Carbon Capture Journal

CCUS in AUS/NZ

Legal and policy pathways for robust CDR in Aotearoa New Zealand

CO2-EOR for energy resilience and scaling storage

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Kairos@C wins EU funding

Image: Air Liquide

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KEPCO: operating the world's largest gas chemical looping combustion plant

Sector benchmarking for Post-Combustion Capture: Closing the Data Gap

Post-combustion carbon capture (PCC) has reached a level of maturity in several applications where technology readiness is no longer the primary constraint. Instead, project execution is increasingly constrained by the availability of high-quality, comparable performance data for front-end engineering design (FEED), technology selection, and financial underwriting. By Rouzbeh Jafari Ph.D. PEng and Madison Lynch MEng, Technology Centre Mongstad (TCM).

Despite extensive pilot results, available datasets remain fragmented and inherently non-comparable. Variability in flue gas composition, operating conditions, sampling methodologies, and vendor-specific reference frameworks introduce significant uncertainty. Consequently, industrial operators evaluating PCC solutions across sectors such as cement, natural gas combined cycle (NGCC), Waste-to-Energy, and Aluminum lack a consistent basis for decision-making. This uncertainty translates into conservative design margins, delayed final investment decisions (FID), and elevated project risk.

To address this gap, the Technology Centre Mongstad (TCM) will launch the CESAR1 Sector Benchmarking Campaign in Q4 2026. The campaign will generate an independently validated PCC performance dataset, supported by third-party review and verification, across eight industrial flue gas conditions, establishing a licensor-independent benchmarking reference framework for amine-based PCC systems to support FEED validation.

At the core of the campaign is the CESAR1 solvent, a well-characterized aqueous blend of 2-amino-2-methyl-1-propanol (AMP) and piperazine (PZ). Its extensive peer-reviewed foundation and independence from proprietary licensing constraints ensure that the dataset serves as a neutral benchmark for comparison across solvent-based PCC technologies. The campaign spans eight sector-specific environments covering a broad range of industrial PCC applications: Power (NGCC), BECCS, Cement, Steel, Aluminum, Refining, Waste-to-Energy and Pulp & Paper.

For each sector, TCM will execute a structured experimental matrix under both steady-state and dynamic operating conditions. Key performance indicators will include:

- Capture efficiency relative to energy consumption (specific reboiler duty) and overall utility demand
- Solvent management, including degradation mechanisms and emissions (e.g., amine slip, nitrosamines, aldehydes, ammonia, aerosol formation, and VOCs)
- Dynamic and part-load operation, including operational stability and transient response
- CO2 product quality and impurity characterization for transport and storage

All test conditions, analytical protocols, and data processing methodologies will be predefined and reviewed by an independent third party to ensure reproducibility, transparency, and technical integrity.

Participation provides both technical and strategic benefits. The campaign establishes an independently validated operational reference for PCC under industrial operating conditions, supporting validation of design assumptions and improving understanding of system performance across operating scenarios. Participants gain direct access to the site and TCM's technical experts, whose experience spans multiple capture technologies, including start-up behavior, solvent management, emissions control, and system integration.

The structured dataset also enables advanced modelling and digital applications, including process simulation, digital twin development, and data-driven optimization—capabilities increasingly critical for fleet-wide decarbonization strategies.

More broadly, participation enables:

- Access to a largely technology-neutral operational baseline within solvent-based PCC systems, independently reviewed and validated to accelerate CCS deployment with reduced risk
- Development of in-house operational and engineering capabilities through engagement with TCM's subject matter experts
- Verified environmental performance data under industrial operating conditions
- CO2 product quality data to inform compression, conditioning, and transport interface specifications
- An investment-grade, evidence base performance data, supporting project development and regulatory compliance

TCM will launch the CESAR1 Sector Benchmarking Campaign in Q4 2026

The campaign is structured as a pre-competitive collaboration, providing access to validated and independently reviewed data, technical engagement, and cross-sector knowledge exchange while protecting sponsor-specific intellectual property.

By delivering high-fidelity, independently reviewed and validated data under representative industrial operating conditions, the CESAR1 Sector Benchmarking Campaign addresses one of the key barriers to large-scale PCC deployment: the lack of a trusted, standardized, and sector-relevant performance reference.

Organizations interested in shaping and benefiting from this unique dataset are invited to engage with TCM and join the CESAR1 Sector Benchmarking Campaign.

More information

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Front cover: Kairos@C by Air Liquide and BASF will capture CO2 from the companies' existing chemicals plants located in Antwerp for underground storage in the North Sea (pg. 13)

Back cover: The Prinos CO2 Project aims to safely receive and permanently store emissions offshore Greece targeting operations by 2029 (pg. 33)

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Leaders - CCUS in Australia / New Zealand

Projects and policy

Capture and utilisation

Transport and storage

Beyond forestry: legal and policy pathways for robust CDR in Aotearoa NZ

In this article, the authors spotlight the Carbon Removal Project and discuss the legal and policy pathways needed to move New Zealand beyond forestry offsets and toward a mature, diversified, and credible carbon removal system. By Jennifer Campion and Professor Barry Barton, University of Waikato.

Aotearoa New Zealand's climate change response has relied primarily on forestry-based offsets to meet emissions reduction commitments. However, government strategy now recognises that achieving net-zero by 2050 will require a broader, more durable portfolio of carbon capture and storage (CCS) and carbon removal (CDR) approaches.

At the same time, innovative New Zealand research is exploring novel CDR technologies. However, for these technologies to reach their potential, New Zealand faces a legal and policy challenge: how to design robust systems for measuring, verifying and reporting (MVR) carbon removals so they can be trusted, incentivised, and integrated into national climate accounting frameworks.

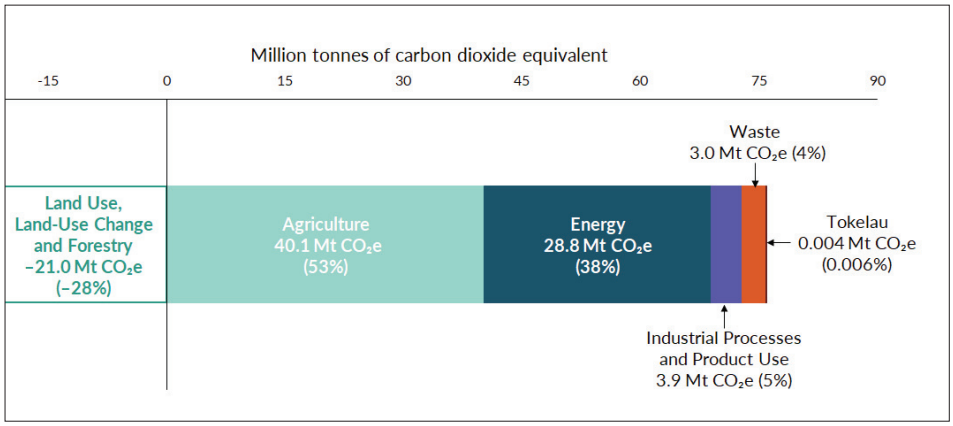


Figure 1 - Breakdown of New Zealand's emissions (in Mt CO2e) by sector in 2024. Source: New Zealand's Greenhouse Gas Inventory 1990–2023: Snapshot" (2025)

Carbon Removal Project

The Carbon Removal Project is a five-year, interdisciplinary research project which is developing negative-emissions technologies capable of locking away carbon for centuries.[1] It focuses on three promising CDR pathways suited to New Zealand's natural and industrial landscape: burning forestry slash at geothermal plants and reinjecting captured CO2 for mineralisation underground; enhancing farmlands with carbon-absorbing crushed rock; and producing carbon negative cement substitutes from wood ash.

By the end of the project, the research team will produce and publish three case studies outlining how different CDR technologies might be established and how these might be deployed across New Zealand.

Alongside the technological work, researchers will also conduct wider analysis to explore how CDR technologies could work for New Zealand by mapping regional opportunities; assessing energy system requirements for deployment; evaluating storage options such as geothermal reservoirs and saline aquifers; and examining potential environmental trade-offs and regulatory challenges.

Law and policy challenges: CCS

Although New Zealand has been an active participant in the United Nations Framework Convention on Climate Change and the Paris Agreement and has an ambitious Nationally-Determined Contribution (NDC) in place, it has struggled to put law and policy in place to reduce its GHG emissions and increase its removals.

Agriculture looms large in its emissions profile – methane and nitrous oxide emissions from livestock account for 48.6% of its emissions[2] – but there is no policy in place to reduce its effect, except by investing in research.

It introduced an Emissions Trading Scheme (NZ ETS) in 2009, and a 'zero carbon' legislative framework for targets, budgets, plans, and independent advice in 2019, but the results have been meagre. Prices of units in the NZ ETS are too low to cause real change, around NZD 40 per tonne. The main source of units is forestry, where landowners can earn NZ ETS units for planting trees. There is little government support in the form of subsidies or mandates for electric vehicles, renewables, or decarbonization generally.

As for CCS, the New Zealand government has been slow to put policy in place to allow the activity to occur, let alone encourage it. This sluggishness stands in stark contrast to many other countries; Australia, for example, with its Offshore Petroleum and Greenhouse Gas Storage Act 2006. CCS caught the eye of policymakers for a period 2011-2013,[3] but it then dropped out of sight for another ten years.

1. Carbon Removal Project: https://www.carbonremoval.tech/
2. Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2023: Snapshot" (2025), available at: https://environment.govt.nz/facts-and-science/climate-change/new-zealands-greenhouse-gas-inventory
3. It commissioned the report B Barton, K Jordan and G Severinsen, Carbon Capture and Storage: Designing the Legal and Regulatory Framework for New Zealand (Hamilton: Centre for Environmental, Resources and Energy Law, University of Waikato, 2013)

In fairness, CCS is not at the top of any list for solving New Zealand's emissions problems; it doesn't address the big agriculture problem, the electricity system is already mostly renewable, and there are not many large point-source emissions.[4] High levels of tectonic activity have produced a great deal of geological folding and faulting, which complicates the search for storage formations.

For all that, CCS came onto the agenda in the late 2010s, with a NDC pledge for Paris, and then the production of an Emissions Reduction Plan (ERP) in 2022 to make good on the pledge. Another goad for action was recognition of the difficulties that undue reliance on forestry removals would lead to. The first ERP called for the natural gas industry to produce a Gas Transition Plan, and that in turn led to policy activity on CCS.[5]

In June 2024 the government released proposals for CCS policy, and later that year it decided on a full package for new legislation, containing many elements common internationally.[6] Credits in the NZ ETS would be available, not tied to any one technology; the government would assume NZ ETS liability for leakage from geological storage, but only after a verification procedure and no sooner than 15 years after closure; and a new regulatory regime would be established.

After a short period it was decided that the Environmental Protection Authority would be the regulator. There was follow-up in ERP-2 in December 2024, projecting an abatement of 1 million tonnes of CO2. However the necessary legislation did not appear as promised in 2025 and is unlikely to appear and be enacted before the New Zealand election expected in November 2026.

Possibly the slippage is because the most foreseeable CCS projects were gas processing plants, and many of the country's gas fields showed serious declines in production in 2024 and 2025.

Figure 2 - ERP-2 policies with the greatest potential emissions savings

Law and policy challenges: CDR

As progress on CCS regulation has slowed, the policy focus has shifted to CDR. Recent government work highlights the need for a diversified national removals portfolio.

Removals feature in the second Emissions Reduction Plan of 2024, and the Ministry for the Environment has produced an Assessment Framework for Carbon Removals,[7] which will provide a process for applications for proposed CDR activities to be considered for inclusion in the national inventory system and the NZ ETS.

This process provides for a scientific assessment and a more policy-oriented inclusion assessment for evaluating whether proposed new CDR activities meet requirements (for example, by determining that they are sufficiently robust, additional, and measurable). The Assessment Framework forms part of

4. B Field, M Arnot, J Begg, K Bland, M Bunch, B Doody, S Edbrooke, R Faulkner, R Funnell, A Griffin, K Higgs, P King, M Rattenbury, B Ricketts and D Strogen, "New Zealand carbon dioxide storage site assessment: Phase 2", Cooperative Research Centre for Greenhouse Gas
5. Barry Barton, Carbon Capture and Storage: Taking Action under the Present Law (Centre for Environmental, Resources and Energy Law, University of Waikato, Research Report, 2023)
6. See Ministry of Business, Innovation and Employment, "Carbon capture, utilisation and storage" (2025), https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/carbon-capture-and-storage; Ministry for the Environment, ""A Carbon Storage Regime (2025), https://environment.govt.nz/publications/a-carbon-storage-regime/
7. Ministry for the Environment, Assessment Framework for Carbon Removals (2025), https://environment.govt.nz/assets/publications/climate-change/Assessment-Framework-for-Carbon-Removals_final.pdf

the Government's broader climate strategy to diversify removal methods beyond forestry and ensure credible market participation.

Progress to-date includes establishing the Assessment Framework's criteria, defining readiness and sufficiency standards, and signalling the release of an online self-assessment tool in 2026 to help applicants prepare for assessments. Future work is expected to focus on operationalising the assessment process, developing aligned domestic standards for voluntary markets, supporting innovation in emerging CDR technologies, and refining how new removal activities may interact with the NZ ETS and New Zealand's NDC.

The Assessment Framework process can also be used for voluntary market projects, but it emphasizes the distinction between national-level activities of some scale, which could go in the inventory and therefore count towards the NDC, and smaller project-level activities which could be considered for the voluntary markets. The Assessment Framework intends to apply to activities that remove CO2 directly from the atmosphere, and not CCS in the sense of activities that reduce, avoid or capture emissions from an industrial point source.

Voluntary carbon markets in New Zealand can provide a mechanism for organisations and individuals to purchase credits generated from CDR projects. These markets are not specifically regulated by the NZ Government and operate independently of the NZ ETS, although the Ministry for the Environment (MfE) has produced guiding principles.[8] As in other countries, voluntary markets rely on independent verification systems (such as the Verified Carbon Standard and the Gold Standard) to confirm that carbon removals are measurable, additional, and permanent.

These assessments often include validation of project design, baseline calculations, monitoring requirements, and third-party audits before credits can be issued. To-date, NZ voluntary market projects have primarily focused on forestry removals;[7] even so, the Government is developing a voluntary nature credits market, which, although broader than CDR, will include projects that provide measurable climate benefits.[9]

Currently, forestry is the only CDR activity recognised as contributing at scale to Aotearoa New Zealand's climate change targets.[7] However, there is already a form of removal, or reduction, where geothermal power companies have begun to reinject the CO2 that comes up with geothermal fluids. Emerging research shows that New Zealand's geothermal fields, such as Ngāwhā, could enable on-site biogenic CO2 sequestration through reinjection wells, offering permanent mineralisation pathways and potentially generating negative-emissions electricity.[10]

The Assessment Framework outlines how a removal activity might transition from voluntary markets into consideration for NZ ETS inclusion. This may mean that voluntary markets will serve as an innovation space for new CDR approaches, before these approaches are ready to enter the formal, regulated NZ ETS pathway.[11]

Law and policy challenges: MRV

Measurement, reporting, and verification (MRV) are essential for getting credit for CCS, CDR, or any other emissions reduction activity. If it's at the country level, the country wants credit for its removals when its performance against its NDC is evaluated through the Enhanced Transparency Framework of the Paris Agreement; at the project level, proponents want units under the NZ ETS that they can sell to emitter companies that must surrender units to stay in compliance; and in voluntary markets the purchasers want an emissions reduction story that will enhance their environmental credibility.

It's therefore vital that the relevant decision makers are satisfied with the quality of the measurement data, as to quantity, permanence, and additionality of the removal. But obtaining data can be expensive, so there is a balance to be struck between the quality and the cost of MRV.

At the country level, the methods for measuring and reporting GHG emissions and removal are governed by the 2006 IPCC Guidelines, produced by the Intergovernmental Panel on Climate Change and adopted by the parties to the United Nations Framework Convention on Climate Change and the Paris Agreement. So, to count as part of a country's climate efforts, a removal activity must be acceptable under the Guidelines.

While there is some room for the exercise of judgement about what can be included, the IPCC has started work on removals to make them more readily acceptable, and plans to produce a Methodology Report on removals in 2027.

The opportunity for New Zealand

The limits of a forestry-dominated removals strategy in New Zealand are now clear, while emerging science and policy signals point toward a more diverse, resilient, and credible carbon removal portfolio. The Carbon Removal Project demonstrates that a range of durable CDR technologies rooted in New Zealand's unique geology, energy systems, and industrial by-products could meaningfully complement existing nature-based removals.

