Carbon Capture Journal

CCS in the U.S.

Expanded tax credit could boost projects and start a CCS gold rush

Moody's: Coal will continue secular decline without CCS

Capturing and using CO2 from ethanol

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STEMM-CCS: improving the safety of offshore CO2 storage

- Energy Institute report shows oil & gas industry support for CCS
- Negative emission technologies role in meeting Paris Agreement
- 'Early warning' CO2 monitoring technique using noble gases
- Update on technology testing at the National Carbon Capture Center

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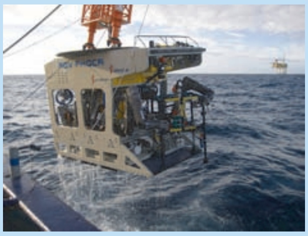


Front cover: The STEMM-CCS project will help to improve safety for offshore CO2 storage sites. The image shows the ROV (Remote Operated Vehicle) Phoca being deployed from RV Poseidon. The Goldeneye platform is on the horizon.

Carbon capture journal (Print) ISSN 1757-1995
Carbon capture journal (Online) ISSN 1757-2509

Leaders - CCS in the United States

Projects and policy

Capture and utilisation

Transport and storage

U.S. bill includes Carbon Capture Tax Credit that could boost CCS

A broad bipartisan coalition of industry, labour, and environmental interests backed the FUTURE Act which included provision to extend and reform a tax credit for CCS and CO_2-EOR.

The U.S. budget bill passed by Congress and signed into law by the President included the FUTURE Act, legislation introduced last year in the U.S. Senate to extend and reform the federal Section 45Q tax credit.

Key provisions of the FUTURE Act provide needed financial certainty for private investors and developers of carbon capture projects by lifting the current cap on available 45Q credits and increasing their value for each ton of CO_2 captured and safely stored or put to beneficial use. The incentive is performance-based, so only projects that successfully capture and store CO_2 can claim the credit.

The FUTURE Act was cosponsored by one quarter of the U.S. Senate and backed by the National Enhanced Oil Recovery Initiative (NEORI), now rebranded as the Carbon Capture Coalition, a coalition of energy, industrial and technology companies, labour unions and environmental organizations.

Proponents expect the revamped 45Q credit to drive private investment in commercial deployment of technologies to capture carbon dioxide from power plants and industrial facilities for enhanced oil recovery (CO_2-EOR) and other forms of geologic storage and for beneficial uses of CO_2.

David Hone, Chief Climate Change Advisor for Shell, believes the Act is a potential game changer for CCS, by effectively introducing a $50 per tonne pricing mechanism, and talked of a 'CCS gold rush'.

"While $50 per tonne of CO_2 isn't sufficient for every type of CCS project today, this amount could well be enough to unlock a wave of innovative projects, leading to new infrastructure, storage sites and technology improvements, giving birth to a real industry. Politics aside, this contribution from the United States could be the single most important step that any country takes in helping society reach the goal of the Paris Agreement," he said.

Key aspects of the FUTURE Act

- It increases the value of the existing federal 45Q tax credit to $35 for every metric ton of CO_2 captured from a power plant or industrial facility and stored through enhanced oil recovery (CO_2-EOR), $50 per ton for CO_2 stored in other geologic formations and $35 per ton for CO_2 captured and put to beneficial use in producing fuels, chemicals, and useful products.

- Existing 45Q tax credits will soon run out, so this legislation extends the incentive, providing the financial certainty needed to drive private investment in carbon capture projects.

- Importantly, the bill expands eligibility to smaller-scale industrial facilities, such as ethanol and fertilizer plants, and increases flexibility for tax-exempt electric cooperatives and other entities to use the tax credit more effectively.

- It is fiscally and environmentally responsible. The CO_2 captured and stored through CO_2-EOR will extend domestic production from existing oil fields, displace more carbon-intensive imported crude and generate new federal and state revenue, all while significantly reducing carbon emissions. In fact, analysis by the International Energy Agency estimates that a barrel of oil produced through EOR using power plant or industrial CO_2 results in a 37 percent net emissions reduction over a conventional barrel of oil, even after accounting for the additional oil produced in the process.

- The incentive is performance-based, so only projects that successfully capture and safely and permanently store CO_2 can claim the credit. No taxpayer dollars will flow to projects that fail to do so.

Frederick R. Eames and David S. Lowman, Jr. from Hunton & Williams LLC explain the changes.

"Prior to enactment of this new law, Section 45Q provided a $10 per ton credit for CO_2 permanently stored and used as a tertiary injectant (i.e., for EOR), and a $20 per ton credit for CO_2 not used as a tertiary injectant and permanently stored - for example, injection into a saline formation."

"Both credit amounts are adjusted for inflation. 'EOR' is used here also to refer to enhanced natural gas recovery, which has been and will continue to be eligible for the Section 45Q credit."

"The theory behind the differentiated credit is that the market will pay for CO_2 for use in tertiary injection. The credit was limited to the first 75 million tons claimed by all projects, regardless of whether used to claim the $10 per ton credit or the $20 per ton credit. The credit is applicable to the entity that owns the facility, captures the CO_2, and uses or disposes of it. More than two-thirds of the credit have been claimed since its enactment in 2008."

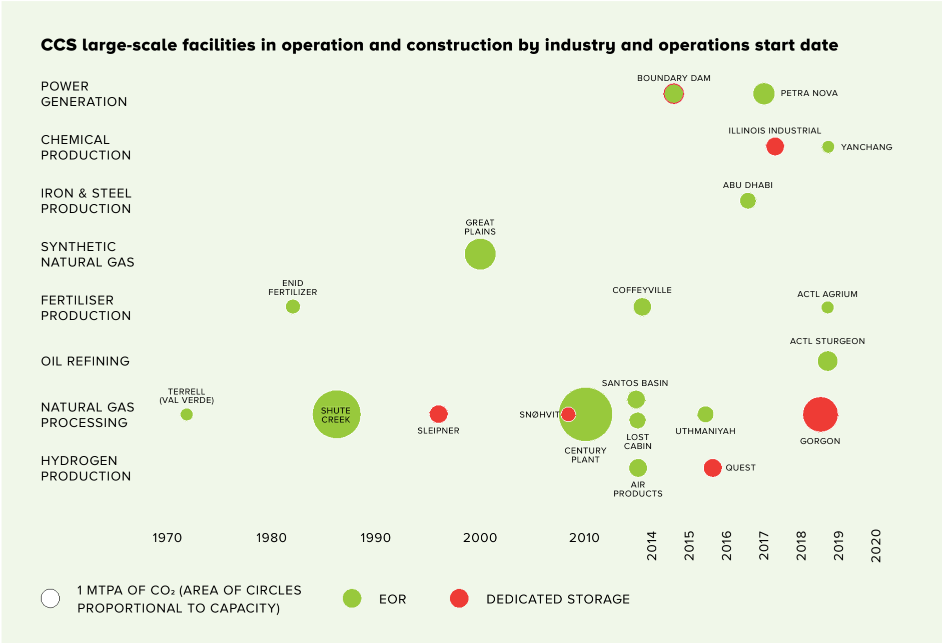
"The new law largely leaves the above-described tax credit in place for facilities using carbon capture equipment that was placed in service prior to the date of enactment. For facilities placed in service on or after that date, the Act extends and substantially increases the credit."

"The Act also expands the 'EOR credit' to carbon oxides used for other industrial purposes, changes the definition of the entities to whom the credit applies, and sets capture thresholds for small facilities, electric generating facilities, and direct air capture facilities."

However they also point out that some confusion still remains over the definition of 'secure geological storage' which is a requirement for the credit and which needs to be clarified.

The legislation marks the culmination of more than six years' work by NEORI's industry, labour, and environmental participants and their coalition partners to build support for the extension and reform of the 45Q tax credit. Their effort also helped garner bipartisan backing from the governors of Kansas, Montana, North Dakota, Oklahoma, Pennsylvania, and Wyoming who co-signed a letter to Congress this week urging action on 45Q.

Over the past several years, organizations such as the Western Governors Association (WGA), National Association of Regulatory Utility Commissioners (NARUC) and Southern States Energy Board (SSEB) have passed resolutions calling on Congress to enact legislation to reform and extend Section 45Q based on recommendations developed by NEORI and its coalition partners. Legislators in states including Alabama, Kentucky, North Dakota and Texas have also passed resolutions of support.



Most CCS projects to date have benefited from offsetting costs through Enhanced Oil Recovery. The new tax credit will help to incentivise further EOR projects, but also by putting a higher price on dedicated CO2 storage projects, this sector could receive a boost (Source Global CCS Institute Status of CCS: 2017)

Carbon Capture Coalition

The National Enhanced Oil Recovery Initiative has rebranded as the Carbon Capture Coalition and added new members including Shell and NET Power, although the Natural Resources Defense Council has also left.

The Coalition is a diverse, non-partisan national coalition dedicated to fostering widespread adoption of carbon capture technologies.

"Building on growing momentum and political support that culminated in the passage of landmark legislation in Congress earlier this month, the Carbon Capture Coalition becomes the new brand for the six-year-old National Enhanced Oil Recovery Initiative (NEORI). The Coalition will now undertake a more expansive agenda."

The growing breadth and diversity of support for carbon capture is reflected by the fact that 12 companies and organizations joined three dozen existing NEORI participants to form the nearly 50 member-strong Carbon Capture Coalition. The new Coalition participants are: Bipartisan Policy Center, Carbon Wrangler, LLC, ClearPath Foundation, EnergyBlue Project, LanzaTech, Mitsubishi Heavy Industries America, National Farmers Union, NET Power, New Steel International, Renewable Fuels Association, Shell and Third Way.

"With congressional passage of the 45Q tax credit, carbon capture policy has become an important part of the national conversation on energy, job creation and emissions reductions," said Brad Crabtree, vice president of fossil energy at the Great Plains Institute and one of two co-conveners of the Coalition. "The Carbon Capture Coalition will harness this powerful new incentive by promoting deployment of carbon capture technology nationwide and by continuing to expand support for further policies and strategies to advance this commonsense solution."

Going forward, the Coalition will broaden its mission and priorities to include:

• Enacting complementary federal and state incentives to the revamped 45Q tax credit to attract greater private investment in carbon capture projects, such as tax-exempt private activity bonds and master limited partnerships that are currently available for other energy technologies and infrastructure;

• Engaging in federal infrastructure policy deliberations in the coming months to ensure that carbon capture and CO2 pipeline infrastructure are part of the equation;

• Maintaining robust federal support for carbon capture research, development, and demonstration to help bring the next generation of carbon capture technologies into the marketplace; and

• Working with governors, state policymakers and local stakeholders to support deployment of carbon capture, pipeline infrastructure and CO2 utilization and storage projects in states and regions around the country.

• The Coalition launched a new website and the existing @CCSTechFacts Twitter account to share information about carbon capture technologies will become the official account of the Coalition.

More information

carboncapturecoalition.org

David Hone is Chief Climate Change Advisor for Shell

blogs.shell.com

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Update on technology testing at the National Carbon Capture Center

The National Carbon Capture Center (NCCC) at the Power Systems Development Facility (PSDF) is a cost-effective, flexible test center for evaluating the critical components of advanced CO2 capture and power generation technologies, managed and operated by Southern Company for the U.S. Department of Energy (DOE). It hosts technology developers from around the world, including premier research organizations, universities, and engineering firms.

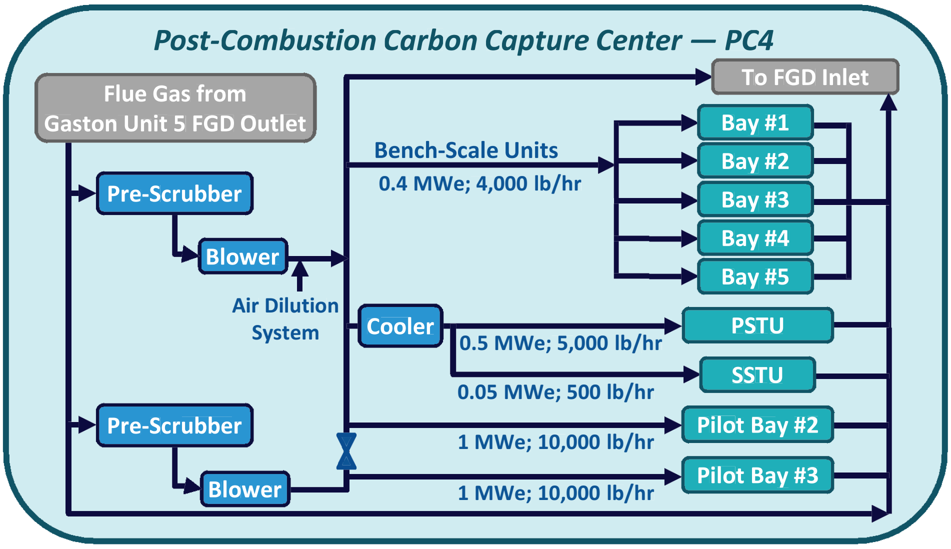
Offering a world-class neutral test facility and a highly specialized staff, the NCCC accelerates the commercialization of advanced technologies to enable fossil-based power plants to achieve near-zero emissions. In undertaking its mission, the NCCC is involved in a range of activities to develop the most promising technologies for future commercial deployment, thereby maximizing the impact of project funds.

Research is focused on development of post-combustion CO2 capture for incorporation into pulverized coal power plants and pre-combustion CO2 capture for integration into the new generation of coal gasification power plants.

The test facilities include two sites: the Post-Combustion Carbon Capture Center (PC4), located at Alabama Power Plant E.C. Gaston; and the original PSDF site, which houses the gasification process and pre-combustion CO2 capture test site. The NCCC includes multiple, adaptable slipstream units that allow technology development of CO2 capture concepts using coal-derived flue gas and syngas in industrial settings.

Because of the ability to operate under a variety of flow rates and process conditions, research at the NCCC can effectively evaluate technologies at various levels of maturity. Exposure of developing technologies to coal-derived gas with the concomitant impurities provides critical information on material and process suitability for scale-up to commercial applications.

Post-combustion and gasification/pre-combustion CO2 capture work has accumulated over 94,000 hours of bench- and pilot-scale testing of solvents, enzymes, gas separation membranes, sorbents, and catalysts, as well as other novel processes. Testing at the center has validated the technical feasibility of several concepts, serving as a stepping-stone toward further development, including process scale-ups and commercial deployment. Another major benefit of testing has been the identification of operational issues, not evident in lab-scale testing, which in most cases has yielded the bases for process improvements.



Layout of the Post-Combustion Carbon Capture Center (PC4), located at Alabama Power Plant

Post-Combustion CO2 Capture

The PC4 utilizes flue gas from Plant Gaston Unit 5, a base-loaded, 880-MW gross supercritical pulverized coal boiler fired with medium-sulfur bituminous coal. The unit meets all environmental requirements utilizing state-of-the-art controls, such as selective catalytic reduction, flue gas desulfurization (FGD), and an activated carbon injection baghouse. Thus, the flue gas extracted for testing is fully representative of commercial conditions.

As shown in the figure above, the center provides sites for technology developers' bench-scale and pilot-scale test units. The Pilot Solvent Test Unit (PSTU) and the bench-scale Slipstream Solvent Test Unit (SSTU) are fully integrated systems for comprehensive characterization of developer solvents. An air dilution system is also available for CO2 capture testing under simulated natural gas flue gas conditions.

