial CCS project in Louisiana

Image: ExxonMobil