By leveraging its scientific expertise, renewable energy strengths, and export-oriented industries, New Zealand can become a regional leader in high-integrity carbon removal solutions. Yet progress will depend on having the legal, regulatory, and MRV infrastructure in place to ensure that new technologies are scientifically robust, environmentally responsible, and internationally recognisable for climate accounting.

By investing in governance as seriously as innovation, New Zealand has the opportunity to move beyond incrementalism and toward a long-term strategy that secures genuine, high-integrity carbon removals aligned with its 2050 net zero ambition.

More information

Campion and Barton acknowledge funding from the Ministry of Business, Innovation and Employment (MBIE) under the 2022 Endeavour Fund Research Programme (grant number UOC2456).

www.waikato.ac.nz/cerel

8. For example, Ministry for the Environment, "Guidance for voluntary carbon offsetting – updated and extended until 31 December 2021" (2020), https://environment.govt.nz/assets/Publications/Files/guidance-for-voluntary-carbon-offsetting-updated-and-extended-until-31-December-2021.pdf
9. Ministry for the Environment, "Government backs voluntary nature credits market" (2025), https://environment.govt.nz/news/government-backs-voluntary-nature-credits-market/
10. K Titus, D Dempsey, R Peer & F Hanik, "Carbon Negative Geothermal: Theoretical Case Study for Biogenic CO_2 Removal at Ngāwhā Power Station" (2023) 45th NZ Geothermal Workshop, https://ir.canterbury.ac.nz/server/api/core/bitstreams/d986c68b-33bd-45fc-908f-3d6747d31255/content
11. Ministry for the Environment, "Voluntary nature credits market in New Zealand" (2025), https://environment.govt.nz/what-government-is-doing/areas-of-work/biodiversity/voluntary-nature-credits-market-in-new-zealand/

Could CO2-EOR help strengthen energy resilience while scaling CO2 storage?

Researchers from CO2CRC found that CO2-EOR in Australia could make a meaningful domestic supply contribution from existing mature fields while also helping scale the storage capability that underpins CCS.

Recent discussion about Australia's fuel security has highlighted the importance of strengthening domestic energy resilience alongside ongoing decarbonisation efforts.

Against that backdrop, earlier work by CO2CRC points to a separate and potentially important opportunity: the role CO2-enhanced oil recovery, or CO2-EOR, could play in increasing output from mature oil fields while also supporting the development of domestic carbon capture and storage infrastructure.

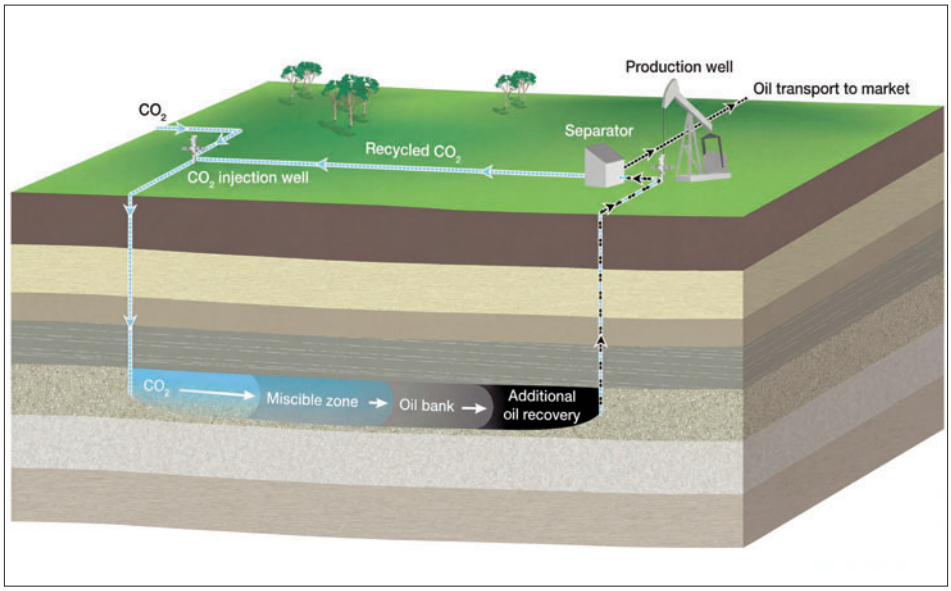
In the context of current policy priorities around both energy security and emission, this work highlights a potential complementary pathway.

CO2-EOR is a well-established process in which captured carbon dioxide is injected into mature oil reservoirs to help mobilise remaining oil while permanently storing CO2 underground. Internationally, the technology has operated for decades and has played a significant role in building early CO2 transport, injection and storage capability.

Importantly, CO2CRC's work in this area was not primarily undertaken as a way of boosting oil production alone. Rather, it examined whether CO2-EOR could provide a practical pathway to safely and economically store CO2 while also increasing domestic oil output from existing mature fields.

In studies undertaken between 2021 and 2023, CO2CRC assessed mature onshore fields in the Cooper/Eromanga and Surat/Bowen basins. Across 104 technically suitable reservoirs, modelling indicated the potential to store around 116 to 128 million tonnes of CO2 and produce an additional 248 to 518 million barrels of oil, depending on the injection strategy applied.

On the basis of Australia's current crude and condensate production, that volume is equivalent to roughly three to six years of domestic output at current rates.



How CO2-EOR works: captured CO2 is injected into a mature oil field to improve oil recovery, with a significant share of the CO2 remaining stored in the reservoir

CO2CRC Senior Manager, Technology, Dr Max Watson, said the strategic value of the work lies in its dual benefit.

"This study was not about increasing oil production for its own sake," Dr Watson said.

"It was about examining whether Australia could increase output from mature fields while also safely and economically storing large volumes of CO2, and in doing so help build the transport and storage capability needed for Australia's broader CCS deployment."

The potential for Australia

Globally, CO2-EOR has been an important enabler for early geological storage projects, delivering a significant share of stored CO2 and helping demonstrate sustained large-scale injection, storage and monitoring.

CO2CRC Subsurface Lead Dr Hadi Nourollah said the Australian study highlighted the scale of what may be possible in selected mature basins.

"What stood out was the extent of the remaining opportunity across technically suitable reservoirs in the Cooper/Eromanga and Surat/Bowen basins," Dr Nourollah said.

"The modelling showed there is potential not only to recover additional oil from existing mature fields, but also to store substantial volumes of CO2 in the subsurface."

The work also suggests CO2-EOR could contribute to energy resilience by lifting domestic production from existing basins and leveraging established infrastructure. At the same time, it could help support the early development of CO2 transport and storage systems needed for long-term emissions reduction.

Dr Watson said it was important to keep the opportunity in perspective.

"CO2-EOR would not remove Australia's dependence on imported liquid fuels," he said. "But it could make a meaningful domestic supply contribution from existing mature fields while also helping scale the storage capability that underpins CCS."

The studies focused on onshore reservoirs only. Offshore regions, including Gippsland and parts of the North West Shelf, may add materially to the national opportunity, although offshore projects would likely be more complex and more costly to develop.

That distinction is particularly relevant as broader public discussion continues around future domestic oil prospects. While other resources may attract attention because of their scale, CO2-EOR presents a different proposition: one based on mature fields, existing infrastructure, earlier deployment potential, and the added benefit of CO2 storage.

Under some operating conditions, CO2CRC's modelling also suggested the system could approach net-negative emissions, with more CO2 stored underground than emitted across the lifecycle of the oil produced.

As Australia continues to consider how best to deploy large-scale CCS, revisiting this earlier technical work may help inform the discussion. While CO2-EOR is not a complete answer to fuel security or emissions reduction, it may offer a practical way to support both domestic resilience and the scale-up of CO2 storage capability.

For readers interested in the technical detail, the relevant publications are available in the APPEA Journal.

"The modelling showed there is potential not only to recover additional oil from existing mature fields, but also to store substantial volumes of CO2 in the subsurface" - Dr Max Watson, CO2CRC Senior Manager

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Bason, D., Nourollah, H., Kuuskraa, V., Wallace, M., Duff, T., & Raab, M. (2023). Carbon dioxide-enhanced oil recovery in Australia – techno-economic evaluation, carbon dioxide source/sink networks and current policy landscape. The APPEA Journal, 63(S1), S341–S346.

More information

www.co2crc.com.au

https://connectsci.au/ep

Australia opens Round 2 funding for CCUS technologies

The Carbon Capture Technologies Program aims to accelerate the research, development and demonstration of novel and emerging carbon management technologies.

Grants will be offered to pilot and demonstration projects that capture, utilise and remove CO2 and have the potential to create new, low-emissions or net-zero industries. Round 2 closes on May 6, 2026.

Examples of eligible technologies, include but are not limited to:

- novel or emerging carbon capture and/or utilisation for hard-to-abate sectors
- novel or emerging carbon removal technologies such as
- direct air capture
- enhanced rock weathering
- biomass carbon removal and storage, including durable sequestration of carbon in biochar
- mineral carbonation technology, such as capturing carbon in building and other materials.

Conventional and land-based approaches that use natural biological systems, without technological intervention, are not eligible, including:

- afforestation/reforestation,
- peatland or wetland restoration
- agroforestry are excluded from this program.

The objectives of the program are to accelerate the development of emerging priority CO2 capture, utilisation, and removal technologies through supporting research, development and demonstration in hard-to-abate industries such as cement, chemicals and steel and to demonstrate verifiable permanence of CO2 sequestered via a range of utilisation applications.

More information

https://business.gov.au

CSIRO: building Australia's capture and storage foundation

The Carbon Capture and Storage Impact Assessment Report (CCSIAR) presents CSIRO's foundational role in national CCS development, evaluating its contributions to carbon CCS over the past 25 years.

Australia has a national commitment to achieving net-zero emissions by 2050. To get there, it must accelerate renewable energy deployment and scale up carbon management solutions like CCS.

CCS is a critical tool in Australia's emissions reduction strategy, complementing energy system decarbonisation and efficiency improvements. Hard-to-abate industries such as cement, steel, and fertilisers face complex challenges on the path to net zero.

When CSIRO began major CCS research, the technology lacked frameworks, monitoring systems, and commercial validation. We asked a fundamental question:

Is CCS a viable option to help manage the massive volumes of carbon dioxide generated by Australian industry?

The response

Inspired by this question, CSIRO's involvement in CCS started with early capacity assessments around topics like capture development and storage research with a focus on establishing fundamental knowledge and building national capability from the ground up.

The research evolved through distinct phases, shaped by shifting government policies, fluctuating investment landscapes, and the persistent dedication of its scientists.

The Carbon Capture and Storage Impact Assessment Report (CCSIAR) undertaken by Consulting & Implementation Services (CIS) is a summary of this work, evaluating CSIRO's contributions to carbon capture and storage over the past 25 years.

The independent assessment is based on qualitative analysis of CSIRO's project portfolio and extensive consultations with national and international experts and stakeholders.

The report outlines the scope and depth of CSIRO's long-term, strategic approach to building Australia's CCS capability across seven key areas summarised below:

Establishing Australia's CCS foundations

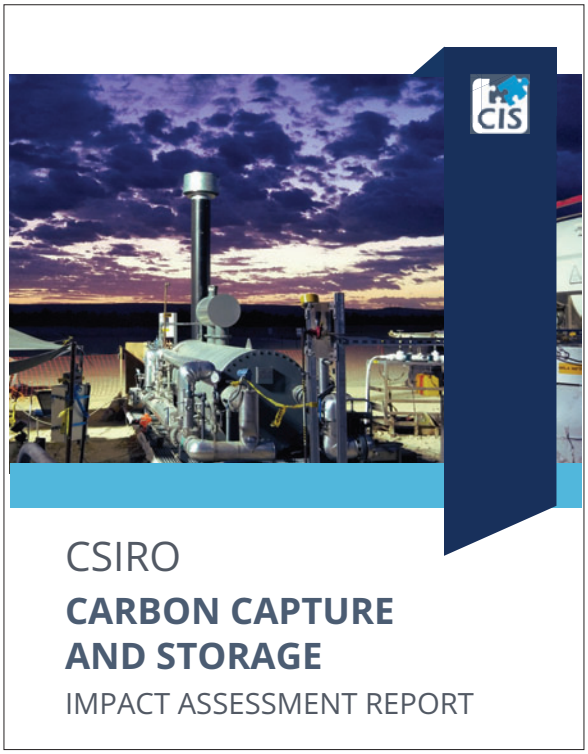
CSIRO's journey in CCS began in 1999, when CCS was largely a theoretical concept in Australia. Its involvement and collaborative ethos have helped to build the foundational knowledge and collaborative structures that have seen CCS transform from a promising idea into a field of operational research.

Advancing CCS science and technology

CSIRO's research has expanded the technological frontiers of CCS and been instrumental in de-risking CCS for deployment globally. From pioneering new capture chemistries to developing innovative methods for monitoring stored CO2, its work has bridged laboratory research and field deployment, building confidence in the technical feasibility, safety, and scalability of CCS.

Underpinning policy and investment with credibility

Over the past two decades, CSIRO has played a pivotal role in enabling CCS investment and informing policy via its unique combination of scientific authority, institutional neutrality, and deep technical expertise. Trusted independent advice have helped to build regulatory frameworks and de-risk major project investments.



CSIRO has been instrumental in transforming CCS from a theoretical promise into a feasible option according to the report from consultancy CIS

Building national CCS capability

For more than 25 years, CSIRO has helped build out Australia's sovereign capabilities in CCS through developing a portfolio of leading research infrastructure and adopting a highly collaborative approach that has helped build a highly skilled and experienced workforce.

Building public trust and social licence

Public trust is a critical enabler of CCS deployment. CSIRO's research has demonstrated that science-based engagement helps foster understanding and build public confidence through transparent, evidence-based communication.

Global standing and international influence

CSIRO's international engagement has provided a consistent and powerful strength in helping build Australia's reputation as a top-tier CCS research nation and becoming an influential partner in major collaborations engaging North American, European, and Asian institutions and networks.

Navigating the path to commercialisation

The path from a successful pilot plant to a commercially viable, large-scale operation is fraught with obstacles, often referred to as the "valley of death", where promising technologies can falter due to a lack of investment, uncertain market signals, and inconsistent policy support.

The CCSIAR outlines how CSIRO's research has recognised this critical gap by generating a portfolio of de-risked, commercial-ready technologies and developing invaluable expertise, preparing Australia for large-scale CCS deployment.

CSIRO scientists took on leadership roles across multiple phases of the CO2CRC Otway Project, including Stage 1 and Stage 2. Their work focused on the complex mechanisms of CO2 trapping in both depleted gas fields and saline formations

The results

CCSIAR is a comprehensive view into CSIRO's contribution to the science that informs the carbon capture and storage sector, providing a clear understanding of the impact of our sustained CCS investment.

Through 25 years of collaborative research, CSIRO has:

- Positioned Australia as a global leader.
- Reduced commercial risk for industry and investors through rigorous science.
- Built trust with regulators and communities, unlocking capital for major projects.
- Created a critical mass of expertise, infrastructure, and international partnerships.

Looking ahead, CSIRO is working to integrate CCS into industrial hubs, enabling shared capture and storage infrastructure for multiple emission sources.

From the initial explorations of geological storage potential to the operation of sophisticated pilot plants and the development of advanced monitoring techniques, CSIRO's work has played a critical role in strengthening the capacity to evaluate and deploy CCS as a key part of Australia's net-zero future and global climate change efforts.

More information

www.csiro.com

https://consultingis.com.au

Gravity's subtle effect on light could improve carbon storage monitoring

University of Wollongong (UOW) study shows how optical technology can detect tiny gravity changes, with potential applications in environmental monitoring and navigation.

A study by University of Wollongong physicist Dr Enbang Li has demonstrated that gravity can subtly influence the behaviour of light, a breakthrough that could underpin future technologies for monitoring groundwater, tracking glacier melt, locating mineral deposits and detecting underground changes linked to volcanic activity and carbon storage.

The study, published in Scientific Reports, shows early experimental evidence that photons – particles of light – interact with the Earth's gravitational field in measurable ways, laying the groundwork for a new generation of ultra-sensitive gravity sensors.

Dr Li said the work could lead to more precise and compact next-generation sensing technologies for environmental monitoring, navigation and underground mapping.

"Tiny shifts in gravity can reveal critical changes beneath or around us, from underground water levels to magma build-ups below volcanos that could indicate future eruptions. Our research suggests light-based sensing technologies may one day provide a new way to detect and monitor those changes with very high precision," Dr Li said.

Gravity sensing is already used in mining, infrastructure, defence and geoscience to "see" beneath the Earth's surface by detecting differences in underground density of rocks, minerals, water or tunnels.

Experimental setup on a moving cart

Dr Enbang Li has developed laser-based gravity sensors that work reliably on moving platforms

However, photonic gravity sensors could offer advantages over conventional technologies through improved sensitivity, stability and miniaturisation.