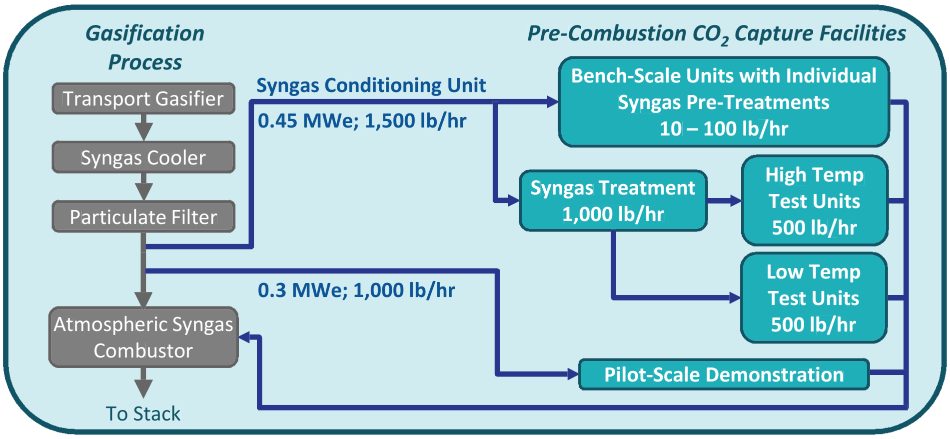
Operation of the PC4, which began in 2011, has included multiple test campaigns with the PSTU for over 14,400 test hours and about 33,000 test hours with technology developer test units. More than 6,000 test hours have been achieved under simulated natural gas flue gas conditions.

PSTU Operation

The PSTU was designed to achieve 90%

CO2 capture using a 30 wt% aqueous MEA solution. Previous testing demonstrated the PSTU's ability to achieve this objective with a regeneration energy requirement ranging from 1,530 to 1,706 BTU/lbCO2, while also achieving mass and energy balances near 100%.

The five major sub-systems of the PSTU are: a pre-scrubber which removes the small amount of SO2 remaining in the flue gas; a cooler/condenser unit that cools the flue gas to appropriate reaction temperatures and removes flue gas moisture; an absorber to promote efficient gas-liquid contacting to remove CO2 from the flue gas; a wash tower that cools the CO2-depleted flue gas, removing trace amounts of entrained solvent; and a regenerator that provides heat to release the CO2 from the solvent.



Layout of the syngas conditioning unit (SCU)

To date, 14 test campaigns have been conducted with technology developers' solvents.

Post-Combustion Projects Currently Under Development

NCCC has made preparations and provided design support for 2017 testing at the PC4 of the following projects:

• TDA Research will test a 0.5-MWe system to capture CO2 using an alkalized alumina sorbent in fixed bed reactors.

• Gas Technology Institute is developing a hollow fiber gas-liquid membrane contactor to replace conventional packed bed columns to improve CO2 absorption efficiency. Testing will be conducted at a 0.5-MWe scale.

• AECOM and UT-Austin will utilize the PSTU to test a piperazine solvent with an advanced flash stripper for solvent regeneration.

• Trimeric Corporation will test a project for incorporating NO2 scrubbing into the Pilot Bay 3 pre-scrubber to allow concurrent removal of SO2 and NO2.

• The NCCC is evaluating the feasibility of installing an SO3 additive system to aid in amine emissions studies following the Unit 5 baghouse installation.

Gasification & Pre-Combustion CO2 Capture

Using the Transport Gasifier, the NCCC generates coal-derived syngas which is available for testing technologies related to pre-combustion CO2 capture and high efficiency coal-based power generation. Under the current contract, the gasification process has operated over five test runs for about 3,800 hours.

The infrastructure for pre-combustion CO2 capture testing provides for a wide range of test conditions, and includes the Syngas Conditioning Unit (SCU), a flexible slipstream facility that can accommodate multiple, bench-scale tests, and test areas for small pilot-scale projects.

Shown in the figure above, the SCU consists of small reactor vessels, arranged to allow operation in series or in parallel, which accommodate a range of syngas flow rates, temperatures, and pressures. The facilities also have the capacity to test technologies in off-line operation with bottled gases.

Gasification/Pre-Combustion Projects Currently Under Development

The NCCC supported several projects that are to be tested in 2017, as listed below.

• TDA Research will test a 50-lb/hr unit comprising CO2 sorbent coupled with water-gas shift functionality.

• Tests will be conducted with a water-gas shift catalyst and a CO2 sorbent from the Korea Electric Power Corporation.

• A Scruton Well thermowell will be tested in gasifier service.

• MPT will test Arizona State University's zeolite membrane for hydrogen separation.

• Testing is planned for a hydrogen membrane from the Research Institute of Innovative Technology for the Earth.

Conclusions

The stated results from testing at the NCCC has proven the center's value in fostering the commercial development of advanced CO2 capture technologies crucial for future fossil-based power generation. The center has adapted its facilities to accommodate numerous technologies for both post-combustion and pre-combustion technologies.

Several of the technologies tested have been or are now being scaled-up as they move toward commercial deployment. The NCCC provides unique support equipment and services while generating reliable, accurate data.

The post-combustion and pre-combustion facilities are continually being modified as technology developers take the opportunity to perform multiple and long-duration tests while other technologies are being removed or added. Collaboration with additional developers for future tests is on-going.

More information

To download the full research update and other technical papers go to:

www.nationalcarboncapturecenter.com

Moody's: U.S. coal production to continue sharp secular decline without CCS

U.S. coal will remain in sharp secular decline unless CCS technology alters the dynamics according to a research report from Moody's.

Coal consumption by US power generators has steadily declined, with coal's share of the nation's fuel mix falling from roughly 45% in 2010 to 30% in 2017, says the report. The rapid contraction was brought on by cheap natural gas, advancements in renewable technology, regulatory uncertainty and consumer demand for green energy.

"Absent disruptive changes in available technology, policy and prices, we expect this trend to continue, with coal's share of US energy generation likely dropping to 20%-25% within a decade. At the same time, international thermal coal markets seem unlikely to bring material long-term relief to US producers, which are higher on the global cost curve and geographically removed from the growing coal-consuming regions in Asia."

While the long-term trend is not promising for US coal miners, the beleaguered industry may find a ray of hope in an unlikely place - the global climate-change movement, where a number of voices are calling CCS technology essential to curbing global warming.

"US market dynamics are not in coal's favour now, but this could change if policies supported CCS."

"Even without tax credits, and without CCS, building a new coal plant in the US today would be generally more costly relative to combined cycle natural gas, solar PV, and onshore-wind generation. We also note that the cost estimates for a new CCS equipped coal-fired plant on average are 25% higher than a conventional coal-fired plant, based on the current technology."

Costs vary widely, however, depending on region. If CCS were to be deployed in a more cost-effective manner, coal plants could become attractive investments in some areas from the economic, as well as environmental, perspective. According to the IEA, there is rich potential for cost efficiencies in further CCS development, with the first-of-a-kind CCS projects already identifying future cost reductions close to 30%.

At the moment, no new coal plants are being built in the US, partially due to the uncertainty surrounding the Clean Power Plan (CPP), issued by the Environmental Protection Agency (EPA) in August 2015. The Clean Power Plan essentially prohibited the building of new coal-fired power plants, unless they were equipped with CCS technology. Although EPA proposed to repeal the CPP

Key highlights from the report

- US coal production will continue a steady, secular decline without policy support for, and continued investment in, carbon capture and storage (CCS) technology. We believe any positive effect CCS development could have on the US coal industry is many years away. It would also require significant policy support and a substantial ramp-up in investment.

- If coal were to become more cost-competitive vis-a-vis other fuels such as natural gas, environmental concerns would likely still keep the industry in decline, unless CCS technology were widely adopted. Although we do not expect economics to change in coal's favor in the near-term, its competitive position may be helped in the long run by, for example, growth in liquefied natural gas (LNG) exports.

- A number of entities, including the International Energy Agency (IEA) are calling carbon capture technology essential to curbing global warming, because some coal-fired electricity generation will remain in the global fuel mix if all of the world's population is to enjoy access to electricity and modern lifestyle.

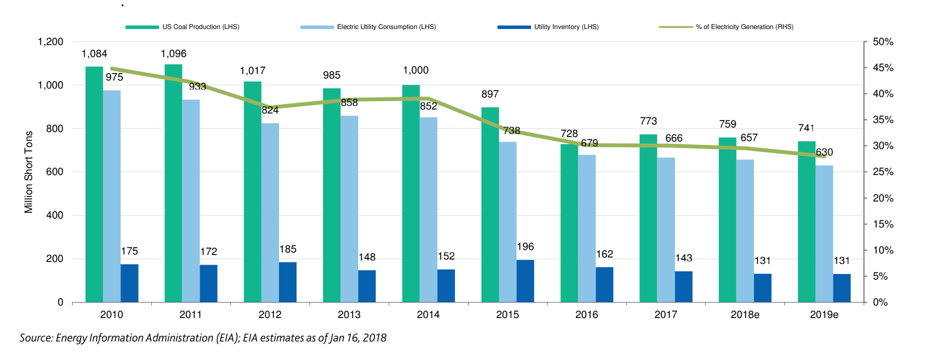
- Thanks to several CCS projects already in operation, many technological barriers to its continued deployment have been lifted. Its continued development could be a gamechanger for US coal producers in the long run, in that it could curb the slide of coal consumption at home.

- However, the necessary investment has been lagging, because of local cost economics as well as political and regulatory factors. Most CCS projects currently in operation or under development are in Canada and the US. This is partially due to using captured CO2 to enhance oil recovery, which offers an additional revenue stream in these areas. Nevertheless, the developed nations are focusing their decarbonization efforts on shifting the fuel mix away from coal, primarily due to abundant availability of cost-competitive (and often subsidized) alternative fuels.

- Clean-coal technologies are essential to ensuring environmental sustainability in Asia. This is where developing economies are poised to drive a steady growth in global coal consumption over the next two decades. However, due to the lack of opportunities to use captured CO2 in oil fields, CCS development has not gained momentum in the region. Implementing CCS in these areas would require the development of carbon transport and storage infrastructure. This is a complex and costly undertaking that would likely require cooperation among governments, substantial funding, and a system to manage related long-term environmental liabilities.

in October, public hearings with respect to this move are ongoing and the future of the regulation is uncertain.

Coal is an abundant resource that plays an important role in grid reliability and fuel diversity, and these factors could move to the forefront of policy considerations, particularly if the environmental footprint was less of a concern. The recent study on grid reliability by the US Department of Energy noted baseload power generation, critical for grid stability, is generally provided by nuclear, coal, or natural gas steam generators. The DOE called for further study and reform to address services essential to grid reliability and resilience.



US coal consumption is in secular decline

For example, it highlighted that the increasing use of variable renewable energy (VRE) sources such as wind and solar could make grid resource management more complex.

Such reliability considerations, along with deep decarbonization requirements, could support CCS development over time. Policy support and continued investment in CCS could be a game-changer for US coal miners, particularly if there was a material change in price dynamics between coal and natural gas.

"Although we don't expect economics to change in coal's favor in the near-term, its competitive position could be changed in the long run, for example, by growth in liquefied natural gas (LNG) exports which could increase the price of natural gas. It's worthwhile noting, for example, that IEA expects the US to become the leading LNG exporter by mid-2020s."

More information

Download the full report:

www.moodys.com

Capturing and using CO2 from Ethanol

The ethanol industry has a strategic opportunity to deploy technology and infrastructure that would both increase its revenue and beneficially reduce carbon emissions says a report from the State CO2-EOR Deployment Work Group.

In a paper, the State CO2-EOR Deployment Work Group explored the opportunities for energy production, expanded economic development and emissions reduction potential from capturing and utilizing CO2 from ethanol production. The paper also described the federal and state policies needed to foster further commercial deployment. The Work Group turns to this topic as a follow-up to its December 2016 report recommending federal and state carbon capture deployment incentives.

These incentives are essential to enabling private investors to finance carbon capture at ethanol facilities, power plants and other industrial facilities, as well as pipelines to transport the CO2 to oilfields and saline formations where it can be used and stored.

The biofuels industry has a history of innovation to reduce energy and water use, drive down costs, generate new sources of revenue from value-added byproducts, and lower the carbon intensity of ethanol. As it has improved energy efficiency and lowered emissions, the industry has sought new revenue opportunities from products that add value beyond the ethanol itself.

Fermentation in ethanol production yields 99.9 percent pure CO2, which can become an additional value stream; in fact, the industry has sold biogenic CO2 to the EOR industry for nearly a decade. Further deployment of carbon capture presents a significant economic opportunity for the ethanol industry through the oil industry's purchase and beneficial use of CO2.

Proposed federal and state financial incentives and credits obtained by storing CO2 geologically through EOR or its injection into saline formations could provide additional economic value. Moreover, when the carbon accumulated in corn or other biomass feedstocks through photosynthesis is captured during fermentation, rather than released back to the atmosphere, even deeper reductions in lifecycle carbon emissions can be achieved. This, in turn, enhances the value of the ethanol produced in key markets where public policy increasingly demands reductions in carbon intensity.

Net lifecycle emissions reductions from the capture of biogenic CO2 from ethanol fermentation can be significant. The application of carbon capture to cornethanol plants in the U.S. has the potential to reduce the carbon intensity of resulting biofuels production by upwards of 40 percent, if the captured CO2 is stored in saline geologic formations. In the case of storing captured CO2 in oilfields through EOR, large net emissions reductions still result, even after accounting for the additional oil produced.

Recent analysis from the International Energy Agency (IEA) shows that, after accounting for the additional oil produced and global market effects, every ton of anthropogenic CO2 delivered for CO2-EOR results in a 63 percent emissions reduction.

The paper focuses on commodity use and geologic storage of CO2 from ethanol production through EOR, the most commercially-ready pathway that could scale rapidly with policy reform, as well as on storage in saline formations. However, other innovative technologies and processes are under development to transform CO2 directly into valuable fuels, chemicals and other valuable products. These alternative utilization options will benefit from the policies discussed, and they also have the potential to add value to ethanol producers, while reducing carbon emissions.

Public policy is needed to overcome challenges to commercial deployment of carbon management in the biofuels industry. At today's low oil prices, the cost of carbon capture, compression, dehydration and pipeline transport from ethanol fermentation exceeds revenue from selling that CO2 to the oil industry. While the costs of carbon capture from ethanol are low compared to most other industries, the heartland of U.S. ethanol production in the Central Plains, Upper Midwest and Midwest is geographically distant from large oil basins with the greatest potential for EOR and storage. This requires investment in large-volume, high-pressure pipelines needed to transport CO2 over long distances.

Some ethanol production does occur in close proximity to suitable saline reservoirs, but saline storage provides no revenue from CO2 sales for EOR, offsetting the financial advantage of avoiding major pipeline investments. Fortunately, economic analysis completed for the Work Group suggests that federal and state financial incentives under consideration could help bridge the current cost gap in the marketplace and mitigate investment risk by incenting private capital to invest in carbon capture at ethanol plants and pipeline corridors to serve ethanol-producing regions.

The Great Plains Institute and Improved Hydrocarbon Recovery, LLC modeled CO2 capture, dehydration, compression, and pipeline transport from Midwestern ethanol plants to oilfields for EOR under two illustrative scenarios: a pipeline network connecting 15 ethanol plants in Nebraska and Kansas to multiple oilfields in Kansas; and a regional-scale pipeline network linking 34 of the largest Upper Midwestern ethanol plants to the Permian Basin in Texas.

The analysis finds a CO2 price in the range of $54 and $73 per metric ton (MT) is required across the two scenarios to cover CO2 capture, dehydration, compression and pipeline transport. The results of this analysis show that federal and state policies under consideration, coupled with revenue from the sale of CO2 for EOR, could help make deployment of carbon capture from ethanol production and CO2 pipeline infrastructure commercially feasible.

The Work Group's highest policy priority was extension and reform of the federal Section 45Q Tax Credit for Carbon Dioxide Sequestration, which has now been achieved.