Most current gravity sensors rely on mechanical systems that are susceptible to vibration and movement, limiting their use on moving platforms. Light-based sensing technologies could overcome those limitations, with the potential to produce gravity sensors that work reliably on moving platforms such as planes or submarines.

Dr Li said the findings also build on fundamental questions in physics dating back more than a century.

"In 1905, Albert Einstein postulated that the speed of light in a vacuum is constant and independent of the observer's motion. Our experimental results suggest that photons can interact with the Earth's gravitational field in ways that may influence how light transmits, which provides a new perspective on this longstanding assumption," Dr Li said.

The work is at an early, proof-of-concept stage, and further development will be required before practical applications can be realised. Future research will focus on refining the measurement approach and exploring additional interactions between light and gravitational fields to better understand the underlying physics and potential technological uses.

More information

www.uow.edu.au

Taiwan's CCUS development: policy, geological potential, and demo projects

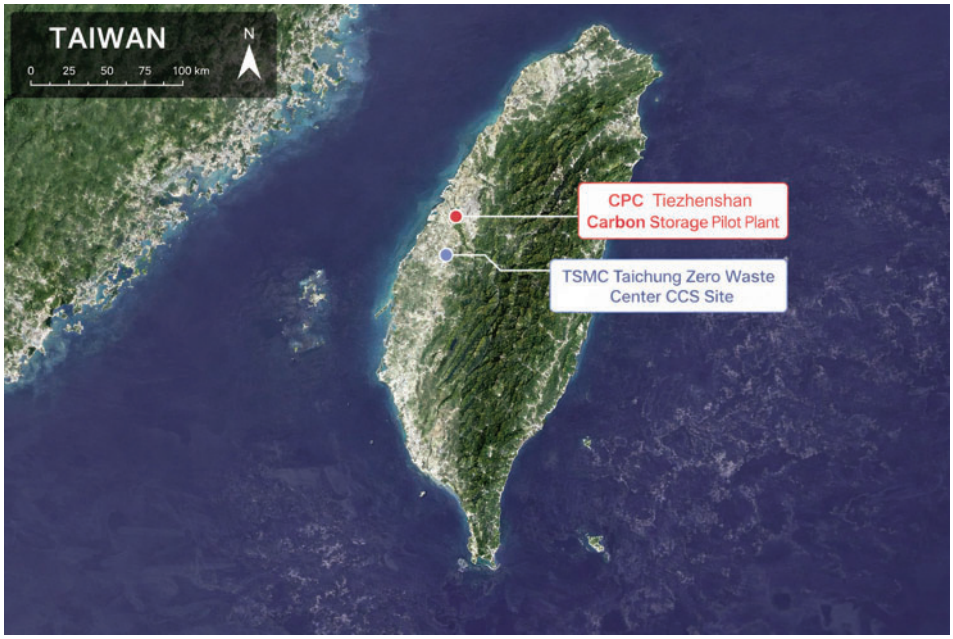
This article examines the current state of Taiwan's CCUS ecosystem through a systematic review across three dimensions: the policy and regulatory environment, geological storage resource potential, and representative engineering demonstration projects.

Carbon capture, utilisation and storage (CCUS) technology plays an indispensable role in driving hard-to-abate industrial sectors toward deep decarbonisation, and the Taiwanese government has explicitly incorporated it into the national "Net-Zero Emissions by 2050" strategy.

Two landmark in-situ case studies are analysed in detail. The first is the Tiezhenshan Carbon Storage Pilot Project led by Taiwan's national oil company CPC Corporation, , which uses a depleted natural gas reservoir and deep saline aquifer as storage sites and achieved mechanical completion by end of 2025, marking the successful delivery of Taiwan's first integrated CCS demonstration project.

The second examines the demonstration facility established by Taiwan Semiconductor Manufacturing Company (TSMC) at the Central Taiwan Science Park, which validated the feasibility of membrane-based carbon capture technology in semiconductor manufacturing processes and demonstrated an execution strategy for delivering EPCC (Engineering, Procurement, Construction, and Commissioning) within an exceptionally compressed timeframe.

The article concludes with an assessment of offshore western saline aquifer storage capacity, along with observations on the challenges of economic competitiveness and policy incentives currently facing large-scale deployment.



Two landmark carbon capture, utilisation and storage projects are examined in detail

Introduction

In the face of global climate change, industries across all sectors are under intense pressure to reduce emissions. While the expansion of renewable energy and electrification can address the majority of energy-related emissions, for hard-to-abate sectors such as steel, cement, petrochemicals, and thermal power generation, the CO2 produced during manufacturing processes and the demand for high-temperature heat make CCUS an essential pathway to achieving decarbonization targets.

In the "2050 Net-Zero Emissions Pathway" released in 2022, Taiwan designated CCUS as one of 12 key strategies, and established its legal foundation through the Climate Change Response Act enacted in 2023.

Taiwan's CCUS governance currently operates under a cross-ministerial collaborative model: the Ministry of Environment is responsible for overseeing storage activities and environmental safety monitoring, while the Ministry of Economic Affairs focuses on the development of capture technologies and the promotion of downstream industrial utilisation.

According to national development planning, Taiwan has established a clear deployment timeline, targeting annual storage capacity of 1.76 to 4.6 million tonnes by 2030, with CCUS projected to contribute over 10% of total carbon reduction by 2050.

Geological Storage Potential in Taiwan

Multiple Cenozoic sedimentary basins are distributed along Taiwan's western coastal region, with stratigraphy comprising alternating sequences of thick sandstone and shale formations. These geological structures possess favorable porosity and permeability characteristics, making them ideal sites for geological storage.

Deep Saline Aquifers

Deep saline aquifers are regarded as Taiwan's most significant storage resource. Preliminary studies indicate that saline aquifers within 50

kilometers of the western coastline hold a theoretical storage capacity of approximately 45.9 billion tonnes; focusing on the economically accessible zone within 25 kilometers offshore, the potential remains as high as 16.8 billion tonnes. Key advantages include large capacity, broad geographic distribution, and relatively minimal interference with existing oil and gas development activities.

Depleted Oil and Gas Reservoirs

In addition, Taiwan has identified 14 potential depleted oil and gas reservoir sites, including Tiezhenshan and Chuhuangkeng. Benefiting from decades of hydrocarbon exploration data, the geological characterisation of these sites is well-established, with cumulative storage potential estimated at approximately 2.8 billion tonnes.

The Tiezhenshan Carbon Storage Pilot Project led by Taiwan's national oil company CPC Corporation completed construction by the end of 2025

Engineering Case Study I: Tiezhenshan Carbon Storage Pilot Project

Led by CPC Corporation, Taiwan, the project aims to validate the feasibility of CCS technology using depleted natural gas reservoirs and deep saline aquifers in Miaoli. Beyond collecting operational injection data, a core objective is to establish localized environmental monitoring systems and administrative approval procedures.

Engineering Execution Strategy

The project adopted a "dual-track strategy" with the simultaneous development of surface facilities (compression and injection systems) and subsurface infrastructure (injection and monitoring wells). Despite tight schedule pressures, the project successfully achieved its mechanical completion milestone by the end of 2025.

Construction Challenges

In practice, the most significant challenge arose from the constrained site area of approximately one hectare. This placed severe limitations on the mobilization of large drilling rigs, heavy equipment maneuvering, and construction logistics, placing extreme demands on on-site management capabilities.

Current Project Status

3D seismic surveys and baseline environmental monitoring have been completed, and two monitoring wells have been successfully installed. Although the hardware construction is complete, the formal commencement of storage operations remains pending receipt of the final injection permit.

Engineering Case Study II: Carbon Capture Application in the Semiconductor Industry

TSMC established a demonstration facility at the Central Taiwan Science Park to conduct CO2 capture trials on flue gas emitted from spent solvent incineration processes.

Technology Selection

In consideration of the space and safety requirements of high-technology facilities, the project adopted membrane-based carbon capture technology. Compared to conventional amine-based systems, membrane technology offers modular design, a smaller footprint, and ease of operation, making it better suited for applications where capture volumes are modest and plant space is limited.

Accelerated Engineering Execution

To meet the extremely compressed project schedule of approximately one year, the project introduced innovative management practices, including the early release of critical design documents, the use of repeat equipment orders, and the integration of bulk material procurement and installation responsibilities into a single construction contract, ensuring efficient sequencing of the EPCC process.

Lessons Learned

With regard to change management, the project strictly limited acceptable changes to those arising from equipment additions or deletions, rejecting cost adjustments resulting from minor layout modifications. Furthermore, practical experience demonstrated that failure to clearly define installation responsibilities for bulk components during the procurement phase frequently generates unforeseen additional costs during the construction phase.

Current Project Status

TSMC's Taichung Zero Waste Manufacturing Center has successfully commercialised MTR's Polaris™ membrane technology, entering the phase of "scale-up validation and resource recovery."

By using modular units to separate CO2 from flue gas and converting it into industrial feedstock via cryogenic liquefaction, the project achieves an annual carbon reduction of 40,000 metric tons.

Following MTR's new financing in April 2026, TSMC is now standardising this model for its 2nm fabs and collaborating with the government to expand its application to public infrastructure.

Regulatory Framework Development

Taiwan is accelerating the development of dedicated legislation governing geological storage, with regulations covering exploration permit applications, environmental impact assessments, and long-term post-closure monitoring obligations. The regulatory framework emphasizes that operators must ensure transparency of pressure data in order to alleviate public concerns.

Barriers to Large-Scale Deployment

Despite encouraging progress in demonstration projects, commercialisation continues to face the following obstacles:

• First, cost remains a barrier, with current capture costs still as high as US$50–70 per tonne.

• Second, incentives are insufficient, as Taiwan currently lacks robust financial support mechanisms comparable to the U.S. 45Q tax credit.

• Third, infrastructure is inadequate, as a dedicated CO2 transportation pipeline network has yet to be planned and constructed.

Conclusion

Through the Tiezhenshan and semiconductor sector demonstration projects, Taiwan has taken a critical step forward in the practical deployment of CCUS. With a clearly defined policy trajectory in place, further strengthening of economic incentives and the regulatory framework could position Taiwan as a significant contributor to the energy transition across the Asia-Pacific region.

The demonstration facility established by Taiwan Semiconductor Manufacturing Company (TSMC) at the Central Taiwan Science Park is validating the feasibility of membrane-based carbon capture technology in semiconductor manufacturing

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More information

www.ctci.com

www.tsmc.com

https://mtrccs.com

Kairos@C project receives EU state aid approval for €260M

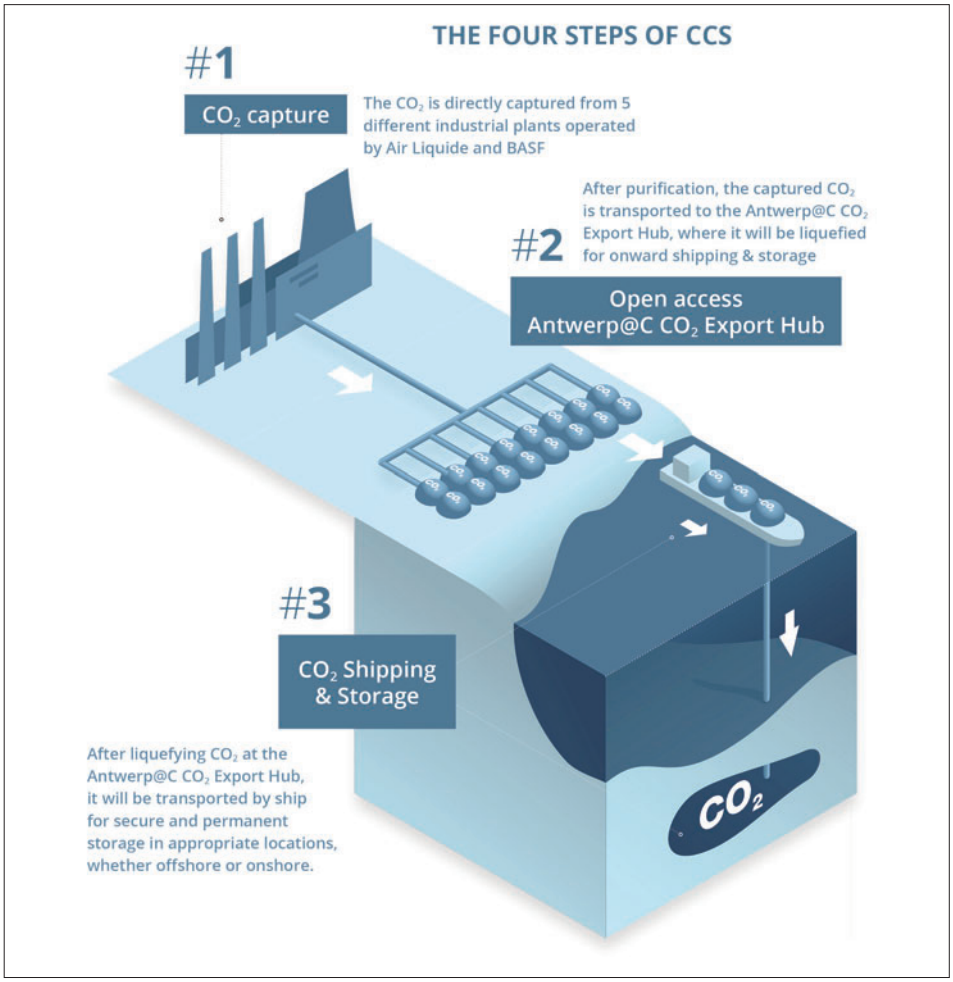
The joint CCS project by Air Liquide and BASF will capture CO2 from the companies' existing plants, located in Antwerp, that produce hydrogen, ammonia and ethylene oxide for underground storage in the North Sea.

The project aims to create an integrated, cross-border CCS value chain at industrial scale, which will result in around 20 million tonnes of net GHG emissions avoided, over 15 years, allowing the beneficiaries to produce low-carbon hydrogen and low-carbon ammonia.

The Kairos@C project is a graduate of the first large-scale Innovation Fund call of 2020 and was awarded a grant of over €365 million. However, due to, among others, exceptional inflation over the past years, the project costs have significantly increased and as a result it could not start without additional aid.

The Innovation Fund is an EU funding programme for the demonstration of innovative low-carbon technologies. During the first Innovation Fund call for large-scale projects, seven projects, including the Kairos@C project, were selected for funding, covering a wide range of sectors to decarbonise various parts of Europe's industry and energy sectors.

The measure will be financed through the budget of the Flemish region. The aid will take the form of a direct investment grant of €30 million per beneficiary, which will be complemented by an additional grant that will be paid out in ten annual instalments of €10 million per beneficiary, provided that minimum GHG emission reductions are achieved.



The Commission's assessment

The Commission assessed the Belgian measure under EU State aid rules, in particular Article 107(3)(c) of the Treaty on the Functioning of the EU ('TFEU'), which enables Member States to support the development of certain economic activities under certain conditions, and the 2022 Guidelines on State aid for climate, environmental protection and energy ('CEEAG').

In particular, the Commission found that:

• The measure facilitates the development of an economic activity. In particular the capture, collection and storage of CO2, as well as the decarbonisation of the production process of ammonia, ethylene oxide and hydrogen;

• The aid has an 'incentive effect', as the beneficiaries would not carry out the relevant investments without the public support;

• The aid is necessary and appropriate to promote environmental protection in the targeted economic activities. In addition, it is proportionate, as it is limited to the minimum necessary and does not lead to overcompensation;

• The measure has sufficient safeguards to ensure that undue distortions of competition are limited. The aid does not alter the production capacity of the beneficiaries, and if the project generates extra net revenues, the beneficiaries will return to Belgium part of the aid received. The beneficiaries will also disseminate the technical know-how gained through the project;

• The aid will bring about positive effects that outweigh any potential distortion of competition and trade in the EU.

More information

https://kairosatc.eu

https://cinea.ec.europa.eu

KEPCO: operating the world's largest gas chemical looping combustion plant

By achieving stable, long-term continuous operation of the 3 MW_{th} CLC steam generation system for over 300 hours and demonstrating the world's first simultaneous production of high-pressure steam and liquefied CO2 in an integrated system, KEPCO and KIER have substantially advanced the technology toward commercialisation. By Jeom-In Baek, Myounghoon Choun.

To reduce carbon emissions in the energy industry, such as power generation or heat supply, replacing coal with natural gas (NG) or renewable energy is globally underway. According to the International Energy Agency's World Energy Outlook 2025, energy supply in the electricity and heat sectors by 2050 is predicted to see a 27.4% decrease in coal and a 26.6% increase in natural gas compared to 2024. Consequently, there is a growing demand for technologies that can economically reduce carbon emissions from NG combustion facilities.

Technologies for reducing CO2 emissions in natural gas combustion facilities such as Natural Gas Combined Cycle (NGCC) plants and NG boilers include post-combustion CO2 capture, oxy-fuel combustion, and chemical looping combustion (CLC). In CLC, NG is combusted in a fuel reactor using pure oxygen provided by solid particles called oxygen carriers (OC), which are primarily composed of metal oxides.

Since the flue gases from fuel combustion contain only CO2 and water vapor, CLC does not require separate, energy-intensive capture facilities like post-combustion capture systems. The oxygen-depleted solid particles are regenerated by contacting air in an air reactor to regain oxygen and are then recirculated to the fuel reactor for reuse.

Furthermore, unlike oxy-fuel combustion, CLC eliminates the need for expensive air separation units (ASU) to separate pure oxygen from the air.

Therefore, CLC is evaluated as a highly economical and energy-efficient technology for power and heat production when CO2 capture is considered. However, there exist significant hurdles to the scale-up and commercialisation of this technology.

Sufficient physical and chemical performance of the oxygen carrier and development of a circulating fluidized bed (CFB) CLC system capable of stable, long-term operation while maintaining high fuel conversion efficiency near complete combustion should be ensured first.

KEPCO and collaborating institute have constructed a 3 MW_{th} CLC plant, the world's largest for gas-fueled CLC, and successfully completed long-term operation to verify NG combustion performance using KEPCO's proprietary oxygen carriers.

Furthermore, it has demonstrated the world's first steam and liquefied CO2 production using a CLC system, proving its potential for commercialisation as a low-carbon energy supply facility.

This article summarises KEPCO's CLC technology development process and achievements and suggests future directions.

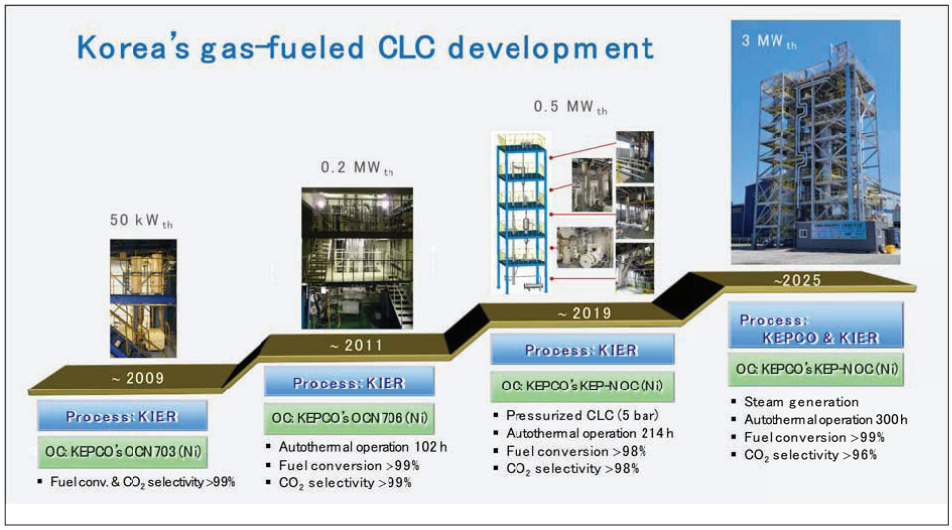


Figure 1 – Korea's NG-CLC technology development path

KEPCO's CLC Technology Development: From 50 kW_{th} to 3 MW_{th}

The KEPCO Research Institute (KEPRI) has led CLC technology development in Korea in collaboration with the Korea Institute of Energy Research (KIER). KEPRI focused on oxygen carrier composition development and mass production technology, while KIER managed the development of the CFB CLC system.

Through the stepwise development of atmospheric 50 kW_{th}, atmospheric 0.2 MW_{th}, and pressurized 0.5 MW_{th} NG-CLC systems, KEPCO and KIER secured high-durability oxygen carriers suitable for NG combustion and process technologies for scaling up to 3 MW_{th}.

KEPCO adopted spray drying technology for the mass production of synthetic oxygen car-

riers with a spherical shape and particle size suitable for fluidized-bed processes. By using nickel oxide (NiO) as the metal oxide and developing an optimised support composition, KEPCO developed particles with high mechanical strength and high oxygen transfer capacity of 12 wt%.

In continuous operations exceeding 100 hours at the 50 kW_{th}, 0.2 MW_{th}, and 0.5 MW_{th} plants designed based on these particles, KEPCO achieved excellent results: both fuel conversion (the conversion of NG to CO2, CO, and H2O) and CO2 selectivity (the conversion of NG to CO2 on a dry gas basis) exceeded 98%.

Building on these achievements, KEPCO launched the development of a 3 MW_{th} NG-CLC system to verify commercial viability of CLC technology. It aimed to demonstrate the world's first steam production by recovering heat generated from the redox cycles of the oxygen carrier. KEPRI's CFB boiler research team joined the project to perform heat recovery system design and thermal analysis of the entire process integrated with the CLC facility.

The 3 MW_{th} NG-CLC steam generation plant, the world's largest gas-fueled CLC facility, was constructed in Ulsan, Korea, in 2023. The plant consists of a CFB CLC reactor system for redox reaction of oxygen carrier, a boiler system for steam production, and a CO2 treatment system that compresses the flue gases to produce liquefied CO2.

Excluding the CO2 treatment system, the plant dimensions are 28 m in width, 20 m in depth, and 30 m in height. The CO2 compression and liquefaction plant was built to process a portion of the flue gases, capable of producing up to 7 tons of liquefied CO2 per day. The predicted steam production from the 3 MW_{th} thermal input, considering heat losses, was 2.53 MW_{th} (3,000 kg/h, 35.8 barg, and 323°C).

Calculation on oxygen carrier inventory showed that approximately 10 tons of oxygen carriers were necessary for 3 MW_{th} plant operation. A total of 14 tons were produced using commercial spray drying facilities. Despite significant losses of supplied oxygen carriers during the commissioning test to identify and repair construction defects, plant operation remained possible.

In the continuous operation test, natural gas was supplied at approximately 255 Nm^3/h, equivalent to a thermal input of 3.09 MW_{th}. Throughout more than 300 hours of steady-state continuous operation, the average temperatures of the air reactor and the fuel reactor were maintained at 1045°C and 945°C, respectively, with stable solid circulation.

Fuel conversion and CO2 selectivity reached 99.5% and 96.6%, respectively, and NOx emissions were approximately 17 ppmv. Steam generation performance recorded 2.46 MWth (2,677 kg/h, 35.0 barg, and 440°C), reaching 97% of the design capacity.

Figure 2 – 3 MW_{th} NG-CLC steam generation plant

In integrated operation with the CO2 treatment system, 5.4 tons of 100% pure liquefied CO2 were produced daily, demonstrating the world's first simultaneous steam and liquefied CO2 production via a CLC system.

KEPRI has also completed the development of eco-friendly, low-cost manganese-based oxygen carriers with commercial-grade performance to replace nickel-based oxygen carriers and is preparing for the next phase of technology development.

Conclusions

Due to its inherent advantages, research on application of CLC technology to various fields, such as chemical looping reforming, is actively ongoing. However, most of these studies remain at the proof-of-concept stage and are far from commercial viability.

By achieving stable, long-term continuous operation of the 3 MW_{th} CLC steam generation system for over 300 hours and demonstrating the world's first simultaneous production of high-pressure steam and liquefied CO2 in an integrated system, KEPCO and KIER has substantially advanced the technology toward commercialisation.

It is expected that carbon emission reductions can be economically achievable in the energy industry by applying the technology secured through the research on the 3 MW_{th} NG-CLC steam generation system to various fields, including NG-boilers, combined heat and power (CHP), bioenergy carbon capture and storage (BECCS), high-efficiency power generation integrated with supercritical CO2 (sCO2) power cycles, and the provision of thermal energy required for the operation of post-combustion capture plants.

More information

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CCUS Hub Study identifies five Asia-Pacific sites and welcomes new partners

The CCUS Hub Study is investigating the technical and commercial feasibility of common infrastructure in the Asia-Pacific region as an emissions reduction option for hard-to-abate industries (primarily steelmaking).

An industry Consortium developing a first-of-its-kind CCUS Hub Study for Asia has identified five hubs as potential storage options after assessing over 3,000 site locations.

Yonghee Kim, Vice President, Process R&D Sub-Division, Hyundai Steel Company, said, "As we conclude Phase 1 of the project, we have not only identified five highly promising CCUS hubs, but also laid a strong foundation for large-scale CO2 reduction through close collaboration among the Consortium members."

"The participation of new Consortium members is expected to further enrich perspectives and strengthen cross-industry cooperation."

"Hyundai Steel remains committed to leading the development of CCUS and other low-carbon technologies, contributing to enhanced sustainability across the industry."

The Study focuses on the capture, transport, and long-term storage of carbon dioxide emissions from hard-to-abate sectors, including steel, cement and chemicals.

The Consortium, comprised of leading steelmakers ArcelorMittal Nippon Steel India, JSW Steel, Hyundai Steel Company, and other value chain players, BHP, Chevron, and Mitsui & Co., Ltd., commits to strong industry collaboration in advancing CCUS pathways. It welcomes three new partners, which will deepen the Study's input across the value chain and expand the scale of the opportunity geographically:

• "K" LINE joins as the strategic expert in shipping technology for carbon dioxide.

• Kobe Steel LTD. brings deep technical steelmaking experience and abatement commitments.

• LETA provides industry-leading expertise on global lower-emissions technologies.

The industry Consortium commenced a prefeasibility study in August 2025 to evaluate the development opportunity of CCUS hubs across Asia.

Dr Ben Ellis, Vice President Marketing Sustainability, BHP, said, "BHP is committed to supporting our steelmaking customers to decarbonise as demand for high quality steel continues to grow to expand energy networks, build infrastructure and support a growing population."

"With more than 1 billion tonnes of production a year in Asia coming from blast furnace capacity that is relatively early in its production life, it's important for industry to progress technologies to lower the emissions intensity of existing steelmaking assets while new commercial pathways to decarbonise steelmaking are developed over time."

"Innovative solutions-like the potential of CCUS-are an essential part of decarbonising hard-to-abate sectors such as steelmaking. This study will play an important role in leveraging shared knowledge and resources across the industry with many of the world's leading steelmakers mentioning carbon capture, utilisation and storage (CCUS) in their decarbonisation plans."

Through a high-level options study, Phase 1 of the project assessed more than 3,000 potential storage sites across the Asia-Pacific. This process narrowed the field to five hubs located in India (two hubs), Indonesia, Malaysia, and Australia - each selected for their potential performance across the full CCUS value chain, including capture, aggregation, transport, export to storage, utilisation approaches including technology and commercial readiness and market evaluation, and the policy and commercial conditions needed for deployment.

The five hubs were chosen on the basis of them providing a diverse set of characteristics, helping the Study examine important trade-offs, shape the CCUS development pathway, and pinpoint the practical steps required for feasibility. The selected hubs represent regional and international locations and include both onshore and offshore storage.

The findings to date demonstrate that regardless of which hub is selected, strong policy support, targeted incentives, and clear regulatory frameworks are critical to making CCUS commercially viable.

Phase 2 of the Study will undertake detailed engineering and commercial analysis of the five shortlisted hubs. This includes maturing engineering definition and developing potential implementation roadmaps to address key opportunities and challenges. The work will culminate in conceptual development plans outlining the business case, value chain design, CO2 forecasts, and potential pathways to abatement realisation for each hub.

By uging shared infrastructure and economies of scale, the Study seeks potential applications for captured CO2 in industrial processes, or transport captured CO2 via pipeline or shipping to storage sites.

The purpose of the Study is to deliver tailored analysis that supports industry understanding of CCUS. The Study also aims to increase public understanding of CCUS in Asia.

The CCUS Hub Study is being delivered by Hatch as Project Management Officer in collaboration with Pace CCS, McDaniel, and Global CCS Institute.

The Consortium continues to welcome new partners and emphasised that CCUS remains a critical pathway for industries wanting to achieve net zero emissions.

More information

www.bhp.com

Delivering (a) DREAM - Italy's first full-scale cement decarbonisation project

After the signature of the European Union Innovation Fund Grant Agreement in March, the Heidelberg Materials project at the Rezzato–Mazzano cement plant in Brescia is now entering the next phase of its development.

The kick-off meeting of the DREAM (Decarbonisation of the Rezzato and Mazzano cement plant) project took place on Monday, 13 April, following the official start of its implementation under the European Union's Innovation Fund as of 1 April 2026.

During the meeting, the project was presented with a focus on the CO2 capture technology planned for the Rezzato–Mazzano cement plant and on its role within the CCS value chain. The captured CO2 may be transported and permanently stored in depleted gas fields offshore the coast of Ravenna, which are currently under development.

The work plan, key project phases, timeline, milestones, deliverables, and the financial framework were also outlined, in line with the provisions of the Grant Agreement signed between Heidelberg Materials Italia Cementi S.p.A. and CINEA in March. The Grant Agreement regulates the funding awarded by the European Commission under the Innovation Fund. CINEA further presented the management, monitoring, and communication requirements applicable to projects supported by the Innovation Fund.

The kick-off meeting represented a key moment of discussion and alignment between the Company and CINEA, confirming the reference framework of the DREAM project and establishing the foundations for its development in compliance with the requirements of the lump-sum funding scheme.

With the signature of the Grant Agreement, the funded project officially "came to life" and entered its procedural implementation phase, aimed at achieving the technical and economic objectives approved by CINEA to benefit from EU funding.

A key milestone will be the parent company's final investment decision; its crucial enabling factors include a clear and complete definition of the CCS regulatory and legislative framework in Italy, the related national incentive scheme, as well as the development of transport and storage infrastructures, which are essential for the implementation of the DREAM project based on CO2 emissions capture.

As of 1st April, the DREAM project has officially started, with the ambitious objective of becoming Italy's first successful large-scale business model for CCS in the cement sector

DREAM represents Italy's first industrial-scale CCS project in the cement sector, aiming to implement a highly innovative, tailor-made CO2 capture solution for the decarbonisation of both production lines at the Rezzato Mazzano cement plant, located in the Province of Brescia.

For CO2 capture, the project envisages two distinct technologies, one for each of the two clinker production lines—the intermediate product at the core of cement manufacturing. The grey clinker kiln line will be converted to oxy-fuel combustion technology, enabling the production of process exhaust gases with a higher CO2 concentration; capture will then be completed through a cryogenic separation process.

For the white clinker production line, a post-combustion capture solution based on chemical absorption solvent-based has been designed. Through a waste heat recovery system integrating and interconnecting the two production lines, the thermal energy required for solvent regeneration will be largely met. In addition, the off-gas from the cryogenic unit will be routed to the white clinker kiln line, where it will be further processed.

The overall benefit will be not only the maximisation of energy efficiency, but also an increase in the CO2 capture rate. The captured CO2 will be destined for permanent storage. In line with the development of the relevant regulatory framework, it may be transported and stored in depleted gas fields offshore on the coast of Ravenna, which are currently under development.

More information

www.heidelbergmaterials.com

Bergen's largest climate measures are halted by lack of government framework

After an overall assessment, Norway's BIR has terminated the active investment in establishing carbon capture at the incineration plant in Rådalen.

"It is not a lack of will, expertise or technological maturity that lies behind it," said CEO Borghild Lekve. On the contrary, the work that has been done shows that carbon capture in Rådalen is technically possible, and that BIR's project has been developed over several years in collaboration with Eviny Termo and with support from Enova.

What is stopping the project now are external framework conditions: lack of and unpredictable support schemes, ambiguity about future taxes, lack of clarifications for transport and storage of CO2 and a financial risk picture that is too large for BIR to proceed alone.

"We find that the most important climate measure in Bergen is being stopped, not because the technology is lacking, but because the framework conditions are not in place. This is deeply regrettable," said Renate Friele Hjortland, Chairman of the Board of Directors of BIR.

A crucial climate measure

BIR's incineration plant in Rådalen has an important social function. The plant handles residual waste that cannot be recycled and supplies energy equivalent to almost 10 percent of the energy supply in Bergen. At the same time, the plant is the city's largest point emitter of CO2.

Carbon capture has therefore been considered to be the single most important measure to reduce emissions significantly, with a capture of about 100,000–130,000 tonnes of CO2 annually. About half of this is biogenic CO2, which provides the basis for negative emissions. Over the plant's lifetime, this could result in a total climate effect of several million tonnes of CO2.

The incineration plant in Rådalen is also a key part of Bergen's local emergency preparedness.

"The plant ensures safe handling of waste and at the same time produces electricity and district heating that keeps buildings and homes warm – even in crisis situations. Local energy production that is not dependent on imports is important for security of supply," said Borghild Lekve, CEO of BIR.