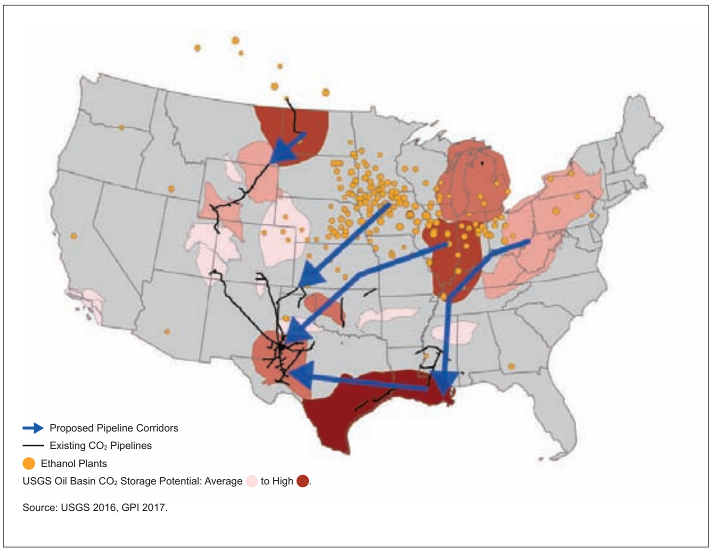
The absence of pipeline infrastructure in key states and regions poses a further obstacle to scaling up carbon management in ethanol production. The Work Group released a paper earlier this year recommending that Congress and the Administration incorporate and prioritize the buildout of long-distance, large-volume CO2 pipelines as part of a broader national infrastructure agenda; help finance increased capacity for priority trunk pipelines in states and regions not currently served by such infrastructure; and identify and foster the development of five priority CO2 pipeline corridors through support for planning, permitting, and financing.

At the state level, policies to reduce the carbon intensity of transportation fuels, particularly low carbon fuel standard (LCFS) policies, could complement federal incentives in stimulating private investment in carbon capture and CO2 pipeline infrastructure. In some cases, such as California's LCFS, carbon credits valued at approximately $80 per MT could drive project deployment, with or without additional federal policy. The relative impact and benefit of LCFS policies in California and other jurisdictions depends largely on the regulatory framework that accompanies their implementation. The Work Group has significant concerns that proposed regulatory requirements in the California Air Resources Board's (ARB) current rulemaking would make it impossible for the ethanol and EOR industries to establish a viable carbon management business model based on LCFS compliance.

While the ethanol and oil industries traditionally have different interests in energy and environmental policy, Work Group participants believe important common ground can be forged around expanding the capture and beneficial use of biogenic CO2 from ethanol production and its associated carbon management through EOR and saline storage. Federal policies recommended by the Work Group in this paper are not expected to spur construction of new corn ethanol plants or increase overall production.

However, working in partnership with the EOR operators, ethanol producers and their investors could harness the revamped 45Q tax credit, together with PAB and MLP eligibility, to tap into evolving lowcarbon fuel product and credit markets, positioning them to capture financially the added environmental value inherent in producing fuels with a lower carbon footprint. These policies would also foster a marketbased approach to American energy independence and job creation by producing oil here at home through CO2-EOR, helping to displace current imports of more carbon-intensive imported crude and significantly reducing total emissions in the process. Federal legislative action is critical.

As the paper's analysis of the economics of carbon capture from ethanol production shows, widespread deployment will not occur without financial incentives to enhance financial feasibility and reduce market risk to investors and project developers. Carbon capture merits federal incentives and other policies comparable to those that have proven highly-effective in fostering private investment in early commercial deployment of wind, solar and other low and zerocarbon energy technologies and in achieving innovation and cost reductions.



CO2 Pipeline Corridors proposed by the State CO2-EOR Deployment Work Group

Conclusion

Widespread deployment of carbon capture represents an important next step in the commercial evolution of the biofuels industry, which has a history of innovation to reduce energy and water use, drive down costs, generate new sources of revenue from value-added byproducts, and lower its carbon intensity. As the industry has improved energy efficiency and lowered emissions, ethanol producers have sought diversity and increased revenue from the development and marketing of byproducts that add value beyond the ethanol itself. Carbon capture presents a further opportunity for the biofuels industry to generate additional economic returns from the oil industry's purchase of CO2 and from permanent and safe geologic storage of CO2 through EOR and in saline formations.

However, up-front costs of installing carbon capture, compression, and dehydration and building out new pipeline infrastructure limit further commercial deployment. Federal and state policies could help bridge the financial gap and reduce risk, attracting private capital to invest in carbon capture and CO2 pipeline projects that serve the ethanol industry, which will in turn foster further innovation and cost reductions.

The results of the analysis in this paper show that revenue from the sale of CO2 for EOR, combined with the proposed federal 45Q tax credit and complemented by eligibility for tax-exempt private activity bonds and master limited partnerships, could enhance the feasibility of deploying carbon capture from ethanol production and the necessary pipeline infrastructure to transport that CO2 to oilfields where it can be put to beneficial use and stored. These federal policies also have the potential to support further geologic storage of CO2 from ethanol in saline formations to achieve even greater emissions reductions.

State low carbon fuels policies such as the California LCFS could also help drive private investment in large-scale carbon management by ethanol producers seeking to comply with LCFS requirements by capturing and storing CO2 from fermentation. However, California and other jurisdictions need to develop accompanying regulatory frameworks that enable the industry to establish a commercially viable carbon capture and storage business model around LCFS compliance.

The capture of biogenic CO2 from fermentation in ethanol production can play a key role in scaling up carbon management for domestic energy production and geologic storage, thus contributing to American energy independence, protecting and creating high-paying jobs and significantly reducing net carbon emissions.

More information

www.betterenergy.org

U.S. news

New funding announced by Department of Energy

netl.doe.gov

The U.S. Department of Energy (DOE) has selected six projects to receive $17.6 million in federal funding under the Office of Fossil Energy's Novel and Enabling Carbon Capture Transformational Technologies funding opportunity announcement.

The funding will address the cost and operational challenges associated with current CO2 capture technologies that are commercially available for industry, providing for additional development to these technologies at coal-fired power plants. Some of the challenges that will be addressed include a need to improve the reliability and operational flexibility; reduce high capital costs; and reduce the high-energy penalty associated with operating existing technology.

The National Energy Technology Laboratory (NETL) will manage the selected projects, which will concentrate on transformational technologies that fall under two areas of interest.

Area of Interest 1 focuses on developing transformational materials and processes for carbon dioxide (CO2) capture that will enable step-change reductions in the capital and energy cost. Area of Interest 2 focuses on enabling technologies that facilitate improved performance of transformational CO2 capture processes to reduce capital cost and energy penalties, and improve operational reliability and flexibility.

The following five projects were selected under Area of Interest 1:

• Development and Bench-Scale Testing of a Novel Biphasic Solvent-Enabled Absorption Process for Post-Combustion Carbon Capture – **The Board of Trustees of the University of Illinois** (Champaign, IL) will advance the development of the transformational biphasic CO2 absorption process (BiCAP) technology.

It will also validate its technical advantages by testing an integrated BiCAP system at a bench scale in an actual flue gas environment. BiCAP is a post-combustion CO2 capture technology that has the energy efficiency advantage of a phase-transition process, while incurring low equipment and operating costs.

• Bench-Scale Development of a Transformational Graphene Oxide-Based Membrane Process for Post-Combustion CO2 Capture – **Institute of Gas Technology dba Gas Technology Institute** (GTI) (Des Plaines, IL) will develop a transformational graphene oxide (GO)-based membrane process for installation in new, or retrofit into existing, pulverized coal (PC) or natural gas power plants. The process will be used for CO2 capture with 95 percent CO2 purity.

The proposed transformational GO-based membrane process (designated as GO2) integrates the GO-1 and GO-2 membranes and will offer a new opportunity to explore further reductions in the cost of CO2 capture. The successful development of the proposed technology will enable cost-effective capture of CO2 from flue gases.

• Development of Self-Assembly Isoporous Supports Enabling Transformational Membrane Performance for Cost-Effective Carbon Capture – **Membrane Technology and Research, Inc.** (MTR) (Newark, CA) will develop composite membranes with a transformational performance to reduce the cost of CO2capture.

The project consists of two parallel technology developments. The first development is to double membrane permeance by replacing conventional porous supports used to fabricate composite membranes with novel isoporous supports. The isoporous supports could overcome flow restrictions in conventional supports that hinder further improvement in carbon capture membranes.

The second development is to double the mixed-gas selectivity of the MTR Polaris membrane by building on recent new materials work conducted at the University of New York at Buffalo.

• Mixed-Salt-Based Transformational Solvent Technology for CO2 Capture – **SRI International** (Menlo Park, CA) will develop a water-lean, mixed-salt-based transformational solvent technology that will provide a step-change reduction in the CO2 capture cost and energy penalty. The proposed new formulation should further improve the economics of CO2 capture.

The project team includes experts from SRI International (USA), SINTEF (Norway), Technical University of Denmark (Denmark), OLI Systems (USA), and Trimeric Corporation (USA), representing premier research organizations, academia, and industry.

• A Process with Decoupling Absorber Kinetics and Solvent Regeneration Through Membrane Dewatering and In-Column Heat Transfer – **University of Kentucky Research Foundation** (Lexington, KY) is developing an intensified process to significantly reduce the capital and operational costs associated with CO2 capture. This process could be applied to most advanced solvents (aqueous or non-aqueous) and flue gas derived from either coal or natural gas combustion.

The integrated process consists of a temperature-controlled absorber; a membrane-based dewatering unit; and a multiple-feed pressurized stripper. The successful development of the proposed technology will include continued utilization of abundant, low-cost coal to produce reliable electricity, while affordably meeting and managing environmental concerns.

Major participants include the University of Kentucky Research Foundation, Lawrence Livermore National Laboratory, Media and Process Technology, Smith Management Group, and Trimeric.

The following project was selected under Area of Interest 2:

• Flue Gas Aerosol Pre-Treatment Technologies to Minimize Post-Combustion CO2 Capture Solvent Losses – **Linde, LLC** (Murray Hill, NJ) will research, develop, and validate enabling technologies for solvent aerosol emission mitigation of coal-based flue gas.

The project will evaluate two flue gas aerosol mitigation technologies that have the potential to significantly reduce flue gas aerosol concentrations—which have been shown to contribute to amine losses in solvent-based post-combustion CO2 capture systems.

The results will be used to benchmark the performance and cost of these technologies against existing options for pretreatment of coal-based flue gas for aerosol mitigation. The impact of this reduction in aerosol concentrations could be leveraged across a variety of solvent-based post-combustion CO2 capture systems to minimize solvent losses.

STEMM-CCS: Delivering new approaches, methodologies and tools for the safe operation of offshore CCS

STEMM-CCS will provide a set of tools, techniques and methods to enhance understanding of CCS in the marine environment. A key component of the project is an experiment in the North Sea at the Goldeneye site, which has been identified as a potential CCS storage complex.

Deploying a lander in a precise location is made difficult by sea conditions (Image: P.Linke)

At all stages of the carbon dioxide capture and storage process challenges emerge which require innovative solutions that, in Europe, ensure adherence to the so-called 'CCS Directive'. The crux of this directive is to provide a legal framework to ensure that in whatever type of geological storage the gas is stored, it is done in an environmentally safe manner for the entire life time of the storage site. Having confidence that leaks do not occur, or if they do that they are detected quickly, is key to meeting the directive's aims.

The European Union Horizon 2020 Strategies for Environmental Monitoring of Marine Carbon Capture and Storage (STEMM-CCS) project has been designed to deliver new approaches, methodologies and tools for the selection and safe operation of offshore carbon dioxide capture and storage sites.

Drawing together expertise from across European academia and industry, STEMM-CCS will provide a set of tools, techniques and methods to enhance our understanding of CCS in the marine environment. At the heart of the project is the development or enhancement of sensing technologies, which also have applications beyond the CCS arena and may be suitable for commercialisation.

CO2 - a difficult gas to trace

Not only does CO2 dissolve in sea water it reacts with it too, to form carbonate and biocarbonate ions. CO2 is also crucial in as a source for biogeochemical processes but it can also be a product. So CO2 is a reactive gas with many and varied sources and sinks; this makes it difficult to differentiate between 'natural' CO2 and a leak.

An aspect of STEMM-CCS being led by researchers at Southampton University is to use tracers included as any CO2 is pumped into a reservoir, and detectable in the unlikely event of a leak. Because of the potential scale of commercial CCS any such tracers should be detectable in very low concentrations, have a very low background concentration and/or have a characteristic isotope signature. Such tracers will be useful in all leak scenarios but especially where a leak is weak in environments that may natural fluctuate strongly.

Crucial to the success of exploiting tracers is being able to gain in situ samples for rapid analysis. During the proposed injection experiment at the North Sea Goldeneye site, in collaboration with industry partners, Shell, tracers will be included during injection. The site has already been characterised to determine background levels of any tracers being used, providing baseline data from samples of sediment, pore water and water column.

Natural variability complicates detection

Detecting and monitoring any potential CO2 leakage is complex and can be affected by a range of external influences, including tides, currents, temperature and the natural variability of pH (or pCO2), for example. The chemical signature of a leak might be very small, especially at a distance from the source, so understanding natural variability is essential in detecting potential leaks.

It is known that many physical and biological processes can cause variability over time and spatially. Data are inevitably in short supply and so Plymouth Marine Laboratory's modelling group are using complex simulation models that contain all of the processes known to affect pH in the marine environment in an attempt to determine what are the best criteria to use for distinguishing between natural variability and a leak. The modellers used data from three sites in the North Sea and immediately found that pH dynamics at each of the sites is different.

This implies that any monitoring strategy optimised for one site, might not be suitable elsewhere. Against the background of natural variability which changes slowly, models indicate that rapid rate changes might be better indicators of a leak. At the Goldeneye site, which is the least variable of the three sites, a change as tiny as 0.01 pH units over 20-40 minutes could be considered a robust indicator of an anomaly.

Models quantify leaks

Heriot-Watt modellers have been developing another model – a Multi-Scale Multi-Phase Prediction Model which will show the effects of any leaks across various scales, from centimetres to kilometres, in the North Sea Shelf's coastal waters.

Alongside this model development the researchers are also looking at bubble sizes, which are another contributor to impacts on the marine environment during leakage, with smaller bubbles dissolving quicker and creating a more localised impact than larger bubbles. Both optical visualisation and passive acoustic monitoring techniques are being investigated to identify which is best under differing circumstances.

Deploying skilled models is a much more cost-effective way of derive baseline data, to explore a range of release scenarios and optimize site specific detection criteria than large observational programmes.