The authorities ask for climate cuts – but do not deliver the instruments

BIR's incineration plant in Rådalen. Photo: BIR

BIR started the work in a period where political signals gave the expectation that carbon capture from waste incineration would be followed up with concrete measures.

The project has been developed step by step through studies, technology assessments and pre-engineering, and is now ripe for the next phase. Nevertheless, the necessary support schemes have not been forthcoming.

A carbon capture plant in Rådalen is estimated to cost about NOK 1.6 billion, and requires support for both investment and operation in order to be realised.

"When the authorities ask for climate cuts, but do not establish the instruments that make the cuts possible, the bill and the risk are shifted to local companies and the citizens. That is not sustainable," said Lekve.

Ready to start again when the framework conditions are in place

BIR emphasised that the decision does not mean that carbon capture in Rådalen has been shelved forever. The company will maintain its expertise, participate in relevant projects, follow technology and market developments closely and work for better framework conditions.

"We are not giving up on the goal. But we cannot defend investments in the billions without predictable framework conditions. We are ready to take the next step quickly if the state comes on board with solutions that reduce the risk," said Hjortland and Lekve.

A warning to national authorities

BIR believes that the case raises a bigger question than the future of a single project in Bergen. If Norway is serious about its climate goals, it must be possible to realise carbon capture outside the largest state-supported projects as well.

When a mature project at one of the country's most important waste and energy facilities has to be stopped, it should be a clear signal to the national authorities that the framework conditions are not good enough.

BIR said it will continue maintaining expertise in carbon capture, try to influence for better framework conditions and be ready to resume work when the conditions are right.

More information

https://bir.no

Projects and policy news

EU Commission unlocks €2.7 billion for 54 clean industry projects

https://climate.ec.europa.eu

The Innovation Fund is supporting the deployment of net-zero technologies across Europe with revenues from the EU Emissions Trading System through 54 projects.

Companies selected under the Innovation Fund 2024 Call for Net-Zero Technologies have signed their grant agreements, marking a crucial step in scaling up their technologies. Six additional projects from the reserve list have also been invited to start their grant agreement preparation.

A total of 54 projects will receive €2.7 billion of funding, with individual project support ranging from €1.8 million to €216 million.

The selected projects span 17 countries and 17 different industrial sectors, reflecting the diverse pipeline of innovative technologies that are ready to scale. They support a wide range of solutions, including refineries, cement and lime, manufacturing, and renewable energy such as solar or wind, as well as maritime, aviation and road transport (net-zero mobility). Once operational, the projects are set to avoid around 210 million tonnes of CO2 emissions during the first ten years.

The European Climate, Infrastructure and Environment Executive Agency (CINEA) will guide the 54 newly signed projects throughout the development phase, ensuring compliance with Innovation Fund requirements and supporting smooth progress towards financial close and construction.

Closing the risk gap: How insurance innovation can accelerate CCS deployment

https://energex.partners/energex-ccs/insights

The first in a series of joint papers between Energex CCS and Howden explores why insurance will play a vital role in enabling CCS, and why new, innovative solutions are needed now.

The rapid deployment of CCS infrastructure is essential for achieving global decarbonisation goals. However, the CCS value chain including emitters, transportation, and storage presents a unique set of technical, commercial, and regulatory risks. These risks are amplified by the complexity of ownership structures, cross-border operations, and the nascent nature of the industry at the required scale.

Historically, some governments, such as the UK, have played a pivotal role in absorbing the most challenging risks to jump-start CCS projects. As the sector matures, this approach is unsustainable, and there is a pressing need for innovative risk management strategies and insurance solutions to unlock private capital and ensure project viability.

The paper examines risk allocation across the CCS value chain from the perspectives of emitters and storage providers. It explores the spectrum of risk management approaches – treat, take and transfer – and highlights the limitations of traditional insurance products in addressing the unique challenges of CCS.

The emergence of new insurance solutions, such as technology performance guarantees and cross-chain liability cover, is discussed as a catalyst for industry growth. The analysis underscores that most CCS projects will require a hybrid approach to risk management – one that combines robust commercial negotiations with tailored insurance products.

The paper also identifies critical gaps in current insurance market capacity, particularly for carbon leakage and consequential loss, and calls for further innovation to support the sector's expansion.

Schrödinger's carbon: The hidden uncertainty in every net-zero plan

https://people.utwente.nl/r.arendt

Billions of tons of carbon dioxide are being classified as 'dealt with' in global climate plans before anyone can know whether that is true. UT Researcher Rosalie Arendt has given a name to this problem in a new Nature Correspondence: Schrödinger's carbon.

Carbon capture and storage is a key tool in climate mitigation pathways targeting 1.5°C, particularly for sectors where emissions are hardest to eliminate and for technical carbon dioxide removal from the atmosphere. Yet, carbon capture and storage does not prevent carbon dioxide production. Instead, it functions as a waste management technology, capturing carbon dioxide, transporting it and storing it underground. Despite this, climate models used by governments typically count this carbon dioxide as permanently neutralised.

Rosalie Arendt introduces the term Schrödinger's carbon to describe the uncertainty embedded in this assumption. The concept refers to carbon dioxide that is expected to be captured and stored, but whose long-term fate remains unknowable today. "The name matters," Arendt explains. "Science policy moves when ideas become nameable. 'Net zero' gave policymakers a target. 'Schrödinger's carbon' is an attempt to make a hidden uncertainty visible."

The idea builds on Arendt's previous research on residual emissions and the need to distinguish clearly between emission reductions and removals. The term emerged during her work on cement decarbonisation, where nearly half of projected emission reductions rely on carbon capture and storage. In such cases, today's emissions are effectively reclassified as neutral based on the assumption that carbon capture and storage will prevent them from entering the atmosphere.

Unlike other mitigation measures, carbon capture and storage generates no valuable output. As a waste management technology, it is inherently harder to incentivise and sustain at the scale envisioned than other mitigation measures. Therefore, delivering carbon capture and storage at scale would require decades of uninterrupted political and financial commitment: an assumption that past experience calls into question, with 88% of projects (1972–2018) cancelled or underperforming.

Nearly all major net-zero pathways rely on carbon capture and storage scaling more than a hundredfold by mid-century, but treating this expansion and storage integrity as guaranteed, Arendt argues, risks weakening the urgency to reduce CO2 production. She is not calling for carbon capture and storage to be abandoned; rather, it should be reserved for carbon dioxide production that is truly unavoidable despite strong efforts to reduce demand and production.

Rosalie Arendt's correspondence, 'Schrödinger's carbon: The misclassification of carbon capture and storage as standard mitigation', has been published in the scientific journal Nature.

CO2 utilisation for Lithium Ion Batteries

CO2 has a critical role to play in lithium battery production and recycling and with large-scale long-duration energy storage becoming more prevalent to balance electricity supply, Stephen B. Harrison, sbh4 consulting looks at the investment case.

Electricity demand is on the rise, driven by electrification of industrial processes, data centre build outs and increasing demand from domestic users in developing countries.

To meet the demand, new generation capacity is being added worldwide. However, in many grids, growth of non-programmable renewable generation is outpacing flexible and firm electricity sources. Long-duration energy storage (LDES) is therefore essential to balance the supply and demand of electricity.

Huge utility-scale long-duration energy storage (LDES) facilities using lithium ion batteries are being implemented in many countries

LIBs are the core technology for LDES

For daily balancing with a discharge period of up to 4 hours, lithium ion batteries (LIBs) are unquestionably state of the art. LIBs are the technology of choice for battery electric vehicles (BEVs) and handheld devices such as mobile phones and tablet computers.

Huge utility-scale LDES facilities are being implemented in many countries. They are typically able to supply 100 to 500 MW of power and store up to 2,000 MWh of energy.

For grid balancing, as is the major application in Europe, the discharge period of an LIB LDES scheme is generally optimised at 4 hours. For solar power time shifting in locations such as California, they must work overnight and typically discharge over an 8 to 12 hour period.

CO2 for LIB production and recycling

LIBs are complex electrochemical devices. Throughout their production and re-processing, CO2 has a central role to play.

During charging and discharging electrons flow from the LIB anode and cathode, and vice versa, through an electrolyte which is supported in a carbonate solvent. That solvent is produced utilising carbon dioxide (CO2).

At the end of life, valuable industrial metals such as lithium, cobalt, nickel and manganese are recovered during LIB recycling using hydrometallurgical processes which also utilise CO2.

Carbonate electrolyte solvent production

The electrolyte is supported in a hydrocarbon solvent such as dimethyl carbonate (DMC) or ethylene carbonate (EC).

EC is produced by reacting ethylene oxide with CO2. For every Tonne of EC, 500 kg of CO2 are required. The CO2 purity must be very high to avoid contamination of the EC. For example, the CO2 must contain less than 20ppm of moisture.

DMC has traditionally been produced from the poisonous gas phosgene. The modern process for DMC production avoids phosgene and is therefore much safer. It reacts CO2 with MC and thereby also enables synergy within an integrated ethylene derivatives chemicals complex.

CO2 utilisation for battery electrolyte solvents

In March of 2024, Dow1 announced their intent to invest in a new ethylene derivatives plant on the U.S. Gulf Coast. This will produce carbonate solvents which are used to support the electrolyte in LIBs and will support growth in BEV and LDES markets.

As part of Dow's Decarbonize & Grow strategy, the ethylene derivatives facility will capture more than 90% of the CO2 from Dow's existing ethylene oxide manufacturing process. This CO2 will be utilised to produce the carbonate solvents.

CO2 must be captured during ethylene oxide production to enable process operation, making this one of the lowest cost sources of CO2. Utilisation of the CO2 prevents its direct emission to the atmosphere.

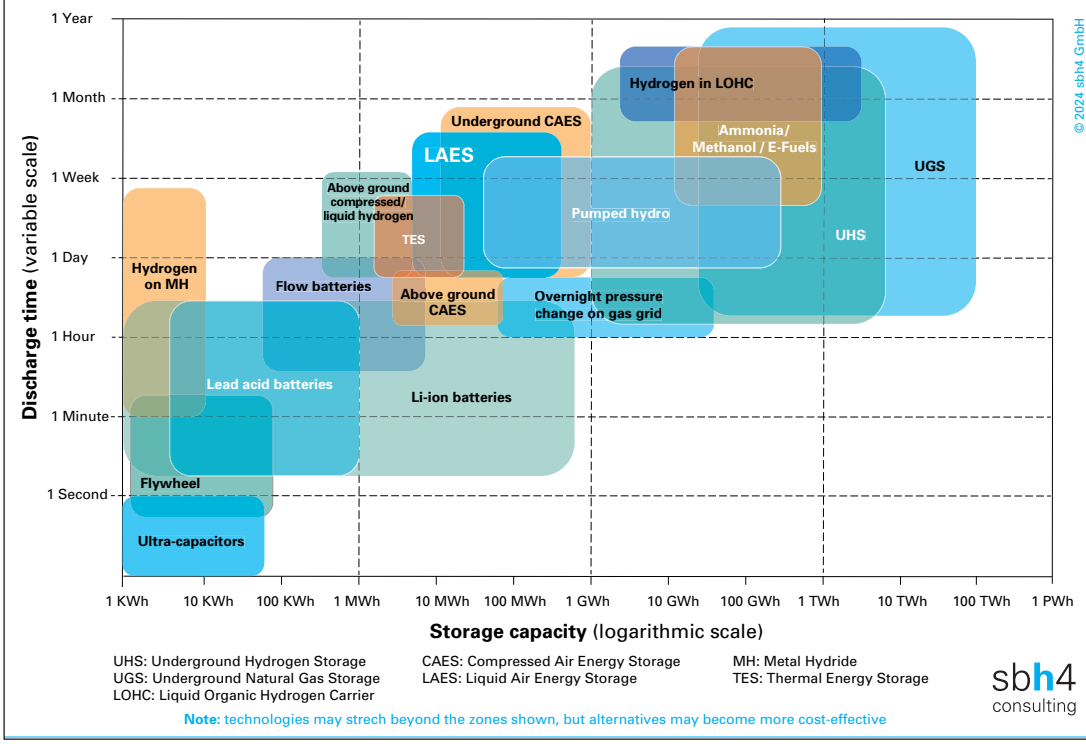
LIB technologies

There are many types of LIBs, each with different active materials in the LIB anode.

The highest energy density is achieved with Nickel, Manganese, Cobalt (NMC) LIBs. These are favoured in premium automotive applications and are displacing Lithium Cobalt Oxide (LCO) LIBs in premium mobile phones to extend their battery life.

Lithium Iron Phosphate (LFP) LIBs are known for their low cost and are regarded as being safer than NMC LIBs. They are heavier than NMC batteries, but for static power storage applications this weight penalty is of no consequence.

Renewable power and energy storage technologies, their capacity and discharge time



UHS: Underground Hydrogen Storage
UGS: Underground Natural Gas Storage
LOHC: Liquid Organic Hydrogen Carrier

CAES: Compressed Air Energy Storage
LAES: Liquid Air Energy Storage

MH: Metal Hydride
TES: Thermal Energy Storage

sbh4 consulting

Note: technologies may strech beyond the zones shown, but alternatives may become more cost-effective

Regulatory drivers and strategic materials

NMC and LCO LIBs contain large amounts of cobalt, manganese and nickel. In the EU cobalt and manganese are both recognised as both strategic and critical materials. Nickel is regarded as strategic. Recovery of these metals during LIB recycling is therefore of paramount importance.

Reflecting these points, the EU Battery Regulation (2023/1542) is now in force. It is a very stringent framework for battery life-cycle management.

In 2026, at least 65% of the total mass of an LIB must be recycled. That requirement rises to 70% in 2030. Zooming into cobalt and nickel, the reprocessing recovery at the end of 2027 must be at least 90%. By the end of 2031, that increases to 95%.

To extract nickel and cobalt, it is necessary to separate them from lithium in the LIB.

CO2 utilisation for Lithium circularity

EU Battery Regulation currently requires 50% of the lithium to be recovered. This is aligned to smelting or pyrometallurgical recovery of LIB materials. However, this jumps to 80% for 2032 and beyond. This increase will force the industry to implement chemical-based hydrometallurgical recycling which is more efficient at recovering lithium from LIBs.

The initial stages of LIB recycling are brutally mechanical. The batteries are crushed to release the electrolyte and its solvent. Copper and aluminium foils are shredded and separated using air blowers. The resulting powder, called black mass, is a mixture of anode and cathode materials. It is rich in metal oxides, lithium and graphite.

Hydrometallurgical recycling mixes the black mass with water. Then, CO2 gas is sparged into the liquor. The dissolved CO2 converts lithium ions to soluble lithium hydrogen carbonate, which can then be precipitated and captured using filtration.

Dynamic market

As with any emerging technology, in the field of LDES and batteries, there is rapid innovation which leads to product substitution and obsolescence.

NMC batteries are being challenged by LFP. The economics and process for LFP battery recycling are very different to NMC LIBs. If NMC batteries are no longer used, the CO2 demand for hydrometallurgy will decline.

For stationary LDES, vanadium redox flow batteries and iron-air batteries are challenging the dominance of LIBs. In EV mobility, solid state lithium ion and sodium ion batteries are potentially safer and more economical options.

If these newer technologies dominate, the need for CO2 to produce EC and DMC electrolyte solvents for LIBs may peak 15 to 20 years from now, plateau and then progressively decline.

Place your bets now

In the short- to mid-term, investing in CO2 supply for LIB electrolyte solvent production and hydrometallurgy, would seem to be an extremely good bet to leverage a rapidly growing LDES market for stationary and mobile applications.

On the other hand, as innovation races ahead and substitute LDES and battery technologies establish themselves as challengers to LIBs, it will be essential to manage investments towards the peak of demand to avoid over-capacity in a declining market.

More information

https://sbh4.de

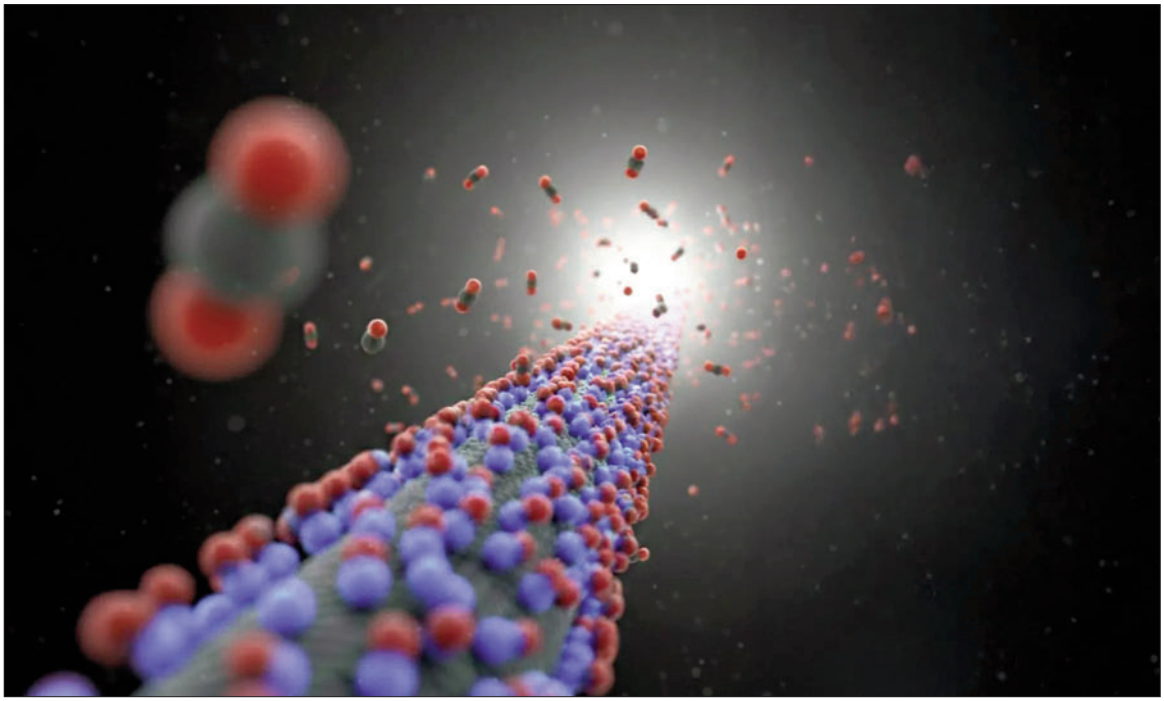
Viciazites: efficient low temperature carbon capture designer materials

Researchers from Japan developed three kinds of 'viciazites', a new type of carbon-based material with precisely positioned nitrogen-containing functional groups, that can release captured CO2 at temperatures as low as 60 °C, paving the way for efficient carbon capture.

Solid materials for carbon capture can help reduce greenhouse gas emissions, but many existing systems remain energy-intensive and costly, because releasing captured carbon dioxide typically requires high temperatures.

A study from Chiba University in Japan shows how precisely controlling nitrogen-containing functional groups in carbon-based materials can enable low-temperature operation (≤ 60 °C).

Even though carbon capture technologies have existed for decades, their widespread adoption has been slow for a straightforward reason: most of them are expensive and inefficient.



This image created using Gemini Pro, depicts an activated carbon fiber functionalized with amine groups (–NH2) at adjacent positions. This arrangement improves the energy efficacy of key interactions, enabling the desorption of captured carbon dioxide at lower temperatures. Image © Associate Professor Yasuhiro Yamada from Chiba University, Japan

For example, aqueous amine scrubbing, which is the most common industrial method, requires heating large volumes of liquid above 100 °C to release captured CO2 and reset the system for reuse. These energy demands translate directly into operating costs, making large-scale deployment challenging.

Carbon-based solid adsorbents have emerged as a promising alternative. These solid, inexpensive materials with large surface area can bind CO2 and then release it with less heat under low temperature, especially when featuring nitrogen-containing functional groups.

Unfortunately, while the performance benefits of these functional groups are apparent, standard synthesis methods can only deposit them randomly and in mixed configurations, making it difficult to know which specific arrangement actually drives efficient performance and why.

Against this backdrop, a research team led by Associate Professor Yasuhiro Yamada from the Graduate School of Engineering and Associate Professor Tomonori Ohba from the Graduate School of Science at Chiba University, Japan, tackled this problem. Their work reports the synthesis and thorough characterization of a new class of carbon materials called 'viciazites,' which contain a carefully controlled configuration of nitrogen groups in adjacent positions.

The paper, published online in the journal Carbon on February 27, 2026, was co-authored by Mr. Kota Kondo, also from Chiba University.

The team synthesized three distinct viciazites, each carrying a different type of adjacent nitrogen pairing. To introduce adjacent primary amine groups (–NH2 groups), they carbonized a compound called coronene at high temperature, then treated the material with bromine and finally with ammonia gas. This three-step process produced adjacent –NH2 groups with 76% selectivity, meaning that the vast majority of introduced nitrogen ended up in the target configuration.

The other two materials were made using different precursors: one carrying adjacent pyrrolic nitrogen was synthesized at 82% selectivity, and the other with adjacent pyridinic

nitrogen was synthesized at 60% selectivity. All three materials were coated onto activated carbon fibers to create practical adsorbent samples.

The researchers used several techniques, including nuclear magnetic resonance spectroscopy, X-ray photoelectron spectroscopy, and computational modeling to confirm that the introduced nitrogen groups were indeed positioned next to each other in an adjacent manner and not scattered randomly. Performance tests showed clear differences between the three configurations.

The materials with adjacent –NH2 groups and adjacent pyrrolic nitrogen both outperformed untreated carbon fibers in CO2 uptake, while adjacent pyridinic nitrogen groups showed little benefit. The most striking result was observed with desorption, which is the process of releasing the captured CO2 to regenerate the material.

"Performance evaluation revealed that in carbon materials where NH2 groups are introduced adjacently, most of the adsorbed CO2 desorbs at temperatures below 60 °C. By combining this property with industrial waste heat, it may be possible to achieve efficient CO2 capture processes with substantially reduced operating costs," said Dr. Yamada.

Additionally, the pyrrolic nitrogen-containing material, though releasing CO2 at a higher temperature, may prove more durable in the long run owing to the superior chemical stability of that functional group. Overall, by showing that adjacent nitrogen configurations can be built deliberately and reproducibly, this study establishes a promising design framework for the next generation of carbon capture materials.

"Our motivation is to contribute to the future society and to utilize our recently developed carbon materials with controlled structures. This work provides validated pathways to synthesize designer nitrogen-doped carbon materials, offering the molecular-level control essential for developing next-generation, cost-effective, and advanced CO2 capture technologies," concluded Dr. Yamada.

The researchers also note that viciazite materials may find uses beyond CO2 capture, such as adsorbents for metal ions and catalysts, given the precise and tunable nature of their surface chemistry.

More information

www.chiba-u.ac.jp/e/index.htm

Cool Planet proceeds with construction phase of Holcim cement CCS facility

Assembly of its 10,000-tonnes-per-annum carbon capture plant at Holcim's Höver cement facility in Germany is now underway, with all major equipment successfully delivered to site.

Cool Planet's construction team is currently installing and connecting the prefabricated modules, which is expected to be completed in April. Capture operations are scheduled to begin in mid- 2026 which will be followed by a 12-month demonstration programme.

The Company's modular membrane-based carbon capture technology enabled the plant to be prefabricated offsite and transported to Höver for final assembly. The process modules were fabricated and assembled by Blackrow Engineering in the UK and will be integrated with other equipment manufactured in the UK, Germany, Netherlands, Belgium and Italy. Blackrow's site team are assisting Cool Planet with the assembly of the plant.

Andrew Corner, CEO of Cool Planet, commented, "We are excited to be in the final stages of the building of our plant at Höver and we look forward to seeing this ground-breaking plant operational in the coming months. This will mark a major milestone in the industrial deployment of our technology and positions Cool Planet at the forefront of lower cost, scalable industrial carbon capture solutions."

The company said its chemical-free process uses significantly less energy than established carbon capture technologies and can be powered entirely from renewable electrical power making it an environmentally friendly technology choice.

The technology is compact, scalable, modular, and operationally flexible making it ideal for both retrofit and new-build applications.

One of the prefabricated modules being installed

Cool Planet has the exclusive rights to commercialise the membrane technology, which was developed by Helmholtz Zentrum Hereon, part of Germany's largest research organisation. It will operate the technology industrially at a scale of 10,000 tonnes of captured carbon dioxide per annum in 2026 as part of the project with Holcim to upscale the technology for the decarbonisation of their Höver plant.

More information

https://coolplanettech.com

Converting CO2 to methanol at high efficiency

Researchers from ETH Zurich can now produce methanol, a a key starting material for chemical products, from CO2 and hydrogen with high efficiency by using isolated metal atoms as catalysts.

With individual, isolated indium atoms on a support material, ETH chemists have created a catalyst that is highly efficient at converting CO2 and hydrogen into methanol and significantly lowers the energy barrier.

In the past, catalysis research often followed a "hit or miss" approach. The newly discovered catalyst allows more precise analysis of the mechanisms taking place on its surface, paving the way for rational catalyst design.

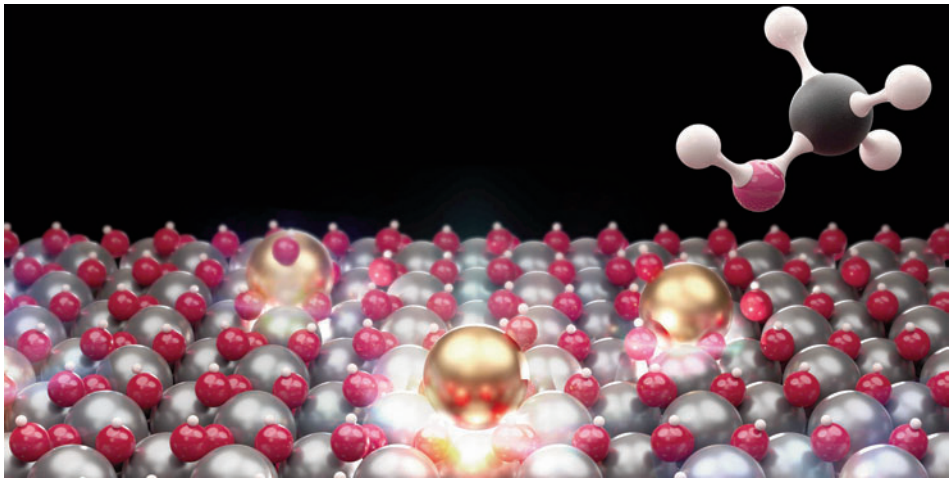
"Methanol is a universal precursor for the production of a wide range of chemicals and materials, such as plastics – the Swiss army knife of chemistry, so to speak," said Javier Pérez-Ramírez, Professor of Catalysis Engineering at ETH Zurich. The liquid therefore plays a vital role in the transition to sustainable and fossil-free production of chemical products and fuels.

If the energy used to produce the hydrogen and for catalysis is generated sustainably, methanol can ultimately even be produced in a climate-neutral manner. This provides a way of using CO2 from the atmosphere as a raw material instead of merely releasing it as we do today.

"Our new catalyst has a single atom architecture, in which isolated active metal atoms are anchored on the surface of a specially developed support material," Pérez-Ramírez explained. In conventional catalysts, on the other hand, metals are usually present as aggregates, usually small particles. Although these particles are tiny, they often contain between a hundred and several thousand metal atoms.

If the atoms can work in isolation, their catalytic properties also frequently change. "Indium has already been used in this catalyst for over a decade," said Pérez-Ramírez.

"In our study, we show that isolated indium atoms on hafnium oxide allow more efficient CO2-based methanol synthesis than indium in the form of nanoparticles containing large numbers of atoms."



In their catalyst, the researchers use the metal indium in an extremely efficient manner – in the sense that each individual indium atom behaves as an active site

In order to anchor single indium atoms to the hafnium oxide surface in a targeted manner, the interdisciplinary ETH team developed various synthetic pathways in collaboration with colleagues from other research institutions. One key part of this development was the specific structure of the support material, which provides the atoms with a stable and, at the same time, reactive environment.

In one tested production process, the starting materials are combusted in a flame at 2,000 to 3,000°C and then rapidly cooled. Under these conditions, the indium tends to remain on the surface, where it is stably incorporated.

With the incorporation of the catalyst atoms into a heat-resistant hafnium oxide support, the ETH chemists show that single-atom catalysts can remain stable even in extreme conditions. Reactions that require high temperatures and pressures are therefore also within reach. For example, the synthesis of methanol from CO2 and hydrogen gas requires temperatures of up to 300°C and pressures of up to 50 times normal atmospheric pressure.

Moreover, the existing nanoparticles used for analysis were a black box. While the catalytic processes only took place at the small number of atoms on the surface, many measurement signals originated from inside the particles, from atoms that were not even involved in the reaction. This made interpretation more difficult. In catalysts with isolated atoms, however, the reaction mechanisms can be analysed with far fewer interfering signals.

Pérez-Ramírez has not only been researching better catalysts for methanol production from CO2 at ETH since 2010 but also works closely with industry and holds several patents in this area. One key factor in the development of the new single-atom catalyst method was the large network that has emerged in terms of catalysis research in Switzerland in recent years, said Pérez-Ramírez.

"The development of the methanol catalyst and the detailed analysis of the mechanism would not have been possible without this interdisciplinary expertise."

More information

www.nccr-catalysis.ch

DAC breakthrough unlocks 3x cheaper carbon removal projects

Sustaera has achieved 90%+ energy efficiency with its 3rd-generation, electrically-powered Direct Air Capture at over 3x lower cost than prevailing technologies.

The company's proprietary electro-thermal approach pulls CO2 from the air at 3-5x lower capital costs than alternative methods, and now it has demonstrated operational efficiencies 3-4x higher than prevailing thermal technologies due to its nano-structured sorbent technology and integrated electric heating.

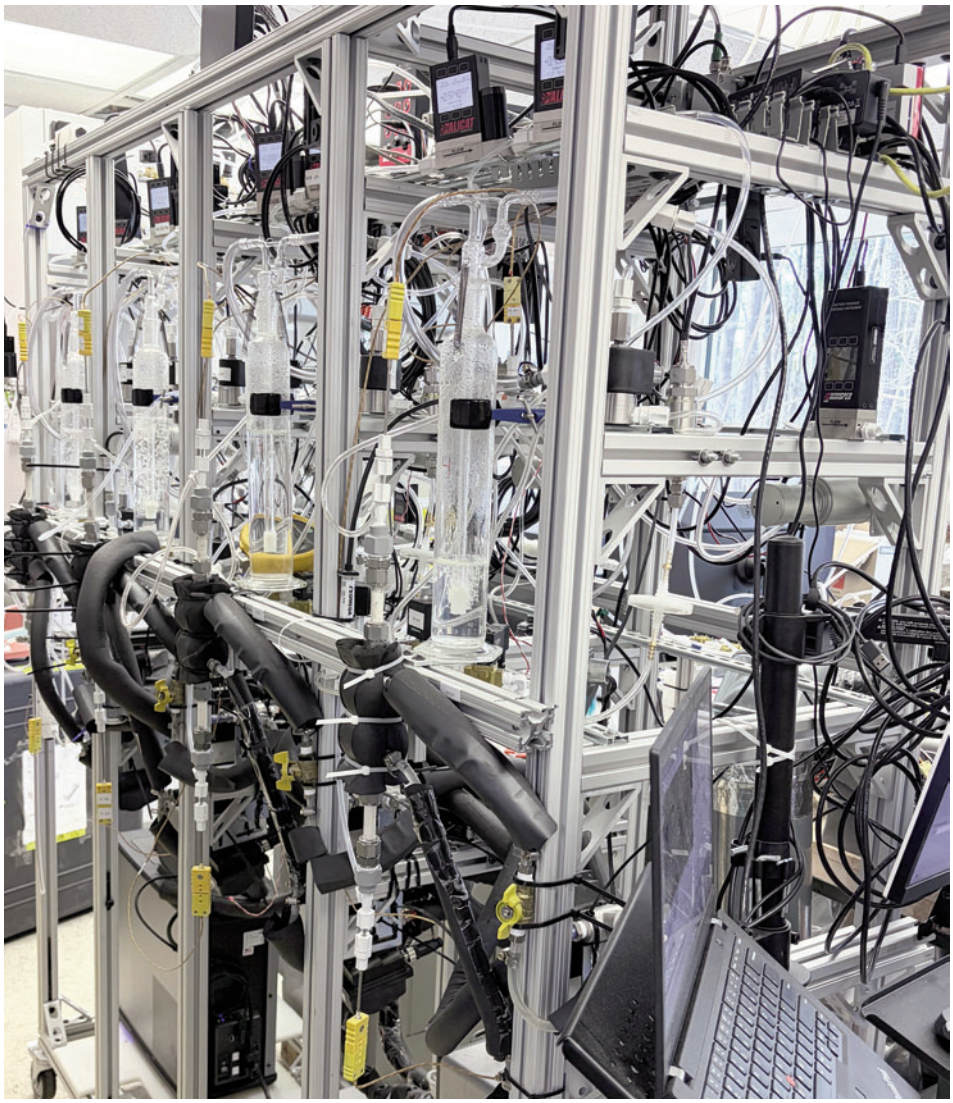
Based in Research Triangle Park, North Carolina, Sustaera is a Direct Air Capture startup with expertise in carbon capture, separations chemistry, and process scale-up. Sustaera said its mission is to deliver low-cost, scalable carbon removal systems to the world to "Restore the Carbon Balance," with a target to remove 500 million tons of CO2 by 2040.