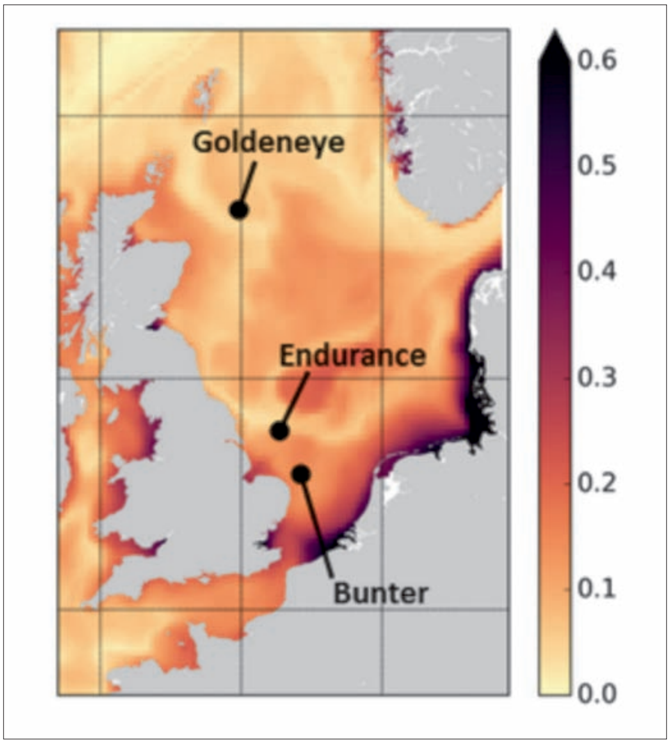
Designing a survey

Detecting real or potential leaks will be a routine operation during monitoring surveys, but areas may be large and choices of likely leakage sites will prove difficult. Autonomous Underwater Vehicles (AUVs) are obvious vehicles for carrying out such work, but how can we be sure that any survey has sampled for CO2 at the correct locations, and how do we decide on those locations in the first place? Guttorm Alendal, (University of Bergen) has been applying Bayesian theory, which offers an approach to update our beliefs in a systematic manner after receiving new information, or learning from experience, to plan survey paths.

The idea is that provided sufficient baseline data is available a CO2 release can be detected away from the direct source, so a sample that shows no evidence of a leak probably also means that a gas leak in the surrounding area is also unlikely.

Surveys will start with a map of what are thought to be the most likely leak locations, determined from the best knowledge available, the map will be updated after every sample is taken, enabling the AUV to 'decide' where to search next. The research also looked at how to conduct a search bearing in mind that the longer the search distances between likely leak sites, the more battery power is used, so is it better to check nearby localities, sample in transit, or simply go from an identified likely site to another likely site?

This work will help to refine search survey path design and inform the positioning of fixed monitoring installations. Of course the initial set up of likely locations has to come from thorough site characterization including environmental baseline studies, transport modelling and knowledge of the processes that influence the sites.



The annual range of pH in NW European shelf seas. (JC Blackford)

Understanding pathways

Understanding how gases and liquids move through geological strata and finding areas of weakness that may provide pathways to the water column is essential when it comes to predicting potential leakage locations, and hence for the positioning of detection and monitoring equipment.

Pockmarks on the seabed are thought to be surface 'fingerprints' of leakage, indicating that gases such as methane have migrated upwards in the recent geological past, and so are obvious points to investigate. The Scanner Pockmark, actually two overlapping pockmarks, each a few hundred metres across, contains sites of active and persistent methane gas venting.

The CHIMNEY project - a UK Natural Environment Research Council-funded project designed to complement STEMM-CCS, has carried out fieldwork to try and understand the geometry and physical properties of the fluid pathways that feed the vents, so giving insight into potential leakage pathways from CO2 storage sites. The theory is that if a subsurface plume should reach the base of a 'chimney' or 'pipe' that is sufficiently permeable, it could provide access to the water column. Seismic reflection data gained during STEMM-CCS surveys shows that such structures cutting through the overburden are ubiquitous within the North and Norwegian Seas.

A team of STEMM-CCS scientists, led by John Bull (University of Southampton), aboard the RRS James Cook carried out seismic surveys over the pockmarks. This work built upon the first STEMM-CCS cruise aboard the RV Maria S Marian, earlier in the year, which collected seismic and electromagnetic data.

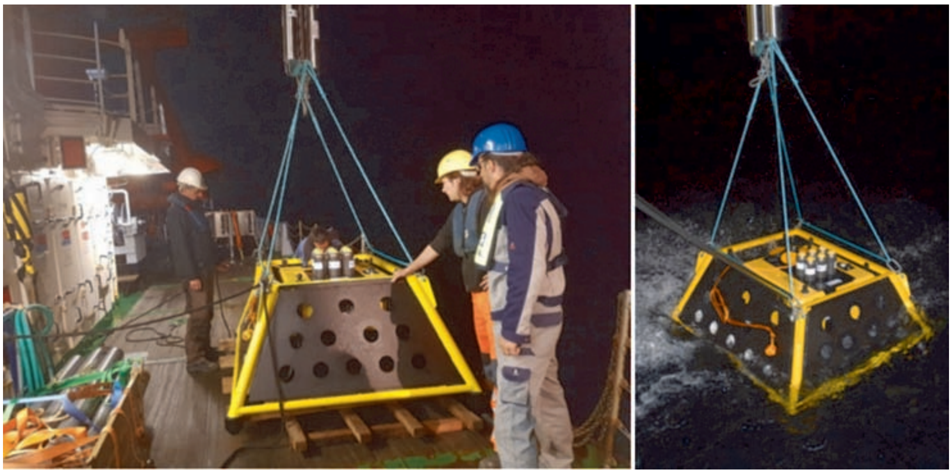
Technological innovation – NOC Lander

When attempting to detect changes in the marine environment, and distinguish between natural and anthropogenic variation, it is essential to obtain environmental baselines for the variables that are to be measured. In preparation for the planned controlled CO2 release in 2019 an autonomous, in situ, seafloor lander has been developed by the National Oceanography Centre, UK and partners at GEOMAR, Germany.

It has been deployed during a research cruise in October 2017, which gave the opportunity to test communications and ensure that all the sensing devices were operating successfully. The NOC-Lander is equipped with an array of sensors to monitor temperature, conductivity, pressure, current speed and direction, hydro-acoustic, pH, pCO2, O2 and nutrients in the experimental area over a period of around ten months.

The NOC Lander has been manufactured by Develogic GmbH - subsea systems and carries, acoustic Doppler current profiler, to sample 40 metres of water column above the seafloor; a SeaBird Scientific Deep SeapHOx system to measure salinity, oxygen and pH at 20 minute intervals with high precision for assessing baselines.; a SONO Vault hydrophone will record underwater sound and 'listen' for bubbles coming from the seafloor as in a leak; Lab-on-a-chip NOC sensors will accurately measure concentrations of chemical elements every six hours, while TUG self-loggers provided by the University of Graz, will monitor pH and pCO2 every hour.

Data will be collected to expendable communication buoys which will 'pop up' to the surface allowing data access via Iridium satellite communication.



Night time deployment of NOC lander during cruise POSS18 (Image: Mario Esposito)

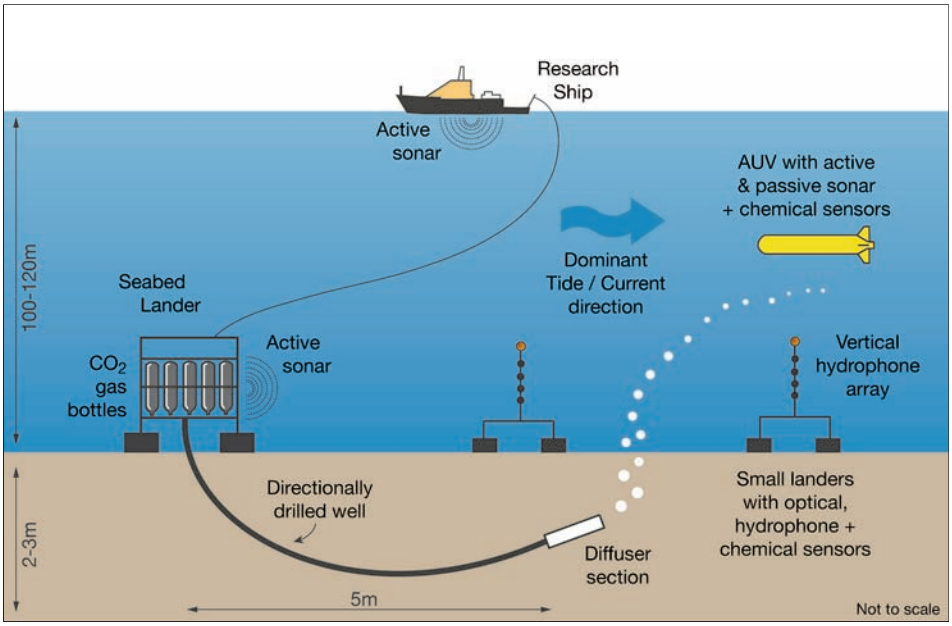
Toward 2019

Developing methods and technologies for CO2 detection is the crux of STEMM-CCS and work continues to gather data, build upon expertise and knowledge through experiences gained during the project. Models are being modified or developed to enable efficient detection and characterisation of leaks: geological survey methods are increasing our understanding of how and when and where leaks might occur. Other work concentrates on how Sealife in the proximity of a leak might be impacted, while models are providing some idea of how long the effects of a leak might persist.

Research and development effort so far has its own interest and significant outputs, but it will really all come together in late spring 2019, when a research cruise to the Goldeneye site puts things through their paces. The site will provide the thoroughly characterised location for an injection experiment involving drilling into the seabed and pumping in CO2 marked with tracers as a test for detection, monitoring for spread and duration of a leak plume.

It may sound easy though the challenges are immense – but the whole STEMM-CCS consortium is confident that what they learn will have wide application across the sub-seabed CO2 storage community.

Engagement with policy makers and stakeholders to ensure the widest possible exchange of knowledge, including with countries outside Europe that are currently developing offshore CCS, is a working priority for STEMM-CCS. Contact details can be found on the website.



Schematic of activities and detection/monitoring technology to be used un the 2019 research cruise

More information

Copies of the STEMM-CCS brochure, which provides an introduction to the project, and issues of the latest newsletters can be downloaded at:

www.stemm-ccs.eu/resources

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Energy Institute report shows oil & gas industry support for CCS

A new report, "The future of gas: The role of natural gas in the future global energy system," published by the Energy Institute, sheds light on the attitudes of global oil and gas professionals towards reducing the climate change impacts of natural gas.

While much of the debate about cleaning up gas has focused on the technologies required, the EI report finds lack of awareness could also be holding back progress.

The survey found 90% of oil and gas professionals see a role for industry in developing and implementing carbon capture and storage (CCS), but two-thirds express surprise at the scope for reducing potent fugitive methane emissions in their own operations.

Speaking at IP Week, EI President Malcolm Brinded CBE FREng FEI said, "There's an elephant in the room of the global energy system and it's called natural gas. It looks like a golden age for gas, with unconventional production soaring and global LNG trade forecast to more than double by 2040. But at the same time the world has committed to keeping temperature increases within 2°C, requiring net zero emissions in the second half of this century.

"Even natural gas's cleaner-than-coal and friend-to-renewables advantages will not be enough to square this circle. For it to fulfil its potential long-term role in the low carbon world, more must be done to clean up how it is produced and how it is burned.

"Oil and gas professionals take a largely positive view of the potential to tackle carbon emissions from combustion. Those surveyed believe carbon capture and storage (CCS) has the greatest potential of any technology to reduce emissions in the natural gas lifecycle. Of those working in potentially relevant organisations, just over half report that their organisations are active in advancing the CCS case."

"It is likely that moving from a few demonstration projects to full-scale implementation will require much more widespread policy support. However, nine out of ten respondents believe that industry has a primary role to play in developing and implementing CCS, with half of these emphasising the need for government-industry cooperation."

"The EI report's findings are a call for action across the industry. Just as health and safety are embedded in operating cultures, tackling climate change in all ways needs to become equally – and profoundly – part of business-as-usual. It must enter all our DNA."

Key findings of the report

- Most respondents to the survey are confident about the role of natural gas through to 2050. They also take a largely positive view of the potential to tackle carbon emissions from combustion, believing CCS offers the greatest potential of any technology to reduce emissions in the natural gas lifecycle. Nine out of ten believe industry has a role to play in developing and implementing CCS.

- But on methane leakage during production, too many professionals underestimate the significance of fugitive emissions, and the possibilities for reducing them cost effectively. Two thirds expressed surprise at the extent of the problem and these possibilities within their own operations.

- Natural gas is an abundant and flexible fuel. It contributes to reducing climate change impacts when it displaces coal in power generation and heating, with some 40% less CO2 emitted. Gas also significantly reduces local air pollution from small particulates and from sulphur dioxide, relative to coal burning and also relative to diesel fuels in transport.

- Nevertheless methane is emitted during the production of gas. Methane as a greenhouse gas is 28–36 times more potent than CO2 over 100 years. The International Energy Agenda (IEA), in its World Energy Outlook 2017, has assessed that much more could technically be done during production and distribution of natural gas to reduce leakage of methane. It found that it is possible to avoid 75% of current methane emissions in the natural gas supply chain, and that 40–50% of these emissions could be avoided at no net cost.

What are the best measures for decarbonisation?

Global oil and gas professionals see carbon capture and storage as essential to decarbonising natural gas, and believe their own industry has a primary role to play in its development.

Respondents ranked large-scale CCS deployed at point of combustion as the most effective technological measure to reduce natural gas emissions. When asked who should lead on developing CCS, industry does not shy away from its role. 46% of respondents believe that their industry should take the lead in developing the technology and pilot plants without relying on government support, while 42% think that CCS should be developed and implemented through close cooperation between industry and government. Only 7% responded that CCS should primarily be the responsibility of governments to either mandate or sufficiently incentivise.

Of those respondents whose organisations could have some involvement with CCS (those who did not select 'N/A'), just over half report that their organisations are active in advancing CCS.

Of the respondents in organisations that could be involved with CCS, 27% support early stage CCS R&D, 24% are involved in some large-scale CCS pilots and projects, 22% try to mobilise government support for an appropriate policy framework to support CCS development and 15% work in some way to make CCS a more investable proposition. In total, just over half of respondents (55%) indicated that their organisation was involved in one or more of these efforts to advance CCS. 42% of organisations have opted not to undertake any activity towards its development.

"The high proportions of respondents replying that industry should lead in developing CCS, and whose organisations were already involved in CCS in some way, indicates that there is interest and activity relating to CCS in these sectors," said Dr Nick Hughes, UCL Institute for Sustainable Resources.

"However, scaling CCS technologies up to full scale demonstrations is not straightforward, and 42% of respondents felt that the development of CCS requires 'close cooperation between industry and government'. It is now crucial for governments to work with industry to understand what such a 'close cooperation' could look like, and what each party's most effective role could be in relation to CCS development."

More information

www.energyinst.org

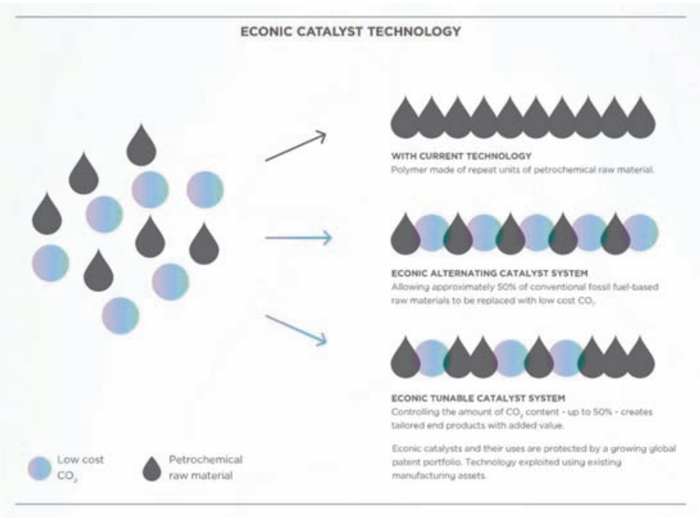
UK's first carbon capture utilisation demonstration plant opens

Econic Technologies has opened a demonstration plant in the North of England to show customers how its catalysts enable the production of polyols for greener plastics.

The new plant is located in Runcorn, at The Heath, one of the UK's leading independently-owned business and technical parks. It comprises all elements of the production process, integrated from reaction through to final product treatment, in a bespoke industrial unit. Opening its new plant at The Heath demonstrates Econic Technologies' long term commitment to the North West following its relocation from London to Cheshire in 2017, with the company adding 12 new jobs across its two Cheshire locations since the move.

The new demonstration plant is an exciting step forward in Econic Technologies' journey to help manufacturers unlock the positive potential of waste CO2. Until now, the creation of polyols from CO2 has been performed in plants at high-pressures and temperatures. Thanks to its new tunable catalyst, Econic Technologies' plant will be able to produce samples of CO2-based polyols at lower, industrially relevant temperatures and pressures.

The launch of the plant comes just weeks after Econic announced that they had closed a major founding round which saw climate investment group OGCI Ventures coming on board alongside existing investors. As well as private capital investment, the demonstration plant has also received substantial European support through a Horizon 2020 SME Award. Rulande Rutgers, Head of Process and Product Engineering at Econic Technologies explains: 'Securing such highly competitive public funding has been an important vote of confidence for Econic Technologies, and is allowing the company to accelerate development pace. Using some of this funding for the new demonstration plant is one way it is helping turn the potential of our catalysts into reality."



Rowena Sellens, CEO of Econic Technologies, commented, 'The demonstration plant is essential to helping our pioneering catalyst technologies develop as they move out of the lab and into the factory.

'As a company, we want to help drive the market adoption of polyols and our new plant provides an opportunity for us to encourage significant uptake in the industry. The interest from polyol manufacturers and downstream polyol users in the plant has been overwhelming already. We are extremely confident that once we start demonstrating what our technology can do, we will help catalyse a transformation in attitude when it comes to the positive potential of carbon.'

Econic Technologies' catalysts enable manufacturers to reuse waste CO2, by allowing it to be incorporated as a feedstock, which offers not only a sustainable benefit by reducing the reliance on fossil fuels but also an economical benefit by enhancing margins. The company hopes that by 2027, 30% of all polyol production will take place using Econic's catalyst technologies, which could save 3.5 million tonnes of CO2 emissions each year – the equivalent to taking two million cars off the road.

More information

econic-technologies.com

Negative emission technologies role in meeting Paris Agreement targets

A report by the European Academies' Science Advisory Council (EASAC) finds that NETs have "limited realistic potential" to halt increases in the concentration of greenhouse gases in the atmosphere at the scale envisioned in the Intergovernmental Panel on Climate Change (IPCC) scenarios.

Senior scientists from across Europe have evaluated the potential contribution of negative emission technologies (NETs) to allow humanity to meet the Paris Agreement's targets of avoiding dangerous climate change.

The report finds that none of the NETs has the potential to deliver carbon removals at the gigaton (Gt) scale and at the rate of deployment envisaged by the IPCC, including reforestation, afforestation, carbon-friendly agriculture, bioenergy with carbon capture and storage (BECCs), enhanced weathering, ocean fertilisation, or direct air capture and carbon storage (DACCs).

"Scenarios and projections that suggest that NETs' future contribution to CO2 removal will allow Paris targets to be met appear optimistic on the basis of current knowledge and should not form the basis of developing, analysing, and comparing scenarios of longer-term energy pathways for the EU. Relying on NETs to compensate for failures to adequately mitigate emissions may have serious implications for future generations," says the European science academies.

Summary

Climate scenarios that keep global warming within Paris Agreement limits rely on large-scale application of technologies that can remove CO2 from the air on a huge scale. This is necessary to compensate for the inadequacy of currently planned mitigation measures, which would lead to cumulative emissions of greenhouse gases (GHGs) overshooting the levels that are compatible with avoiding dangerous climate change. The credibility of such scenarios needs to be properly assessed since relying on such technologies to compensate later for failures to adequately mitigate emissions has serious implications for future generations.

"Having reviewed the scientific evidence on several possible options for CO2 removal (CDR) using negative emission technologies (NETs), we conclude that these technologies offer only limited realistic potential to remove carbon from the atmosphere and not at the scale envisaged in some climate scenarios (as much as several gigatonnes (one billion or 109 tonnes) of carbon each year post-2050)."

Negative emission technologies may have a useful role to play but, on the basis of current information, not at the levels required to compensate for inadequate mitigation measures. Implementation is also likely to be location-, technology- and circumstance-specific. Moreover, attempts to deploy NETs at larger scales would involve significant uncertainties in the extent of the CDR that could be achieved, as well as involving high economic costs and likely major impacts on terrestrial or marine ecosystems.

The dominant role assigned in IPCC integrated assessment models to NETs (in particular bioenergy with carbon capture and storage: BECCS) has yet to take fully into account these limitations. Scenarios and projections of NET's future contribution to CDR that allow Paris targets to be met thus appear optimistic on the basis of current knowledge and should not form the basis of developing, analysing and comparing scenarios of longer-term energy pathways for the European Union (EU).

Future scenarios without NETs, however, show the great difficulty of reaching net zero emissions of CO2 by 2050, which is why NETs have received much attention recently. However, the limited potential for CDR underlines the need to strive as hard as possible to mitigate emissions (through energy efficiency and energy saving by technical and regulatory measures, rapid deployment of renewable energies, land use management, reducing emissions of other GHGs, etc.) to make any need for NETs more manageable. Specifically:

• Firstly, the EU (and other Contracting Parties) should concentrate on rapidly reducing GHG emissions as laid out in the Paris Agreement's 5-year review process of national emission reduction plans.

• Secondly, some of the most technologically credible approaches involve increasing soil carbon and forest biomass, but we remain in an era where deforestation and soil degradation are continuing to add substantial quantities of GHGs. Clearly, as well as considering forests to remove substantially larger amounts of CO2, humanity needs to control the loss of forests, while stopping soil degradation and restoring soil carbon levels requires this to be included in the criteria for agricultural management.

• Thirdly, we emphasise the importance of solving remaining technical challenges in removing CO2 from point sources via carbon capture and storage (CCS), and developing viable business models for CCS implementation to remove CO2 from fossil-fuel power station emissions and from other energy-intensive industries (cement, steel, etc.). Despite the inherently higher efficiencies of CDR when applied to concentrated point sources, CCS plans in Europe have been shelved so that whatever experience is being gained globally is outside Europe.

The loss in momentum in implementing CCS technologies not only has serious implications for mitigation pathways, but also one of the most commonly cited NETs (BECCS) assumes the availability of cost-effective 'off-the shelf' CCS, while another (direct air capture) relies on the widespread availability of CO2 storage. At present, economic incentives for deploying CCS are inadequate (whether through the very low carbon price or targeted government support), while those for NET development are lacking.

While the analysis considers the potential role of NETs at the global scale, the analysis is relevant to the EU's policies on CCS, on research priorities, and on the EU's position within international bodies, including the UN Framework Convention on Climate Change, where a political discussion on the potential role of NETs and on how to translate any global CO2 removal targets to national actions will be needed.

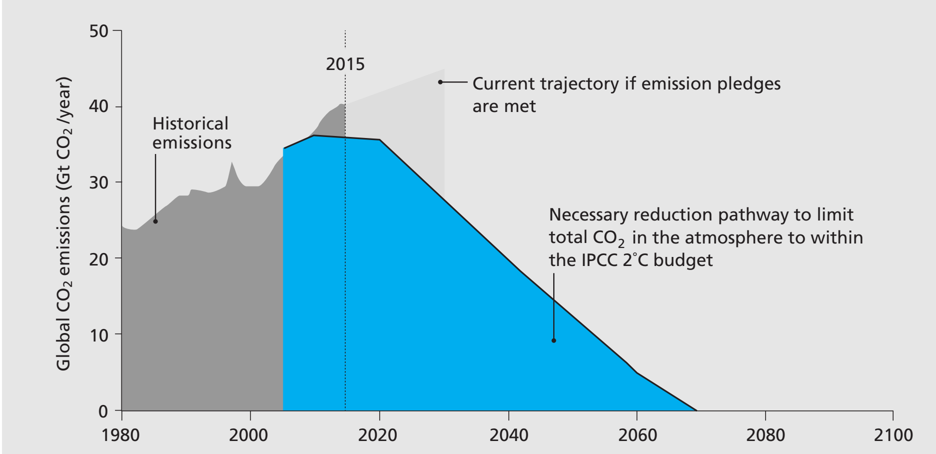


Figure 1 Emission pathways required to limit emissions to within the IPCC budget for 2 ˚C. N.B.: the carbon budget of approximately 800 GtC is the total area under the emissions (in pink). Source: adapted from Anderson and Peters (2016).

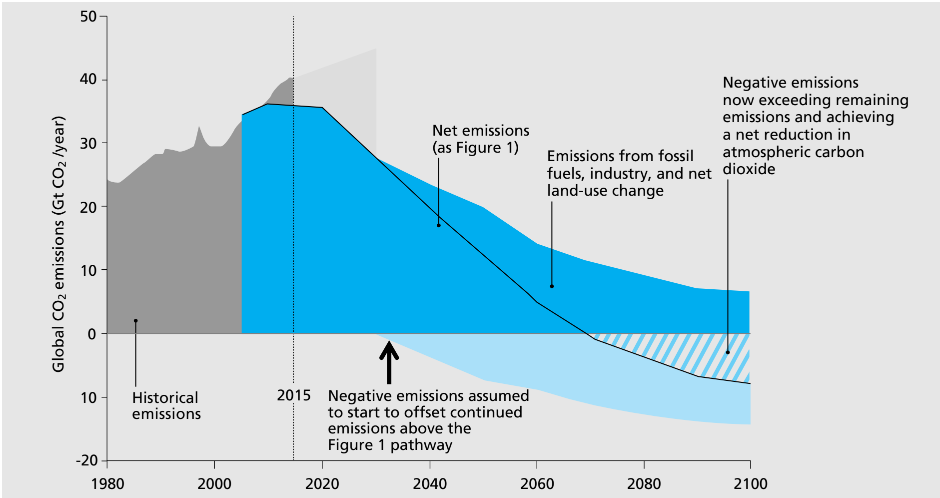


Figure 2 Inclusion of CO2 removal in scenarios, thus allowing larger emissions without breaching the IPCC carbon budget. Source: adapted from Anderson and Peters (2016).

Rationale for negative emissions in future climate scenarios

Because of the long residence time of CO2 in the atmosphere, once emitted it continues to increase the amount of heat absorbed for hundreds of years. The key measure of the impact of CO2 on global warming is thus the accumulated amount of the gas in the atmosphere.

The IPCC (2014a) calculated how much more CO2 can be tolerated in the atmosphere for a given rise in temperature, introducing the concept of the carbon budget, which is the total amount of CO2 that can be added without exceeding the target temperatures. This 'budget' relates to the total amount emitted since the Industrial Revolution, so the more that is emitted now, the less leeway remains and the more difficult becomes the task of constraining future emissions to within the budget limits.

The budget for a 66% probability of meeting the 2 ˚C Paris Agreement target was around 1000 Gt of CO2 (GtCO2). Since the start date of

2011, some 200 Gt have been emitted, leaving around 800 Gt which is the total amount that can be emitted in the future if there is to be a 66% chance of limiting warming to within 2 ˚C. With current emissions (including emissions from land-use change) close to 40 Gt per year, it is very clear that dramatic reductions in emissions need to take place immediately. In recognition of this, the Paris Agreement aimed to achieve zero net emissions by the second half of this century. This would require emission pathways symbolised by Figure 1.

Figure 1 shows not only the dramatic reductions required, but also that there remains the challenge of reducing sources that are particularly difficult to avoid (these include air and marine transport, and continued emissions from agriculture). Many scenarios to achieve Paris Agreement targets have thus had to hypothesise that there will be future technologies which are capable of removing CO2 from the atmosphere.

Including such an assumption allows scenarios typified by Figure 2. In this figure, an emissions reduction pathway that is less challenging and which allows for continued emissions in excess of natural sinks to 2100 and beyond is compensated by a hypothetical technology that removes the excess CO2 that continues to be emitted, and compensates for the overshoot in the budget owing to an inability to adequately constrain emissions. Net emissions are reduced sufficiently and become negative after 2070 only by applying negative emission technologies at increasingly high rates after 2035–2040.

Several points emerge from these figures. Firstly, there is a very large gap remaining between the commitments made in Paris and those needed to limit warming to 2 ˚C let alone 1.5 ˚C. The greater the emissions now, the less remains for future years and generations.

Secondly, the inclusion of CDR in scenarios is merely a projection of what would happen if such technologies existed. It does not imply that such technologies would either be available, or would work at the levels assumed in the scenario calculations. As such, it is easy to misinterpret these scenarios as including some judgement on the likelihood of such technologies being available in future.

More information

easac.eu

UK Clean Growth Strategy does not go far enough says CCC

The UK Committee on Climate Change has produced an independent assessment of the UK's Strategy which finds urgent action is needed.

The Government's Clean Growth Strategy, required under the Climate Change Act, sets out the next steps to reduce the UK's greenhouse gas emissions and tackle climate change.

Although ambitious, the Strategy does not go far enough. Urgent action is needed to flesh out current plans and proposals, and supplement them with additional measures, to meet the UK's legally-binding carbon targets in the 2020s and 2030s, the Committee on Climate Change says.

The findings are part of the Committee's new report, 'An independent assessment of the UK's Clean Growth Strategy: From ambition to action'.

"The Clean Growth Strategy is ambitious in its aims to build a thriving low-carbon Britain but ambitions alone are not enough," said CCC Chairman, Lord Deben. "As it stands, the Strategy does not deliver enough action to meet the UK's emissions targets in the 2020s and 2030s. The Government's policies and proposals will need to be firmed up as a matter of urgency – and supplemented with additional measures – if the UK is to deliver on its legal commitments and secure its position as an international climate change leader."

The UK has made good progress in reducing its greenhouse gas emissions since the Climate Change Act was passed in 2008, nearly ten years ago. Emissions fell by 42% from 1990 to 2016 – faster than the average rate of reduction in the G7.

The Clean Growth Strategy commits to delivering further action towards meeting the fourth (2023-27) and fifth (2028-32) carbon budgets, on the path to reducing UK emissions by at least 80% in 2050 compared to 1990 levels.

The Strategy also reaffirms the UK's desire to remain at the forefront of tackling climate change globally. This makes it all the more important for UK carbon budgets to be met through actions to reduce emissions domestically, the basis on which they were originally set.

However, significant gaps still remain. Even if delivered in full, existing and new policies, including those set out in the Clean Growth Strategy, miss the fourth and fifth carbon budgets by around 10-65 $MtCO_2e$ – a significant margin.

The publication of the Clean Growth Strategy is not the end of the process. Although the Government has proposed a set of milestones to ensure progress is being made, the Committee recommends supplementing these with additional milestones to ensure the required emissions reductions are delivered in time. The Committee will monitor progress in its annual reports to Parliament.

Action needed on CCS

The Clean Growth Strategy sets out three illustrative pathways to 2050, one of which excludes carbon capture and storage (CCS). The Government should not plan to meet the 2050 target without CCS, the report says.

A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve. Furthermore, deeper reductions requiring the deployment of CCS will be needed to meet the aims of the Paris Agreement, whether by 2050 or subsequently.

Although the Strategy states an ambition to deploy carbon capture use and storage (CCUS) in the 2030s, the level of detail and funding (which is directed at innovation only) are not commensurate with its importance. The Government should set out plans in 2018 that kick-start a UK CCS industry in the 2020s.

In particular, the Development Pathway due to be published in 2018 must set out the Government's proposals for: the delivery model for CO_2 transport and storage infrastructure, the funding mechanism for industrial CCS, and the allocation of risks between Government and developers, especially relating to long-term storage liabilities.

Several promising projects exist in strategic cluster locations that could be in operation by 2025. If a decision on the future of the gas grid by 2025 is to be credible, then progress on demonstrating the business model for CCS will be needed before then.