"Thermal technologies max out at around 40% efficiency," said Sustaera CTO Cory Sanderson. "We've recently achieved 90%+ efficiency, using far less capital than traditional thermal approaches, and we're still innovating."

These results put Sustaera on a credible path to sub-$100/ton carbon removal, which has long been heralded as the "holy grail" threshold for unlocking widespread market adoption. This positions DAC to once again compete with emerging carbon removal approaches like biochar.

Until now, DAC technology has failed to fulfill its promises, as incumbents have delivered only a tiny fraction of the carbon removal credits they have sold. 1st-generation high-temperature technologies were inflexible and unable to achieve carbon-negative operations, while 2nd-generation technologies improved efficiencies but still required large baseload power supplies that are increasingly costly and constrained.

Sustaera has previously partnered with leading carbon removal buyers like Stripe and Shopify, and today their validated efficiencies combined with a new technology licensing model further reduce risk. The U.S. Department of Energy and XPrize backed company is now in advanced talks with leading carbon removal developers.



Sustaera said it is on a credible path to achieve sub-$100/ton carbon removal

"Developers can now capture carbon cost-effectively, whether for sequestration or utilization," stated Sustaera CEO Ben Gardner. "The technology is beautifully simple. It delivers measurable results and is easy to scale—potentially even without a grid connection."

Sustaera said it is now positioned to capture a significant share of the $100B+ carbon removal market of the future—especially in water-constrained areas, as the technology uses no water and produces pure water as a byproduct.

More information

www.sustaera.com

www.xprize.org

Holcim and CINEA sign the financing agreement for CPT01 Carbon Hub

It is the first project in Romania funded by the European Union's Innovation Fund and will enable near-zero emission cement production in Eastern Europe.

Developed by Holcim Romania in partnership with Carmeuse, the Carbon Hub CPT01 represents a major step in the decarbonisation of energy-intensive industries and in the transformation of the construction sector in Eastern Europe.

The project will capture the CO2 emissions generated in both the cement and lime production process, and will allow their permanent geological storage, significantly reducing the industrial emissions of the facilities.

Bogdan Dobre, CEO of Holcim Romania, said, "The signing of this financing agreement with CINEA marks a defining moment for our Carbon Hub CPT01 project and for the decarbonisation of the construction sector in Eastern Europe."

CPT01 is expected to be the first large-scale onshore carbon capture and storage project in Eastern Europe

"Through this initiative, we aim to demonstrate that large-scale carbon capture can accelerate the transition to near-zero emission cement, while supporting Romania's role in Europe's climate and industrial transformation."

Carbon Hub CPT01 is projected to become the first large-scale onshore carbon capture and storage project in Eastern Europe, positioning Romania at the forefront of climate innovation and industrial decarbonisation in the region.

Once operational, the project will enable the production of approximately two million tons of near-zero-emission cement annually, marking a major milestone in Holcim's journey towards net-zero emission building materials and supporting the company's NextGen Growth 2030 strategy.

As a key partner in the CPT01 Carbon Hub, Carmeuse estimates that it will produce approximately two hundred thousand tons of lime with near zero emissions annually, contributing to advancing its decarbonization strategy and the goal of achieving net zero emissions by 2050.

At the heart of the initiative is an innovative carbon capture system, designed to process the flue gases generated by two industrial emitters located in the Câmpulung industrial area.

By demonstrating an integrated carbon capture solution for cement and lime production, the project is directly contributing to the decarbonisation of our sector, while strengthening Europe's sustainable construction value chain.

Ionel Ungureanu, Area Production Manager, Carmeuse, added, "Projects like Carbon Hub CPT01 demonstrate that real industrial decarbonisation requires strong partnerships. Together with Holcim and the extended consortium, we are contributing our lime production expertise to build a robust carbon capture value chain that benefits industry, communities and the environment."

More information

https://www.holcim.ro

https://cinea.ec.europa.eu

Turning vibrations into value - a new catalyst converts CO2 into useful CO

Researchers at The University of Osaka have developed a catalyst that uses vibrational energy to convert carbon dioxide (CO2) into carbon monoxide (CO), an important industrial feedstock.

The work demonstrates a new piezocatalytic route for CO2 conversion under mild conditions—at low temperature and ambient pressure, offering a potential path toward future low-energy carbon recycling technologies.

CO2 emissions are a major driver of global warming, and technologies that convert CO2 from a waste product into a useful carbon resource are becoming increasingly important for achieving carbon neutrality. CO is a useful product of CO2 reduction, but conventional production methods require high temperatures and substantial energy input.

A promising alternative is to use catalysts that harness mechanical energy, such as vibration, to drive chemical reactions under mild conditions, although their efficiency and product selectivity for CO2 conversion have remained limited.

The research team designed a catalyst based on barium titanate ($BaTiO_3$), a piezoelectric material that generates electric charges under mechanical stimulation. By depositing nitrogen-doped carbon containing atomically dispersed nickel on $BaTiO_3$ nanocubes, the researchers created a material that efficiently reduced CO2 to CO under ultrasonic vibration at room temperature and ambient pressure.

In five hours of sonication, the new catalyst produced 377 mmol g–1 of CO, compared with 123 mmol g–1 for pristine $BaTiO_3$, corresponding to a 3.1-fold improvement. No H2, CH4, or HCOOH were detected as carbon-reduction products under the tested conditions, indicating almost 100% selectivity for CO among the detected carbon products.

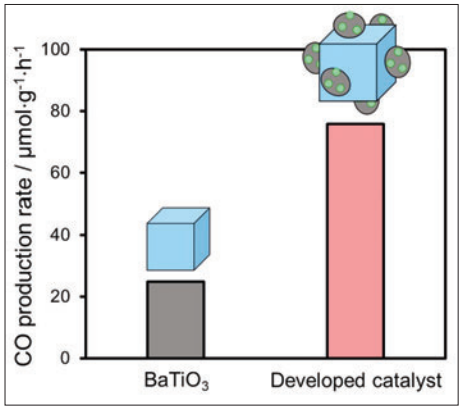


Fig. 2 - CO production rates of developed catalysts under ultrasonic vibration. Image: Yoshifumi Kondo, Tohru Sekino

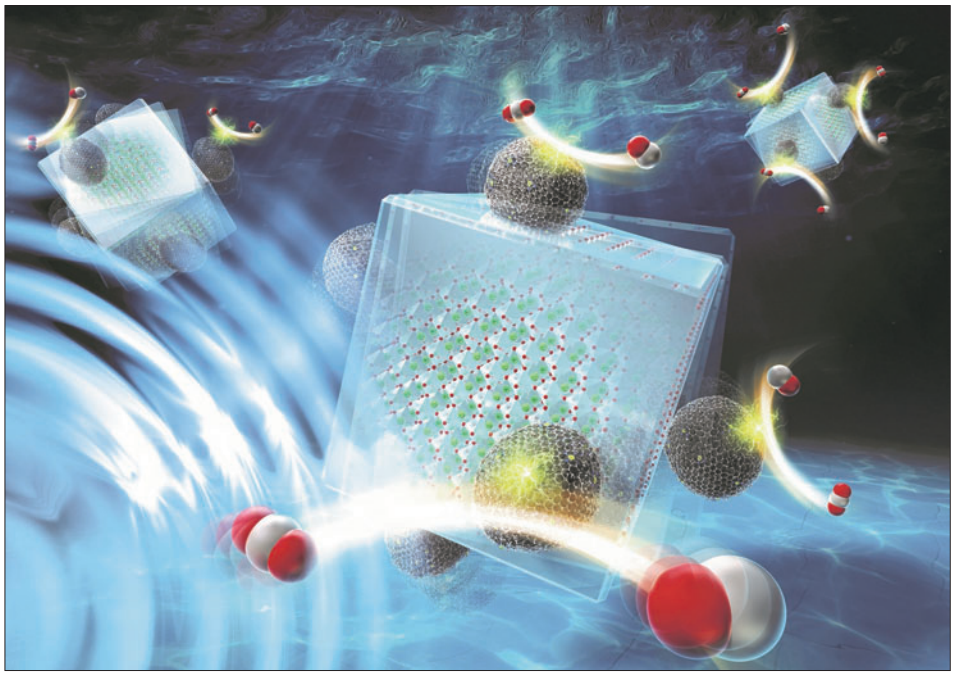


Fig. 1 - Schematic images of piezocatalytic CO2 reduction over Ni single-atom anchored on N-doped carbon deposited on $BaTiO_3$. Image: Yoshifumi Kondo and Tohru Sekino from J. Mater. Chem. A, 2026, 14, 6858

The study also clarified why the catalyst performed so well. The nitrogen-doped carbon helped promote charge separation and transfer, while the isolated nickel single-atom sites acted as highly active centers for CO2 reduction. Structural analysis showed that the nickel atoms were atomically dispersed in a Ni-N4 configuration within the carbon layer. The catalyst also remained stable over repeated cycles, suggesting that the nickel sites were firmly anchored during operation.

The work provides a new design strategy for combining piezoelectric materials with single-atom catalytic sites, opening a possible path toward sustainable CO2 conversion using underutilized mechanical energy.

Dr. Yoshifumi Kondo, senior author of the study, commented, “Establishing technologies to recycle industrially emitted CO2 is essential for achieving carbon neutrality. In this work, we clarified part of the design guideline for reaction-active sites in piezocatalytic CO2 reduction. Going forward, we hope to develop new low-energy CO2 conversion methods that make use of underutilised energy, such as mechanical vibration and waste heat.”

The paper "Ni single-atom doped N-doped carbon deposited on $BaTiO_3$ for efficient piezocatalytic CO2 reduction" was published in the Journal of Materials Chemistry A.

More information

www.sanken.osaka-u.ac.jp/en

Capture & utilisation news

Svante and partner progress BECCS project on paper mill

www.svanteinc.com

The project at a paper mill in the Southeast U.S., being developed in partnership with an integrated sustainable packaging company, has progressed to the feasibility study phase.

Following an extensive screening and pre-feasibility study conducted across several of the partner's mills, the companies will complete further engineering and design activities, cost and schedule estimates, and risk assessments required to evaluate commercial viability ahead of a future engineering study leading to final investment decision (FID). Svante's subsidiary, Svante Development Inc., is co-investing in this phase with the mill owner.

The project is designed to capture and permanently store more than 500,000 tonnes per year of biogenic CO2 generated from mill operations. The biomass fiber used at the site is sourced from sustainably managed forests. The resulting carbon dioxide removal (CDR) credits will meet established monitoring, reporting, and verification (MRV) standards and are intended for sale to organizations aiming to address their Scope 1 and Scope 2 emissions.

"Advancing this work into feasibility provides the information we need to assess cost, project execution strategy, and plant integration requirements," said Scott Gardner, President of Svante Development Inc. "It also aligns with progress on CO2 storage infrastructure in the region, which is a necessary component of any integrated BECCS project."

Machine learning speeds up search for better catalysts

www.bnl.gov/chemistry/crs

Researchers at the Brookhaven National Laboratory developed a new machine learning framework that can accelerate the search for better catalysts, using CO2 to methanol as a test case.

Finding high-performing catalysts can be a slow, expensive process, often relying on years of trial-and-error or massive computational resources. To add to the difficulty, ideal catalyst candidates are rare. The best catalysts must be active enough to drive reactions efficiently, but selective enough to favor the desired product over unwanted byproducts.

"Imagine driving somewhere new without using GPS," said Brookhaven Lab chemist Wenjie Liao. "You'll probably get there eventually, but you'll take long detours and waste time. The discovery of catalysts can be like that."

Researchers in the Catalysis Reactivity and Structure group in Brookhaven Lab's Chemistry Division tackled those discovery challenges with a new multi-layer machine learning approach that screens catalysts step by step, mimicking how scientists evaluate performance in real experiments.

The team successfully used the chemical conversion of carbon dioxide to methanol as a case study for the new approach, which outperformed conventional models. The study also shed new light on how scientists can control key chemical reactions steps that tune two important features that make for an effective catalyst in that process: activity and selectivity.

A paper describing their work was recently published in Chem Catalysis. The research was supported by the DOE Office of Science.

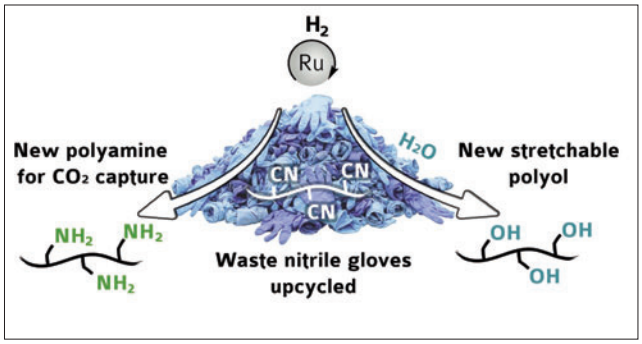
"Highly active and selective catalysts save energy and costs," said Brookhaven Lab chemist Ping Liu, who is also an adjunct professor at Stony Brook University.

"An active catalyst means it doesn't require high pressure or high temperatures to speed up a reaction, and a selective catalyst means it doesn't require purification, which can be costly, to get the product you want."

Recycling rubber waste into new carbon capturing materials

www.st-andrews.ac.uk/chemistry

Researchers at the University of St Andrews have unveiled two breakthrough techniques for chemically recycling and upcycling nitrile-rubber products into new materials that are also capable of capturing carbon dioxide.



The technology could tackle two of the planet's biggest waste problems at once: plastic pollution and carbon dioxide emissions

The development of sustainable methods for the upcycling of plastic waste is one of the most important challenges in achieving a circular economy and can play a significant role in tackling the climate crisis.

Lead author Dr Amit Kumar from the School of Chemistry said, "We are thrilled by this discovery, which lets us turn nitrile glove waste from chemistry labs into valuable new materials. With further development, this technology could tackle two of the planet's biggest waste problems at once: plastic pollution and carbon dioxide emissions."

Among various plastics that need to be recycled, nitrile butadiene rubber (NBR) has received comparatively little attention, despite a large market of 36 million tons or $2.5 billion globally per year. NBR has wide applications ranging from disposable gloves to hoses, seals, and circular seals used to prevent leaks.

NBR is challenging to recycle due to its thermoset nature, with less than 2% currently recycled, often through low-value downcycling. In a paper published in Angewandte Chemie, researchers from the School of Chemistry at St Andrews, introduce two new ways to chemically recycle NBR and turn it into useful new materials.

By using a ruthenium catalyst and hydrogen gas, researchers were able to "unlock" the chemical bonds in NBR and convert it into either polyamines or polyols, depending on the reaction conditions. Remarkably, the process to make polyamines works at temperatures as low as 35°C, while making polyols requires higher temperatures but achieves excellent efficiency.

Carbon storage: unlocking value through technology and partnerships

The EAGE Annual Conference & Exhibition takes place from June 8-11 at Aberdeen's P&J Live – and the North Sea Transition Authority (NSTA) is using the opportunity to turn the spotlight on carbon storage. By Carlo Procaccini, NSTA Chief Technical Officer.

For the first time in its 87-year history EAGE has brought the event to the Granite City and it is particularly appropriate that it does so this year as the event is focused on the role of geosciences in unlocking value through technology and partnerships and, as an important energy hub, Aberdeen is very much at the forefront of the energy transition.

The NSTA is the Regulator for the UK's growing carbon storage industry and plays an important role in issuing licences and permits to companies who wish to transport and store carbon emissions under the seabed.

The NSTA requires licensees to demonstrate that proposed storage sites pose no significant risk of leakage before a permit for storage operations is granted. Monitoring during and after injection is a critical part of the operation and management of stores, and NSTA colleagues will be hosting a Carbon Storage MMV Technology Showcase at EAGE 2026.

Ian Barron, NSTA Senior Geoscientist, said, "EAGE coming to Aberdeen presents a great opportunity to bring carbon storage licensees, technology suppliers and academia together to share and pool knowledge, experience and challenges related to monitoring."

Carbon capture is expected to become increasingly important as the UK aims to achieve net zero greenhouse gas emissions by 2050. The government has signalled its support for the industry by committing up to £21.7 billion of funding over 25 years to make the UK a leader in carbon storage and hydrogen.

The NSTA has already awarded 21 licences in the UK's first-ever carbon storage licensing round and is currently evaluating the applications received in the second round, which launched in December 2025.

The Track 1 Endurance and HyNet projects have been awarded storage permits, which allow them to start development work, and they are making significant progress towards first injection.