Industry comment

Luke Warren, Chief Executive of the Carbon Capture & Storage Association, commented, "The CCSA welcomes the release of the Clean Growth Strategy and the recognition of both the critical role of CCS to reducing CO_2 emissions and the clean growth opportunity this offers to the UK industrial strategy."

"However, delivering a strategy requires action and there is a lack of detail on how these ambitions will be delivered. Government and industry must now work together to define the steps required to deliver CCS and make meaningful progress on these this parliament if the UK is be a leader in this field."

"We have recently seen impressive drops in the cost of other low-carbon technologies. This shows the power of Government and industry collaboration to drive large-scale deployment and cost-reduction. We now need Government to get behind CCS in the same way and the CCSA looks forward to working with the Government to support delivery of this transformational technology."

More information

www.theccc.org.uk

www.ccsassociation.org

Priority Actions to Enable CCS Deployment

The Coal Industry Advisory Board submitted its recommendations to the International Energy Agency outlining a specific suite of policies and incentives that would stimulate the private sector and government to reach the required deployment rate for CCS to mitigate CO2 emissions.

It makes economic sense for there to be an international commitment to CCS that rivals the scale of commitment that countries have made to renewables says the CIAB's report, "Priority Actions to Enable CCS Deployment".

The Coal Industry Advisory Board (CIAB) is a group of high level executives from coal-related industrial enterprises, established by the International Energy Agency (IEA) in July 1979 to provide advice to the IEA on a wide range of issues relating to coal.

In 2016, the CIAB reviewed successful and unsuccessful global CCS projects and CCS policy mechanisms in order to identify policy-related lessons learnt and best practices (CIAB, 2016). The CIAB then recommended a portfolio of policies that would be effective in facilitating CCS investment and in supporting an international commitment to CCS. The policies the CIAB recommended were targeted towards four objectives: stimulating CCS market uptake; supporting CCS project development; enabling capital investment in CCS projects; and advancing next-generation CCS technologies.

The new report builds on these recommendations by examining a specific suite of policies and incentives that would stimulate the private sector and government to reach the required deployment rate. It focuses on the United States, the United Kingdom, Australia and the People's Republic of China – key countries with regards to their overall emissions and that also provide policy lessons for other governments.

Key actions for industry

Industry needs to support government to:

a) Deliver compelling messages that CCS is an essential technology to achieving a low-carbon energy future at the lowest possible cost.

b) Implement incentive-based policies that enable CCS deployment.

c) Distribute technology-demonstration funding among low-carbon energy alternatives to demonstrate each technology at a commercial-scale.

d) Implement international public-private collaboration on CCS projects with equitable cost sharing.

e) Distribute R&D funding, with parity among low-carbon energy alternatives (i.e. renewables, CCS, and nuclear), low-carbon industrial processing (e.g. steel, liquefied natural gas and cement manufacturing with CCS) and focus CCS R&D more strategically.

Conclusions

The cost of meeting emission limits associated with international climate goals is measured in tens of trillions of dollars. That cost more than doubles if CCS is not widely deployed.

Over the past decade, there have been some remarkable advancements that are propelling CCS technology and policies forward across industries. There have also been some notable project and policy shortfalls that are hindering progress.

If there continues to be an aspiration to transition to a low-carbon energy future, deployment of CCS technology is a prerequisite and must be expedited.

By examining the CCS progress and opportunities in the United States, the United Kingdom, Australia and the People's Republic of China, some cross-cutting observations can be made:

• Governments have been very effective at building the technology and regulatory knowledge base to advance CCS. Capacity-building efforts (e.g. the formation of the Carbon Sequestration Leadership Forum, the Global CCS Institute, the United Kingdom-China Clean Energy Partnership, and the United States Department of Energy Regional Carbon Partnership) have helped inform and accelerate private-sector efforts to advance CCS projects.

• Governments have effectively supported efforts to advance basic characterisation of geologic resources. This recognises that geology is quite variable and that geological conditions differ widely between specific locations. Generally, it is difficult for industry to invest in geologic characterisation when there is not a project-specific motive. Given the long lead times associated with such characterisation, if governments are able to pre-screen and pre-qualify geologic resources, this would expedite future industry CCS projects.

The CCS Conundrum

There is consensus among most major countries that the world must move towards a low-carbon energy future to address concerns related to climate change. For these countries, it is essential such a future is achieved cost-effectively and does not result in major economic disruption.

Advanced technology is well recognised as being one of the most effective elements in reducing emissions while simultaneously controlling costs. Developing advanced technologies, however, is neither easy nor free. The upfront investment needed for R&D, pilot-scale tests and commercial demonstrations to aggressively develop CCS is substantial and is likely to amount to tens of billions of dollars worldwide per year for at least a decade. Given that CCS could reduce the overall cost of achieving a low-carbon energy future by tens of trillions of dollars, the societal return on investment is relatively clear.

The conundrum is how to expedite CCS development when government cannot provide the trillions in investment capital to deploy CCS, while for most CCS R&D, demonstrations, and commercial-deployment projects there is not a clear pathway to achieve an acceptable return on investment.

A Way Forward

The solution to this conundrum is a public-private partnership that makes an international commitment to CCS. Making this commitment involves taking five initiating actions. If these actions are taken, this would unlock access to the trillions in investment capital that are required to transition to a low-carbon energy system. With access to capital and a supportive, incentive-based policy environment, the private sector can use its expertise to drive forward the wave of CCS deployments that is required to enable an orderly transition to a low-carbon future. The actions include:

1. Deliver compelling messages that CCS is an essential technology to achieving a low-carbon energy future at the lowest possible cost

Political and industry leaders need to use their respective communication platforms to reinforce in the strongest terms that CCS is an indispensable technology that supports the lowest-cost pathway to realising a low-carbon energy future. Climate agreements must recognise this fact and must incorporate an international commitment to CCS.

2. Implement incentive-based policies that enable CCS to deployment

There must be a concerted effort to put in place incentive-based CCS deployment policies by 2020, or as soon thereafter as practical. Well-designed policies could close the gap between the cost of early CCS projects and what the commercial marketplace can support. The types of incentives contemplated are documented in the CIAB's 2016 report entitled "Policies and Incentives to Enable a Low-Carbon Energy Future" (CIAB 2016). Parties to the Paris Agreement should include policy progress in their periodic review of NDCs as these policies will play a crucial role in helping countries achieve their ambitions to 2025, 2030, and beyond, at least cost.

3. Distribute technology demonstration funding among low-carbon energy alternatives to demonstrate each technology at a commercial scale

Governmental demonstration support for all low-carbon technologies should be sized to provide for commercial-scale demonstrations. For example, a new solar technology may require demonstration over a 1-10 MW range. However, new fossil-based CCS technology or nuclear demonstrations may require demonstration at the scale of 50 – 250 MW. There must be a renewed commitment to demonstration of all low-carbon technologies at commercial scale.

4. Implement international public-private collaboration on CCS projects, with the cost-sharing considering the relative public vs. private benefit.

Where there is a natural alignment of private and public interests, international collaborations involving CCS demonstrations, CCS R&D, and CCS infrastructure should be pursued. The Callide oxy-fuel project is a notable example that involved the Japanese and Australian governments, as well as the private sector. It helped lay the foundation for future, industrial-scale oxy-fuel projects and would not have been possible without an international public-private collaboration.

With respect to CCS infrastructure, a possible future collaboration could be with a country with substantial CO_2 sources, but limited CO_2 -storage opportunities, in collaborating on CCS infrastructure planning (e.g. cross-border shipping or pipelining of CO_2) with a country with suitable geologic resources for CO_2 storage.

5. Distribute R&D funding, with parity among low-carbon energy alternatives (i.e. renewables, CCS, and nuclear), low-carbon industrial processing (e.g. steel, LNG and cement manufacturing with CCS), and focus CCS R&D more strategically

As CCS has greater financial leverage, relative to other low-carbon energy technologies, to reduce the cost of building a low-carbon energy future, it should receive an equal share of annual government R&D funding (not less as it now does). Furthermore, government CCS should be strategically focused. For example:

• Emphasise transformative vs. incremental R&D. Novel carbon capture and innovative energy-conversion technologies, that could ultimately be implemented at industrial scale and offer significant cost-reduction potential, would be two appropriate focus areas. Incremental improvements will take place in the marketplace and should not be a focus.

• Enabling R&D. In those cases where financial returns are unlikely to be directly realised by the private sector, there is a role for government. Examples of enabling CCS R&D include: basin-level geologic characterisation, understanding the geologic mechanisms of CO_2 storage, international collaborations, capacity-building, and CO_2-transport infrastructure planning and development.

• R&D in support of industrial-scale demonstrations. R&D that reduces the risk or decreases the cost of demonstration projects, in a timely manner, would be an appropriate focus of CCS R&D.

As described earlier in the report, actions that the United States, the United Kingdom, Australia and the People's Republic of China could take immediately were recommended. Those specific actions would be an immediate start towards full implementation of the five broader actions above. Certainly, it is recommended that other countries begin taking action now.

As a practical matter, if there are continued agreements and aspirations to transition to a low-carbon energy future, while at the same time limiting costs, then CCS would be a central component to achieving those goals; and governments, industry and other stakeholders should advance CCS by taking the actions recommended herein.

• Projects related to CO_2-transportation infrastructure planning have been relatively limited. It is extremely difficult for industry to justify investment in core transport-infrastructure elements (e.g. trunk pipelines and seaborne port facilities) until incentive-based CCS policy is much more mature. Effective joint planning by government and industry can lead to more efficient investment by both.

• Industry and governments have been able to collaborate effectively on a variety of pilot-scale projects. As new and improved CCS technologies emerge, there will be candidates for pilot-scale testing. The objective of CCS pilot-scale efforts should be to provide the cost and performance data that enables subsequent scale-up, the provision of performance guarantees by the technology providers, and the cost and performance certainty required to secure financing for commercial deployment.

• Over the past five years, austerity has substantially reduced government funding for commercial-scale demonstrations, which are essential to expediting CCS deployment. This represents a mismatch between ambitious carbon emissions-reduction goals (such as those agreed in the Paris Agreement) and adequate government co-funding to conduct demonstrations that are an essential stepping stone to achieving carbon emissions-reduction goals. This mismatch needs to be erased.

• The track-record of establishing government-industry partnerships to conduct commercial-scale demonstrations is mixed. Such projects are absolutely essential to achieving large-scale, widespread CCS deployment. The most successful projects to date have had the benefit of a government capital-expenditure buy-down coupled with one or more of the following:

– a policy mechanism that provides operating-expenditure cost recovery and an acceptable return on private capital expenditure

– a single high-margin revenue stream (e.g. separated natural gas)

– multiple low- to moderate-margin revenue streams (e.g. electricity and CO2 offtake agreements).

Projects which were highly advanced but ultimately stalled were found to have carried more risk (e.g. first-of-a-kind technology risk or project-on-project risk) than commercial markets could absorb, there was no policy mechanism to close the risk gap, and/or the projects ran into timing issues, particularly with respect to policy incentives and programme requirements not being aligned with project-development and financing requirements.

• Governments have successfully promoted and invested in low-carbon renewables. Given that CCS is the technology with the greatest leverage to minimise the cost of a low-carbon future, CCS should receive an equivalent level of governmental R&D support so that both these low-carbon technologies have an equal opportunity to advance in the marketplace.

• The advancement of CCS technologies would significantly benefit from governments using their influence to increase international awareness of the criticality of CCS, and to frame the policy of international financial institutions and multilateral institutions. The IEA is uniquely positioned to inform governments and financiers, including multilateral development banks, on the urgent need to expand investment in CCS across the globe if a low-carbon economy is to be achieved.

• Industry will invest significantly in CCS projects where it sees a financial return commensurate with the financial risk involved. To expedite CCS deployment, the public sector needs to fill the gap between the cost of early CCS projects and the cost and risk commercial markets can bear. This needs to be done within a supportive policy framework. Otherwise, the portfolio of new CCS projects will be limited and the aspirations of many governments to achieve a low-carbon future will be far more costly, if not forfeited.

If the public sector can fill the gap on early CCS projects, industry is well-positioned to deliver the necessary technical expertise and substantial investment capital. As the technology matures, industry will be able to carry a greater and greater portion of the investment costs.

More information

Read the full report and other information:

www.iea.org/ciab

Projects and policy news

MEPs pass law to cut CO2 emissions and fund low-carbon innovation

www.europarl.europa.eu

A law to strengthen EU curbs on CO2 emissions from industry, so as to begin delivering on Paris climate accord pledges, was passed by Parliament.

The new law, already informally agreed with EU ministers, will accelerate the withdrawal of emission allowances available on the EU Emissions Trading System (ETS) "carbon market", which covers around 40% of EU greenhouse gas emissions. It provides for:

an increase in the yearly reduction of emission allowances to be placed on the market (so-called "linear reduction factor") by 2.2% from 2021, up from the 1.74% planned at present; this factor will also be kept under review with a view to increasing it further by 2024 at the earliest;

a doubling of the ETS Market Stability Reserve's capacity to mop up excess emission allowances on the market: when triggered, it would absorb up to 24% of excess allowances in each auctioning year, for the first four years, thus increasing their price and adding to the incentive to reduce emissions.

Two funds to help foster innovation and spur the transition to a low-carbon economy

A modernisation fund will help to upgrade energy systems in lower-income EU member states. MEPs tightened up the financing rules so that the fund is not used for coal-fired projects, except for district heating in the poorest member states.

An innovation fund will provide financial support for renewable energy, carbon capture and storage and low-carbon innovation projects.

The law also aims to prevent "carbon leakage", i.e. the risk that companies might relocate their production outside Europe due to emission reduction policies. The sectors at the highest risk will receive their ETS allowances for free. Less exposed sectors will receive 30% for free.

Cement industry launches industrial-scale carbon capture project

ecra-online.org

Based on extensive research undertaken by the European Cement Research Academy (ECRA), oxyfuel technology will now be im-

plemented in two cement plants in Europe.

HeidelbergCement and LafargeHolcim will dedicate plants in Colleferro (Italy) and Retznei (Austria) respectively to test for the first time how the cement production process can be adapted to accommodate this cutting edge carbon capture technology. The project will require a significant investment volume and will rely on industry contributions, but significant funding from public sources will also be required.

ECRA's long-term carbon capture research project was started in 2007 and has advanced to the stage where definite steps towards establishing an oxyfuel kiln can now be taken. Such kilns are intended to provide insight into the industrial-scale operation of a technology which provides a high CO2 concentration exhaust gas stream for further carbon capture. It is even planned to process a small part of the CO2 to test its further utilisation.

"The technical feasibility of oxyfuel technology can only be proven in real-scale application, but we have sufficient information from our research to believe that we will obtain a positive result after the trials" said Daniel Gauthier, Chairman of ECRA.

Over the past few months ECRA has examined the suitability of sites which could potentially be locations for oxyfuel kilns. From the five sites which were examined in depth, two were identified as the most suitable to host the project from a technical standpoint: the Colleferro plant of HeidelbergCement in Italy and the Retznei plant of LafargeHolcim in Austria.

ECRA's members are leading cement producers, relevant equipment suppliers and cement associations. Through their involvement the project can now be taken further. Based on opportunity studies and in-depth technical feasibility studies, the investment and costs for the test phase will amount to around 80 M EUR. While the cement industry has committed itself to contributing 25 M EUR, it is clear that substantial funding from European or national research schemes will also be required.

Carbon capture and storage has essential role in Scotland says report

www.sccs.org.uk

Scottish Carbon Capture & Storage (SCCS) has welcomed the Scottish Government's publication of its Climate Change Plan, setting out its specific policies and proposals for meeting Scotland's climate change targets.