To further support industry progress, the NSTA has developed a first set of Carbon Storage Stewardship Expectations that set out good practice, and supplement the NSTA's guidance on applications for carbon storage permits, all of which is intended to help companies as they find their feet in this new sector.

EAGE's 2026 theme is 'Maximizing value through technology and partnership'

While it's still a relatively young industry, carbon storage is expected to grow significantly in the coming years, both domestically and internationally, and the NSTA is determined to play its role in supporting and regulation and is using skills and experience gained in the oil and gas industry to do that.

Carlo Procaccini, NSTA Chief Technical Officer, said, "We are particularly interested in discussing technologies that can be matured and used in the field, transferring skills and experience from other energy sectors. Participation in the Showcase will offer a great opportunity to share challenges and experience in a collaborative environment, and to network with peers to support adoption of advanced solutions for the accurate, cost-efficient and timely monitoring of carbon storage."

The Showcase event invites developers and operators to come along and share their knowledge and experience, particularly on the subject of how technologies that can deliver useable, cost-efficient CO2 monitoring can be developed and implemented.

Carlo and Ian will lead the session which will provide a real opportunity for the key stakeholders in the field to share knowledge. And they expect to hear conversations covering the latest innovations on areas such as seismic surveys, in-well fibre and sensors, geochemical and environmental monitoring, data analytics, and automation.

Carlo and Ian added, "Monitoring is an important factor in demonstrating containment and new technology can reduce risk through timely data acquisition and use. The right tools deployed at the right time can also reduce cost, and all these elements together provide confidence in the early projects, supporting further growth of this industry."

The Carbon Storage MMV Technology Showcase at EAGE 2026, organised by the NSTA with the EAGE, the North Sea Technology Leadership Board and supported by the Carbon Storage Task Forces, will be held on 8 June 2026, 8.30am to 4.30pm.

If you're interested to participate and share your experience through presentations and exhibitor displays, please email: **Carlo.Procaccini@nstauthority.co.uk** or **Ian.Barron@nstauthority.co.uk**

More information

https://eageannual.org

www.nstauthority.co.uk

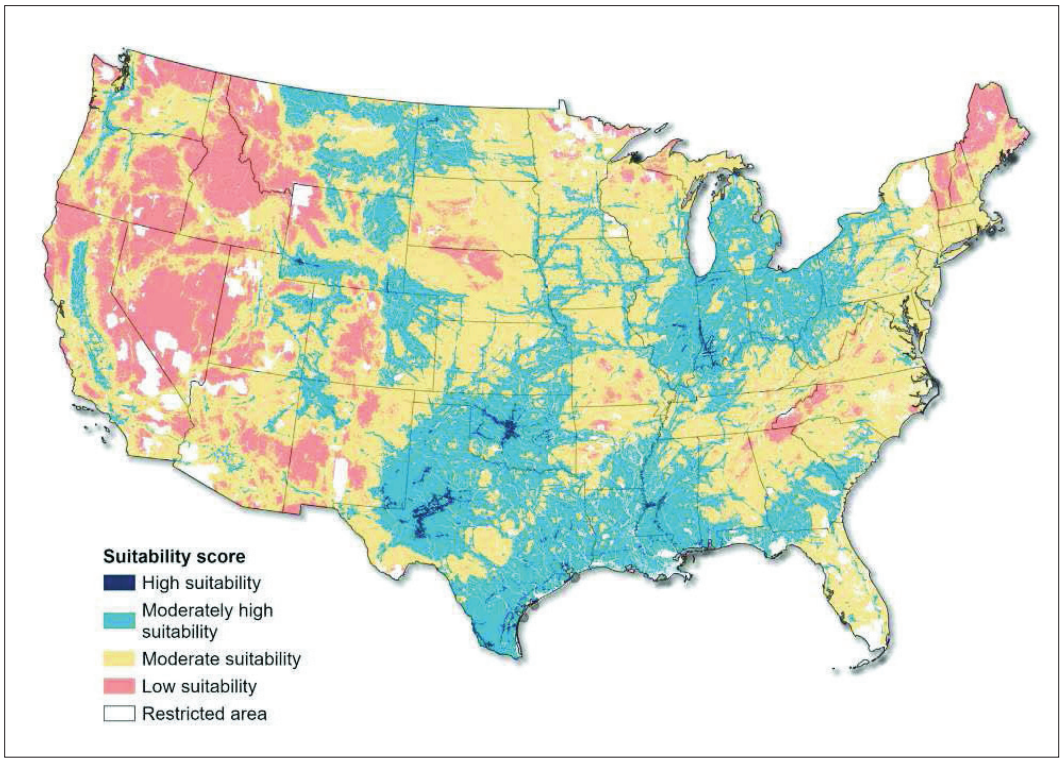
Atlas analyzes US suitability for natural gas power with CCS

A new national atlas from Great Plains Institute provides a comprehensive analysis of the suitability of areas across the United States to support natural gas-fired power generation with carbon capture and storage (NG + CCS). www.betterenergy.org

After decades of relatively stable electricity demand, US consumption is projected to grow significantly, as much as 35 to 50 percent by 2040, according to a recent study by American Clean Power.

The growth is largely driven by artificial intelligence, data centers, and the electrification of industry and transportation. Meeting it while ensuring reliability and reducing emissions will require a diverse mix of technologies.

Natural gas currently provides about 40 percent of US electricity, while it is increasingly being considered for on-site power generation at new data centers. Pairing it with carbon capture offers a pathway to maintain reliable, dispatchable power while lowering emissions.



Baseline scenario results, normalised. The results of the baseline scenario were normalised to the theoretical maximum value that could be given to a location in the baseline scenario

The Atlas of Natural Gas Power with Carbon Capture and Storage uses a national, data-driven multi-criteria decision analysis to evaluate siting conditions, including access to natural gas, carbon dioxide storage, infrastructure, land, water, and proximity to demand.

"This kind of analysis is essential for decision makers who are navigating a rapidly changing energy landscape," said Patrice Lahlum, vice president of Industrial Innovation and Carbon Management at GPI.

"Electricity demand is rising quickly, and leaders across the public and private sectors are being asked to ensure reliability and affordability while also reducing emissions. Tools like this help identify where carbon management can be deployed most effectively, grounding those decisions in data, infrastructure realities, and community context."

The atlas includes multiple scenarios that prioritise different aspects of a project based on what is most important to the developers and communities involved.

The analysis identifies extensive areas of moderate to high suitability, particularly across the Gulf Coast, West Texas, Oklahoma, and parts of the Midwest—including approximately 54,000 square kilometers of highly suitable land and 2.3 million square kilometers of moderately high suitability.

These results underscore the importance of prioritizing access to CO2 storage, with transport networks developed as needed to support NG + CCS deployment at scale.

Using the NG + CCS atlas for project planning

While not project-specific, the atlas is designed as an early-stage screening tool to help policy makers, developers, and system planners focus on the most promising regions and guide more detailed evaluation and infrastructure planning.

However, it does not replace project-level considerations such as siting, permitting, community engagement, and land and pore space ownership. GPI also offers a Decision Support Tool for carbon management that provide shared, accessible data to support informed and inclusive siting decisions.

KBR awarded FEED contract for EcoLog Terminal Amsterdam

The pioneering EcoLog Terminal , the world's first commercial-scale liquid hydrogen (LH2) import and liquid CO2 (LCO2) export facility, is in development in the port of Amsterdam.

Located in one of Europe's most strategic energy hubs, the EcoLog Terminal Amsterdam is expected to serve as a cornerstone infrastructure project to support decarbonisation across Northern Europe, for such sectors as steel manufacturing, heavy duty road mobility, maritime transport and data centers.

EcoLog Terminal Amsterdam is the world's first commercial-scale liquid hydrogen import and liquid CO2 export facility

The facility is planned to receive, store, and distribute both gaseous and liquid hydrogen as well as handle LCO2 for reutilisation or safe export for permanent storage. The terminal is to become operational by the end of 2030, with an initial annual throughput capacity of 200,000 tonnes of LH2 and 1.8 million tonnes of LCO2, which can subsequently be expanded to 600,000 and 4.25 million tonnes, respectively.

Under the FEED award, KBR will define the engineering basis, storage systems, operational envelope, and safety standards for the terminal, helping set a strong foundation for future liquid hydrogen handling and large-scale cryogenic infrastructure. The FEED process is projected to be completed in 2026.

"KBR brings decades of deep technical expertise in complex energy infrastructure, including our work with NASA developing liquid hydrogen infrastructure, and we are thrilled to bring that experience to a client as forward-thinking and ambitious as EcoLog," said Jay Ibrahim, President, KBR Sustainable Technology Solutions.

"This project represents a historic first for the industry and positions both KBR and EcoLog at the forefront of the technologies that will shape future low-carbon supply chains."

The terminal is expected to unlock entirely new supply routes, connecting future hydrogen and CO2 production hubs with high-demand industrial clusters across Europe. It will feature multiple transport modalities, including two hydrogen pipeline connections (high- and low-pressure), a CO2 pipeline connection, a truck loading facility, a barge jetty and a rail connection.

KBR's role will span terminal design, storage architecture, operational safety frameworks, and integration with EcoLog's new vessels and last-mile distribution, supporting the creation of a full end-to-end liquid hydrogen value chain. Additionally, KBR will focus on the synergy between the cold energy released during the LH2 regasification process and its utilization to liquefy CO2.

Ellen Ruhotas, CEO of EcoLog, said, "Commissioning FEED is a proud moment for the entire EcoLog team. It is testament to the work put in and the project's fundamentals. The realization of the EcoLog Terminal Amsterdam holds large promise for Europe's decarbonization ambitions, and we look forward to bringing this to fruition together with KBR."

Beyond its commercial significance, the project presents a rare opportunity to define global engineering standards for the deployment, transportation, and storage of liquid hydrogen; an essential step toward enabling scalable hydrogen economies.

More information

https://ecolog.earth

Norway and Belgium agree to enable cross-border CO2 transport

The bilateral agreement is aimed at facilitating an infrastructure for the transport of CO2 by pipeline from Belgium to the Norwegian Continental Shelf.

The agreement was signed in Stavanger at the Petroleum Museum by representatives from Norway and Belgium.

"This agreement strengthens the foundation for a European CO2 value chain. By coordinating our efforts, the agreement marks an important milestone in the two countries' long-standing energy cooperation and provides predictability for future CCS developments. Today we have taken a concrete step toward supporting industrial decarbonisation in Europe," said Terje Aasland, Norwegian Minister of Energy.

An initiative led by Equinor and Fluxys to develop an infrastructure for transport of CO2 from Belgium to a storage location on the Norwegian Continental Shelf

Belgian industry needs access to large-scale storage solutions to reach national and EU climate targets. Norway, for its part, has paved the way for substantial offshore storage capacity on the Norwegian Continental Shelf based on commercial terms through its permitting policy.

"Norway has more than 30 years of experience with safe offshore CO2 storage. Together with Belgium, we are now laying the groundwork for infrastructure that can help European industry reduce emissions in a cost-effective and predictable manner," said Terje Aasland.

Norway is the largest supplier of gas to the EU, providing roughly one-third of the Union's imports. The energy systems of Norway and Belgium are already closely connected through the two gas export pipelines from Norway to Zeebrugge on the Belgian coast. Zeebrugge plays an important role as a landing point for further distribution of Norwegian gas to Europe.

The agreement is based on the existing pact governing the operation of these two pipelines and the way in which the two countries have distributed jurisdiction between themselves with respect to these gas pipelines. The agreement builds on this partnership and reflects both countries' aim to accelerate the transition to low-carbon solutions.

Potential European CO2 Pipeline System

Annelies Verlinden, Belgium's Minister of the North Sea said, "Belgian industry is at the forefront of the transition to sustainability, including in sectors with emissions that are difficult to reduce. Our strong cooperation with Norway is key to making carbon capture and storage a success in Belgium and across Europe. The North Sea serves as a backbone for our green industrial future, connecting our industry to effective and reliable climate solutions".

The background for the agreement is an initiative led by Equinor and Fluxys to develop an infrastructure for transport of CO2 from Belgium to a storage location on the Norwegian Continental Shelf. In addition to the pipeline for the cross-border transportation of CO2, the initiative includes plans for a land-based terminal in Belgium to receive CO2 from several industrial sources in Europe.

If the pipeline is built, it will represent a significant contribution to European emission reductions and demonstrate how cross-border infrastructure can support industrial transformation.

More information

www.equinor.com

www.fluxys.com

Transport and storage news

EnEarth awards FEED to Kent for Prinos project

www.enearth.earth/what-we-do

https://kentplc.com

The Prinos CO2 Project aims to safely receive and permanently store emissions offshore Greece targeting operations by 2029.

The FEED phase will define the technical scope and execution strategy for the Prinos CO2 project. Kent will develop the front-end engineering design for the new CO2 handling and storage facility, which will receive, store, transport, and inject CO2 into the Prinos aquifer underlying the existing reservoir.

The Prinos facility is being designed to receive and process up to 2.8 million tonnes per annum (MTPA) of liquid CO2 by 2029. CO2 will be shipped from remote emitters via marine carriers to a new marine terminal at the onshore Sigma plant near Kavala, where it will be temporarily stored before being conditioned, pumped and transported through a new subsea pipeline to a standalone CO2 Injection and Water Production (COIWP) platform within the existing Prinos complex.

The Prinos CO2 Storage Project is the first of its kind that has been awarded an environmental permit and a storage permit in the Mediterranean, and one of the very few in Europe. It has been included in the Union list of Projects of Common Interest (PCIs), and secured funding from the EU's Connecting Europe Facility (CEF) and the Greek Recovery and Resilience Facility (RRF).

Paul Wetton, Vice President UK Engineering Services at Kent, said, "Prinos represents one of Europe's most strategically important carbon storage developments, and this FEED award marks a meaningful step toward enabling large-scale industrial decarbonisation in Greece and across the EU."

Northern Lights begins injection of CO2 from wastewater

https://norlights.com

www.inheritcarbonsolutions.com

Northern Lights has started to inject the first biogenic CO2 from wastewater treatment delivered by Inherit to the receiving terminal in Øygarden.

Since February the carbon removal company Inherit has delivered CO2 cargos to Northern Lights from the Veas wastewater treatment plant in Slemmestad near Oslo.

"For the first time, biogenic CO2 from biogas production is being permanently stored underground. I am proud that Inherit is now operational with our first project. This proves that the full value chain works, from capture at a biogas facility to permanent storage below the seabed," said Kaja Voss, CEO Inherit Carbon Solutions

In Øygarden Inherit offloads the CO2 trucks to the tank farm from where Northern Lights transports the CO2 offshore via pipeline and will safely store it 2,600 metres below the seabed

Veas is Norway's largest wastewater treatment plant and handles wastewater from more than 800,000 inhabitants in the Oslo region. As the wastewater is processed in their biogas production unit, biogenic CO2 from the process is captured, liquified and finally transported to the Northern Lights receiving terminal by cargo trucks.

"Inherit develops carbon removal projects from biogas for storage and provides carbon removal credits to companies. This is a pilot project for Northern Lights where we offer capacity to receive up to 7,000 tonnes of CO2 per year from Veas in the agreement period with Inherit."

Tampnet delivers real-time connectivity for Dutch CO2 injection

www.tampnet.com

The company has won a contract with Porthos CO2 Transportation and Storage C.V. to deliver communication services for the first CO2 injection platform on the Dutch Continental Shelf.

Platform P18-A, a former gas production platform currently being converted into an unmanned CO2 injection installation, is a key component of the Porthos CO2 transport and storage project.

Tampnet will provide and operate the communications infrastructure for the CO2 platform in cooperation with Porthos. The solution is designed to support critical operational needs and will enable continuous monitoring and remote control of the platform from shore, marking an important step in the development of CCS infrastructure.

"We are very excited about the collaboration with Porthos, since this will be the first CO2 injection platform in the Dutch part of the North Sea," said Huib Fenenga, Country Manager Tampnet Netherlands.

"Reliable offshore communications will play a key role in enabling safe, efficient and remotely operated platform operations. We will provide a redundant 25Mbit/s communication solution, which is designed to ensure high availability and operational reliability. This will provide a strong foundation for future CCS developments."

Tampnet builds, owns and operated the world's largest offshore fibre network, spanning more than 5,400 kilometres and connecting over 450 offshore installations across the North Sea and Gulf of Mexico.

Porthos is the first large-scale CCS project in the European Union, transporting and storing 2,5 Mton CO2 annually at full capacity to depleted gas fields beneath the North Sea. Through this collaboration, Tampnet will support Porthos in establishing the digital infrastructure required for safe and efficient offshore operations.

Prinos advances to FEED stage with KENT

Image: Energean