SCCS said they are pleased to see unequivocal recognition of the importance of carbon capture and storage (CCS) for reducing greenhouse gas emissions across Scotland. The plan underlines that CCS is the only way to decarbonise many industries and to provide low-cost, low-carbon heat rapidly. SCCS is fully committed to helping Scottish businesses seize opportunities for CCS use.

The Climate Change Plan says while CCS is not required for the delivery of the electricity generation emissions envelope out to 2032, it does represent the only viable technology capable of mitigating industrial scale CO2 emissions in some of the world's most carbon intensive industrial processes.

CCS may also help unlock the potential for large scale hydrogen production. "The near-term demonstration of small scale CCS projects, along with the development of CO2 Utilisation (CCU) applications, will be critical for the cost-effective decarbonisation of heat, power and industry," says the report.

In its evidence on the draft climate plan to the Economy, Jobs and Fair Work Committee, SCCS talked about how CCS can also support the production of hydrogen rapidly at large tonnages and at low cost – providing a carbon-free fuel, which is ideal for heating homes and businesses and powering transport.

The ambitious Climate Plan now has much more detail on the potential role of hydrogen in reducing Scotland's emissions, removing some of the pressure from renewable electricity in meeting our needs across the whole energy system.

Professor Stuart Haszeldine, Director of SCCS, said, "Carbon capture and storage can occur at large and small scale, nationally and locally, across the whole economy."

"We look forward to supporting the Scottish Government's Climate Change Plan by innovating and assessing opportunities to develop demonstration and larger pilot facilities for CCS and CO2 utilisation in a swathe of industries across Scotland. SCCS will boost the Scottish Government's ambitions to undertake just, rapid and practical climate action at accessible cost using CCS."

First free online course on carbon capture technology

www.ed.ac.uk

Edinburgh University has launched a free open course explaining CCS technology in the context of climate change, global energy and economics, use of fossil fuels and global climate policy.

The course from the University of Edinburgh, which begins on 15 March, is suitable for anyone with a keen interest in learning how technology can help rein in the worst impacts of climate change as the world's population and energy needs rise.

Participants should gain a better understanding of climate change mitigation options.

The course seeks to encourage further study, such as in the University's pioneering Masters programme on carbon capture and storage.

The MOOC (massive open online course) will be taught by leading academics at the University, with the option of a verified certificate on completion.

Participants will learn CCS technology can protect the atmosphere from an excess of CO2 and the potential to make fossil fuels relatively safe to use in the context of the 2015 Paris Climate Change Agreement.

The programme will also cover key sectors of the global economy, where CCS can contribute to significant reductions in emissions.

It will also examine how CCS can enable carbon negative approaches to mitigating climate change.

Students will learn how CCS can complement other low-carbon technologies, and the scientific principles of climate mitigation technologies.

The key elements of geology for permanent and safe disposal of CO2 underground, and the international state and scale of the industry in the 21st century, will also be covered in the online course.

The course will be taught by Dr. Mathieu Lucquiaud, Senior Lecturer/Associate Professor in Mechanical Engineering, Dr. Mark Wilkinson, Senior Lecturer in Geological CO2 Storage, Erika Palfi, PhD student, and Thomas Spitz, PhD student, all from the University of Edinburgh.

New Fuel Cell technology runs on solid carbon

A new paper published by Idaho National Laboratory researchers describes a fuel cell that uses three times more carbon.
www.inl.gov

The fuel cell design incorporates innovations in three components: the anode, the electrolyte and the fuel. Together, these advancements allow the fuel cell to utilize about three times as much carbon as earlier direct carbon fuel cell (DCFC) designs.

The fuel cells also operate at lower temperatures and showed higher maximum power densities than earlier DCFCs, according to INL materials engineer Dong Ding. The results appear in the Jan. 25 edition of the journal Advanced Materials and are featured on its inside front cover.

Whereas hydrogen fuel cells (e.g., proton exchange membrane (PEM) and other fuel cells) generate electricity from the chemical reaction between pure hydrogen and oxygen, DCFCs can use any number of carbon-based resources for fuel, including coal, coke, tar, biomass and organic waste.

Because DCFCs make use of readily available fuels, they are potentially more efficient than conventional hydrogen fuel cells. "You can skip the energy-intensive step of producing hydrogen," Ding said.

But earlier DCFC designs have several drawbacks: They require high temperatures — 700 to 900 degrees Celsius — which makes them less efficient and less durable. Further, as a consequence of those high temperatures, they're typically constructed of expensive materials that can handle the heat. Also, early DCFC designs aren't able to effectively utilize the carbon fuel.

Research scientist Dong Ding developing direct carbon fuel cells at INL's Energy Innovation Laboratory

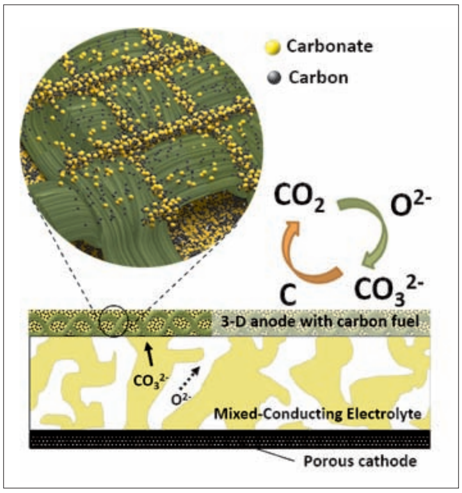
Ding and his colleagues addressed these challenges by designing a true direct carbon fuel cell that's capable of operating at lower temperatures - below 600 degrees Celsius. The fuel cell makes use of solid carbon, which is finely ground and injected via an airstream into the cell.

The researchers tackled the need for high temperatures by developing an electrolyte using highly conductive materials — doped cerium oxide and carbonate. These materials maintain their performance under lower temperatures.

Next, they increased carbon utilization by developing a 3-D ceramic textile anode design that interlaces bundles of fibers together like a piece of cloth. The fibers themselves are hollow and porous. All of these features combine to maximize the amount of surface area that's available for a chemical reaction with the carbon fuel.

Finally, the researchers developed a composite fuel made from solid carbon and carbonate. "At the operating temperature, that composite is fluidlike," Ding said. "It can easily flow into the interface."

The molten carbonate carries the solid carbon into the hollow fibers and the pinholes of the anode, increasing the power density of the fuel cell.



The direct carbon fuel cell (DCFC) design

The resulting fuel cell looks like a green, ceramic watch battery that's about as thick as a piece of construction paper. A larger square is 10 centimeters on each side. The fuel cells can be stacked on top of one another depending on the application. The Advanced Materials journal posted a video abstract here: https://youtu.be/M_wOsvze2qI

The technology has the potential for improved utilization of carbon fuels, such as coal and biomass, because direct carbon fuel cells produce carbon dioxide without the mixture of other gases and particulates found in smoke from coal-fired power plants, for example. This makes it easier to implement carbon capture technologies, Ding said.

The DCFC design has already attracted notice from industry. Ding and his colleagues are partnering with Salt Lake City-based Storagenergy, Inc., to apply for a Department of Energy Small Business Innovation Research (SBIR)-Small Business Technology Transfer (STTR) Funding Opportunity. The results will be announced in February 2018. A Canadian energy-related company has also shown interest in these DCFC technologies.

CHEERS project to improve efficiency of the CO2 capture value chain

On 1 October 2017, a new Research and Innovation Action, designated CHEERS (Chinese-European Emission-Reducing Solutions), was commenced under the EC-Horizon 2020 programme's Low-Carbon Initiative.
By Bellona

Alexander Bell, the founding father of the American telephone, once noted that "great discoveries and improvements invariably involve the cooperation of many minds". Technological progress is indeed rarely achieved without cooperation and collaboration between a plethora of stakeholders, including academia, industry, research institutions and civil society.

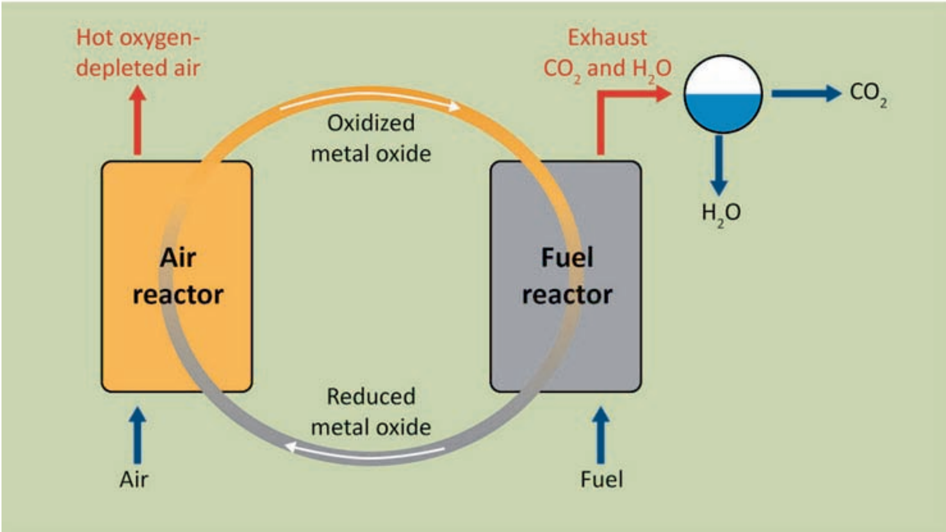
Fruitful results then offer to unlock the learning potential curve and allow for wider applications. This undoubtedly holds true in today's quest for emission reducing solutions. In the case of carbon capture and storage (CCS), one of the key focus areas has still been on improving efficiency of the CO2 capture chain.

In full recognition of the value of multi-stakeholder collaboration, Bellona has teamed up with a range of actors within the so-called Chinese-European Emission-Reducing Solutions (CHEERS) project, with the overarching aim of improving the efficiency of the CO2 capture chain, and subsequently helping the reduction of power sector CO2 emissions.

In November last year, the CHEERS project was formally kicked-off, which will over the course of five years, look to develop, upscale and test a 2nd generation chemical-looping technology in order to produce energy and steam with captured CO2.

The aim of the project is to drastically reduce the efficiency drop of the CO2 capture chain. The innovative concept is deemed capable of removing 96% of combustion-related CO2 while eliminating capture losses to less than 4% (a 50% reduction from current levels of absorption techniques), except for the CO2 compression work.

The system prototype demonstration, which is based on a fundamentally new fuel-conversion process synthesised from prior research and development actions over more than a decade, will be carried out at the Key Laboratory for Clean Combustion and Flue Gas Purification of the Sichuan Province, in Deyang, P.R. China.



The project involves a 2nd generation chemical-looping technology tested and verified at laboratory scale (up to 150 kWth)

Co-financed by the European Union's Horizon 2020 research and innovation programme, the Chinese Ministry of Science and Technology (MOST) and the Chinese industry members, the project has a budget of €16.8 million and seeks to make a major step towards large-scale carbon footprint reduction of power/steam generation system using heavy feed, namely petcoke.

It is anticipated that a successful demonstration will pave the ground for a wider deployment of the CCS technology in the energy-intensive industry, especially processes hampered with combustion-related CO2 such as cement, steel and chemicals production.

The 30 members and representatives of the consortium, comprised of nine parties, including: SINTEF Energi (coordinator, Trondheim, Norway), IFP Energies nouvelles (IFPEN) (Lyon, France), Tsinghua University (Beijing, China), SINTEF Industry (Oslo, Norway), Total (France), Dongfang Boiler Group (Zigong, China), Zhejiang University (Hangzhou, China), Politeknika Slaska (SILESIAN) (Gliwice, Poland), and Bellona (Brussels, Belgium).

More information

www.bellona.org
www.sintef.no

Preem assesses carbon capture from Lysekil refinery

Preem has started a CLIMIT supported carbon capture study on their refinery in Lysekil to build a demonstration plant with the aim of working towards a full-scale integrated CCS project.

Panorama over Lysekil Refinery in Sweden. (Photo: Preem)

The idea study to be conducted in spring 2018 will examine whether it is possible to build a demonstration plant at Preem's refinery in Lysekil to capture CO2 and thus reduce greenhouse gas emissions.

The geographical location of Preem on the Swedish west coast means that it is relevant to consider a connection to the Norwegian full-scale CCS project. The goal is a full-scale CCS capture plant at the refinery, and then transport of the liquified CO2 by boat to the planned CCS hub on the Norwegian west coast for permanent storage in a formation below the seabed 50 km west of Bergen.

The vision is a full-scale CCS plant that radically reduces the greenhouse gas emissions from the refinery. We want to lead the transformation into a more sustainable society, and then we must take responsibility for reducing the climate impact of our businesses. To reduce greenhouse gas emissions through CCS technology is an important step to achieve Swedish and global climate goals, "says Mattias Backmark, Head of Business Development in Preem, in a press release from the company today.

The feasibility study is funded by Gassnova's research and development program CLIMIT and led by the Norwegian research institute Sintef with Preem and Chalmers University in Gothenburg as members of the project for the Lysekil study.

An important part of identifying possibilities for reaching the project objective is to map technology, both in terms of where CO2 capture can be demonstrated at the Preem refineries, and what technology options there are for demonstration. Also, options for on-site liquefaction of captured CO2 will be described and evaluated.

Preem is Sweden's largest fuel company. Their vision is to lead the transformation into a sustainable society.

Preem's two refineries are among the most modern and environmentally friendly in Europe with a refining capacity of over 18 million cubic meters of crude oil per year. But the refineries have CO2 emissions of 1.5 tonnes in Lysekil and 0.5 tonnes in Gothenburg respectively.

More information

www.preem.se

www.climit.no

www.sintef.no

www.chalmers.se

Capture and utilisation news

Capture milestone boosts CO2-to-fuel research goal

www.alignccus.eu

RWE pilot plant captures first 1000 tonnes of CO2 as part of ALIGN-CCUS project.

Scientists at RWE are celebrating their first milestone in work to create synthetic fuels from carbon dioxide (CO2) as part of the broader ALIGN-CCUS project, which secured European funding last year.

The company's CO2 capture pilot plant at their lignite-fired power station in Niederaussem, Germany, has captured its first 1000 tonnes of CO2 for the project, providing a high-purity source of the gas for this unique integrated carbon capture and utilisation (CCU) demonstration.

The testing campaign provides the opportunity to help reduce the operational costs of post-combustion carbon capture, which the team believes would boost deployment of the technology within the power and industrial sectors.

A proportion of the CO2 captured in Niederaussem will be liquified then combined with hydrogen – produced in an electrolyser module – to produce two different fuels: methanol (MeOH) and dimethylether (DME).

Both MeOH and DME are potential gamechangers, providing an alternative to fossil fuels for a variety of vehicles, from agricultural machinery to family cars. The chemicals also burn much more cleanly, eliminating soot and NOx emissions, and only limited adjustments are needed to convert conventional internal combustion engines for their use.

One of the next milestones for the RWE team will be the testing of the synthetic fuels on a car and a stationary peak power generator.

The capture technology testing at Niederaussem is fundamental to the goal of reducing the operational costs of post-combustion CO2 capture.

The pilot plant will operate for a total of around 24,000 hours, allowing the researchers to extensively test conventional and novel solvents, the chemical compounds used to remove CO2 from flue gases.

New solvent monitoring techniques, which will support the development of solvent degradation counter measures and strategies, will also be evaluated under "real-life" conditions at Niederaussem.

The research, which has been made possible through funding from the European Union's ERA-NET Accelerating CCS Technologies (ACT) programme, began last August and the plant has been in continuous operation since then.

U.S. DOE invests $44m in advanced CCS

www.energy.gov

$44 million will be invested in Design and Testing of Advanced Carbon Capture Technologies.

The projects will target two areas: 1) engineering-scale testing of transformational solvent- or membrane-based carbon dioxide (CO2) capture technologies, and 2) designing a commercial-scale, post-combustion CO2 capture system at an existing coal-fueled generating unit. The National Energy Technology Laboratory (NETL) will manage the selected projects.

The following four projects were selected under Area of Interest 1, Scaling of Carbon Capture Technologies to Engineering Scales Using Existing Host Site Infrastructure:

Scale-Up and Testing of Advanced Polaris Membrane CO2 Capture Technology – Membrane Technology and Research, Inc. (MTR) (Newark, CA) will scale up next-generation PolarisTM membranes and modules to a final form for commercial use and validate their potential in an engineering-scale field test at the Technology Centre Mongstad in Norway.

Engineering-Scale Testing of Transformational Non-Aqueous Solvent-Based CO2 Capture Process at Technology Centre Mongstad – RTI International (Research Triangle Park, NC) will advance its non-aqueous (water lean) solvent-based CO2 capture technology and tests will be performed using the existing large-scale pilot infrastructure at the Technology Centre Mongstad in Norway.

This project expands on work conducted with DOE in both the Office of Fossil Energy's and the Advanced Research Projects Agency-Energy's portfolios.

Engineering-Scale Demonstration of Mixed-Salt Process for CO2 Capture – SRI International (Menlo Park, CA) will demonstrate its Mixed-Salt Process at engineering scale, using the existing infrastructure at the Technology Centre Mongstad in Norway. The objectives are to address concerns related to scale-up and integration of the technology in coal-based power plants.

Membrane-Sorbent Hybrid System for Post-Combustion Carbon Capture – TDA Research, Inc. (Wheat Ridge, CO) will design, construct, and operate an engineering-scale 1 megawatt-electric post-combustion, hybrid carbon capture system.

This system consists of a polymeric membrane and a low-temperature physical adsorbent to remove CO2 from the flue gases generated by coal-fired power plants. The membrane, developed by Membrane Technology and Research, Inc., will be responsible for bulk CO2 removal, while the TDA-developed sorbent will extract additional levels to achieve an overall 90 percent system removal.

The following three projects were selected under Area of Interest 2, Initial Engineering, Testing, and Design of a Commercial-Scale, Post-Combustion CO2 Capture System:

Initial Engineering Design of a Post-Combustion CO2 Capture System for Duke Energy's East Bend Station Using Membrane-Based Technology – Electric Power Research Institute, Inc. (Palo Alto, CA) will produce an engineering design and cost estimate of a membrane-based post-combustion CO2 capture system on Duke Energy's East Bend Station in Kentucky. The project team will create a model that replicates the station's performance and will be used to estimate the impacts of retrofitting CO2 capture to the plant.

ION Engineering Commercial Carbon Capture Design and Costing – ION Engineering, LLC (Boulder, CO) will provide a detailed design and cost estimate for a retrofitted, 300-megawatt-equivalent, commercial-scale CO2 capture facility. The facility is located at Nebraska Public Power District's Gerald Gentleman Station Unit 2, in Sutherland, Nebraska.

Initial Engineering, Testing, and Design of a Commercial-Scale, Post-Combustion CO2

Capture System on an Existing Coal-Fired Generating Unit – The University of North Dakota (Grand Forks, ND) will design and determine the cost of installing a post-combustion CO_2 capture system at the Milton R. Young Station, owned by Minnkota Power Cooperative.

The project will design a fully integrated post-combustion CO_2 capture system; test a solvent on coal-derived flue gas; and conduct a techno-economic and pre-front-end engineering and design (FEED) analysis of the system.

Carbon Clean Solutions consortium awarded £900k grant from UK Government

www.carboncleansolutions.com

The grant will enable CCSL to progress its research into further lowering the cost of carbon capture technology. The ultimate aim is to develop a solution that is affordable on a large scale.

The consortium led by Carbon Clean Solutions Limited was awarded a research and development grant worth almost £900,000 by the UK Department for Business, Energy & Industrial Strategy (BEIS).

The grant was awarded based on preliminary research already conducted by CCSL and the University of Newcastle in 2016, the results of which were positive and indicated the potential for the technology to be developed further. The grant will enable CCSL to build a large-scale carbon capture testing facility at the University of Sheffield, which will be the world's first integrated plant of its kind.

CCSL has a strong track record in this area, having launched the world's first fully commercial carbon capture utilisation and storage (CCUS) plant in India in 2016. The ground-breaking project, which was privately financed, captures carbon dioxide (CO_2) at just \$30 per tonne – much lower than the \$60-90 per tonne capture costs typically observed in the global power sector.

With this latest grant, it is hoped that the technology can be further refined to capture CO_2 at \$20 per tonne.

Prateek Bumb, CTO and Co-Founder of CCSL, said: "This grant is a testament to the importance of developing affordable carbon capture technology, which can be rolled out on a large scale. This technology will play a crucial role in helping the UK meet its energy targets. It's really encouraging that the UK government continues to recognise the importance of the work we are doing in this area".

Econic Technologies raises £7m

econic-technologies.com

The company has raised £7m to further develop its CO_2 conversion catalyst technologies.

The total amount raised is £7m with first-time investment from OGCI Climate Investments, alongside additional funds from existing shareholders: IP Group plc and Woodford Investment Management.

The funding will be used to help further develop Econic's pioneering catalyst technologies, which unlock the positive potential of waste CO_2 by allowing it to be incorporated as a feedstock thereby enhancing margins and reducing the reliance on fossil fuels. The team hopes that by 2027, 30% of all polyol production will take place using Econic's catalyst technologies, meaning that potentially 3.5 million tonnes of CO_2 emissions could be saved each year.

In addition to the funds from Econic's existing shareholders, this latest investment round brings backing from OGCI Climate Investments, the one billion-dollar investment fund created by the Oil and Gas Climate Initiative (OGCI), a voluntary initiative led by CEOs of ten global oil and gas companies. The OGCI Climate Investments fund invests in promising technologies and business models that have the potential to significantly reduce greenhouse gas emissions and that are commercially viable and scalable.

Working with OGCI Climate Investments means that Econic Technologies will have access to an impressive network of oil and gas experts, opening the door to future opportunities for the global market to benefit from the positive potential of its catalyst technologies.

Due to the interest expressed by a number of strategic investors, the company has the facility to issue a number of additional shares within a limited time window following this close.

‘Early warning’ CO_2 monitoring technique using noble gases

University of Edinburgh research showing how naturally occurring noble gases can be used to track the movement of carbon dioxide injected underground could provide a reliable monitoring technique for carbon storage operators.

Storage operators must ensure that injected CO_2, captured from industrial processes or power generation, is stored securely. That means being able to track its movement below ground and identify its source.

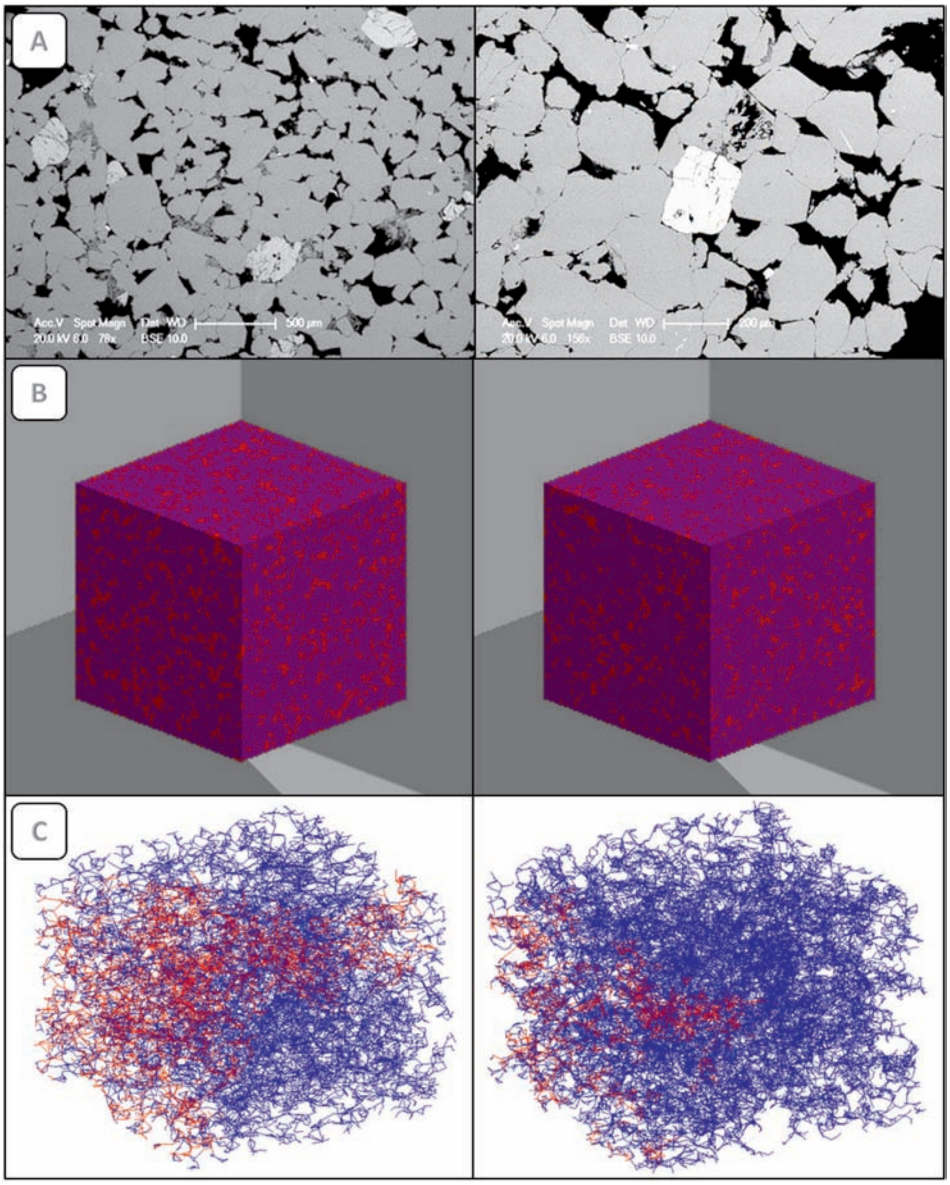
The new method developed by scientists at SCCS partner institute, the University of Edinburgh, stems from previous research suggesting that chemical tracers provide a fingerprint for injected CO_2, which can be clearly distinguished from natural sources. However, the movement of these tracers below ground was poorly understood and it was uncertain whether they could act as an early warning of migrating CO_2.

Using mass spectrometry, the researchers conducted time trials of the gas with different chemical tracers – including noble gases and sulfur hexafluoride – through samples of sandstone.

Their results, published in the journal Chemical Geology, show that the tracers take different times to travel through the same length of rock, with all of them arriving ahead of the CO_2. The findings suggest that, if the tracers were added to CO_2 before storage, any movement of the gas once injected into the store could be quickly detected.

Dr Rachel Kilgallon, formerly a PhD candidate at the School of GeoSciences, who undertook the study said, “Our work highlights that added tracers would provide an early warning of any unplanned migration of the injected CO_2. Our findings confirm results from large-scale experiments in the USA, where tracers were seen to travel faster than CO_2 through the rocks.”

Dr Stuart Gilfillan, also of the School of GeoSciences, who co-ordinated the study commented, “This new knowledge about the behaviour of CO_2 and tracers in the subsurface will help in the development of monitoring techniques to ensure secure carbon storage. We found that the time taken for krypton and xenon to flow through the rock sample was almost identical to that of the standard industry tracer, sulfur hexafluoride. As sulfur hexafluoride is a potent greenhouse gas, our results show that climate-friendly krypton and xenon can be used instead in future tracing applications.”



Results from pore architecture modelling using two images (A) to generate 3D models (B) and digital reconstructions (C). Each column represents a separate original image and final model

Carbon capture in the heart of Edinburgh already happening

The North British Distillery in Edinburgh has been capturing CO2 from the whisky distilling process for 30 years.

Carbon dioxide is a by-product in the production of whisky, resulting when yeast ferments wheat grain, or malted barley, to make alcohol. It's also an important ingredient in fizzy drinks – and one Scottish distillery spotted an opportunity to join these two things up back in the late 1980s.

The North British Distillery, in Gorgie, has long been capturing the carbon dioxide from fermentation, purifying it to a high standard of food safety, and selling it for other food and drink manufacturers to use.

There are many different ways to capture carbon dioxide, and the technology is changing and improving all the time, so SCCS was keen to find out how the North British Distillery does it. Their Environment Manager, Owen Foster, kindly invited us to visit the site where we found out that carbon capture is just the beginning of the story of the distillery's work to reduce its environmental impact. As well as capturing 4 tonnes of CO2 per day, it produces animal feed from syrup by product and from the 'draff' leftover after fermentation and distillation. The site also uses anaerobic digestion to produce biogas, which it uses to provide additional heat and power to the site (and heat to a nearby school), and has made its processes more energy- and water-efficient.

The carbon capture process at this site is relatively simple, because the off gas from fermentation is already very pure in CO2. The process is not about enhancing CO2 concentration, but more about removing impurities. That involves a number of washing stages to remove water and impurities from the gas given off during fermentation, before it is compressed, stored, and eventually transported by road.

The North British Distillery is a large operation – it produces about 1.5 million litres of spirit each week – and it is lucky that its Edinburgh location means it can easily find customers for both CO2 and animal feed.

It's a far cry from the stereotype of the small highland distillery, but it's not the only large distiller in Scotland: there are several other large producers of grain whisky that might want to consider capturing their carbon dioxide, whether for use in other products, or for permanent storage far below the North Sea. Could Scotland's national drink help kick-start a Scottish CCS industry?

More information

www.sccs.org.uk

Transport and storage news

DNV GL launches CCS certification framework

www.dnvgl.com

DNV GL has launched both a framework for certifying geological storage of carbon dioxide and a recommended practice for the design and operation of CO2 pipelines.

The DNV GL certification framework enables verification of conformity with the new ISO standard, ISO 27914:2017 Carbon dioxide capture, transportation and geological storage – Geological storage. This standard represents an international consensus on the requirements for the safe and effective storage of CO2 in geological formations.

The recommended practice DNVGL-RP-F104 Design and operation of carbon dioxide pipelines, provides guidance on safe and reliable design, construction and operation of pipelines intended for large-scale transportation of CO2. The recommended practice enables compliance with the requirements in the new ISO standard, ISO 27913:2017 Carbon dioxide capture, transportation and geological storage - Pipeline transportation systems.

"We now have further confirmation that we are technically ready to be able to use large-scale CCS for onshore and offshore emission sources," said CEO of DNV GL - Oil & Gas, Liv Hovem. "Our new certification framework plus our recommended practice represent an important step towards making the full CCS chain technically feasible, safe and ready for global scaling."

The DNV GL certification framework provides additional clarity about the requirements an operator should meet – and offers a recipe for how to meet them – at different points in the lifecycle of a geological storage project. It thus improves investor predictability and decreases both capex and opex risks.

It has also been subject to a broad international consultation process and received significant support from potential users. One of the certification framework advocates, Luc Rock, a hydrogeologist - MMV Coordinator with Shell, says, "The certification framework makes ISO 27914 requirements and recommendations easier and more accessible by grouping them according to their relevance for decisions."

"Putting foundations like this in place are part of the industry's drive that will hopefully kick-start the growth of CCS as a cost-effective method to remove global fossil fuel emissions."

The updated recommended practice for design and operation of CO2 pipelines helps implement the new ISO standard 27913:2017. It is based on new knowledge gained from the CO2PIPETRANS joint industry project, which was completed in 2016, with specific focus on dense phase CO2 model validation, fracture arrest and corrosion.