Carbon Capture Journal

CCUS in Europe

CO2-DISSOLVED: combining CO2 geological storage with geothermal heat recovery

Pathways to Net-Zero Emissions from EU Heavy Industry

May / June 2019

Issue 69

UK Government should 'green light' carbon capture technology

UK can phase out greenhouse gas emissions by 2050

Making CCS add up - why the figures are wrong on CCS

Separating CO2 out of industrial processes using porous nano rods

Policy priorities to incentivise large scale deployment of CCS

While the critical role of CCS has been demonstrated in many reports, the policies in place today are insufficient to ensure CCS deployment scales up at the rate required. A Global CCS Institute paper seeks to address the current policy gap by describing priorities for policymakers to support the transition from current to future rates of deployment of CCS.

In combination with bioenergy used for power generation or biofuel production, CCS provides one of the few technologies that can deliver negative emissions at scale; unambiguously required to limit temperature rises to meet the Paris climate targets.

The Institute's report, 'Policy priorities to incentivise large scale deployment of CCS,' explores how to stimulate investment in CCS. The paper also identifies concrete policy actions and reviews the progress achieved until now by identifying the policies and commercial conditions that have enabled investment in the 18 large-scale CCS facilities currently in operation, and the additional five that are under construction.

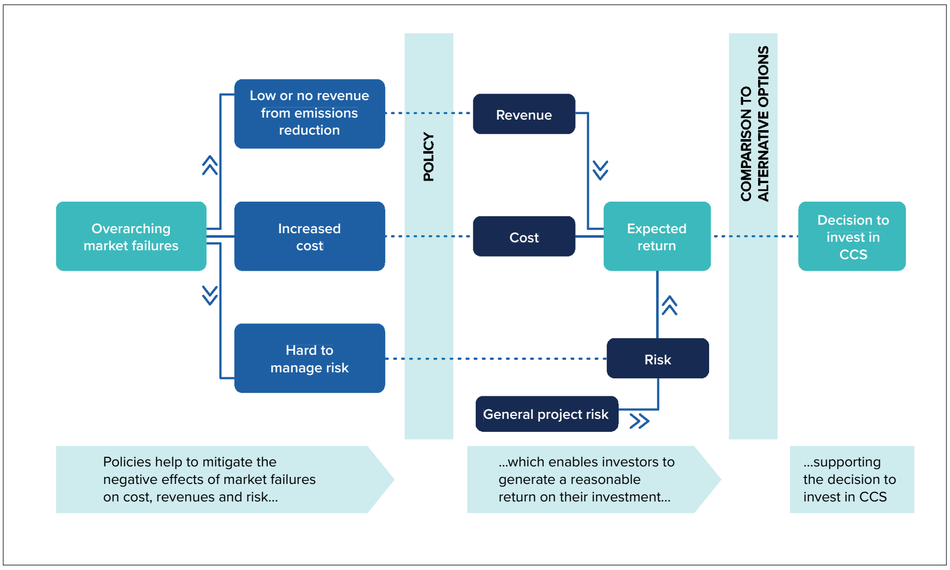

Illustration of how market failures, policy and risks influence the business case to invest in CCS (from Policy priorities to incentivise large scale deployment of CCS)

Conclusions

Accelerating the rate of deployment of CCS is essential to meeting global emissions reductions targets. While progress has been made in recent years, there remain gaps in the policy frameworks across all countries, such that no country has yet to implement a framework that would be consistent with meeting Paris targets.

The report reviewed the conditions that enabled current investments in large scale CCS facilities. Investments have predominantly relied on supportive policies, revenue from Enhanced Oil Recovery and low cost capture, transport and storage opportunities. This coincidence of circumstances has enabled a positive financial investment decision on 23 large scale facilities to date which has proven the technology over almost five decades of operational experience.

However, for CCS to be deployed at the rate required to meet emissions reductions targets, governments must implement policy frameworks that align private and public good investment incentives to drive private capital into CCS at a much greater scale. The report identifies areas where policymakers should focus their efforts in the near-term, and in doing so, derisk investments in CCS projects.

The main priority areas for policymakers are:

• To establish a material value on CO2 to establish a financial incentive for investing in carbon dioxide capture and storage.

• For government to play the critical role of enabling the development of shared transport and storage infrastructure. It can do this by investing directly in transport and storage infrastructure or by setting the regulatory framework within which networks can be developed cost effectively. This will serve to reduce operational costs through economies of scale as well as to address cross-chain risks. • To implement a well-characterised legal and regulatory framework that clarifies carbon dioxide storage operators' liabilities such that long term liability risk does not prevent private sector investment.

• To provide capital support where required, in the form of grants, accelerated depreciation, concessional loans, or other mechanisms to attract private capital to CCS investments, until the business case for investment in CCS is created by market forces.

• To identify and consider additional policy interventions designed to reduce specific risks perceived by financiers and equity investors in order to bring down the cost of capital and enhance the financial viability of future CCS investments. This process should be informed by research to quantify the impact of each class of risk on the cost of debt and equity to ensure the efficiency and effectiveness of policy interventions.

More information

Download the full report:

www.globalccsinstitute.com

Carbon Capture Journal

May / June 2019 Issue 69

Carbon Capture Journal

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Front cover: At the SINTEF carbon capture plant at Trondheim, Norway, research is being carried out into full-scale CO2 treatment. Engineer Lars Hovdahl is checking to see that everything is working as it should. Photo: Thor Nielsen

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

Leaders - CCUS in Europe

Projects and policy

Capture and utilisation

Transport and storage

CO2-DISSOLVED: combining CO2 geological storage with geothermal heat recovery

Storing dissolved CO2 in deep saline aquifers close to small-to-medium-scale industrial emission sources, whilst also recovering geothermal energy: this is the basic idea behind the CO2-DISSOLVED concept, a promising complement to conventional large-scale CO2 storage with a twist.

An international consortium is currently working on preparing the ground for a future full-scale industrial pilot in order to confirm the techno-economic feasibility of this new CCS approach.

Concept

Commercial-scale industrial geological CO2 storage projects generally involve the injection of CO2 in supercritical form, a state where it is both dense -like a liquid, and has low viscosity -like a gas, which maximizes the quantities able to be stored (several million tonnes per year).

A different approach is taken with the innovative concept of CO2-DISSOLVED (CO2 Dependable Injection and Storage System Optimised for Local Valorisation of the Energy Delivered), launched and coordinated by BRGM, the French Geological Survey.

The CO2 produced by small-to-medium-scale industrial facilities (< 150 kt/y) is stored locally on-site by injecting it, in dissolved form, into an underlying deep saline aquifer. The water pumped up via a 'production' well is subsequently reinjected with the CO2 dissolved in the brine via an 'injection' well, the two wells constituting a doublet system (see Figure 1).

When applied in a favourable geothermal context, CO2-DISSOLVED is designed to also recover heat from the extracted brine in order to use it locally for the specific needs of the CO2 emitter and/or to supply a heating/cooling network.

In this manner, in addition to reducing industrial emissions by storing CO2 underground, CO2-DISSOLVED can also offer the added bonus of renewable heat recovery.

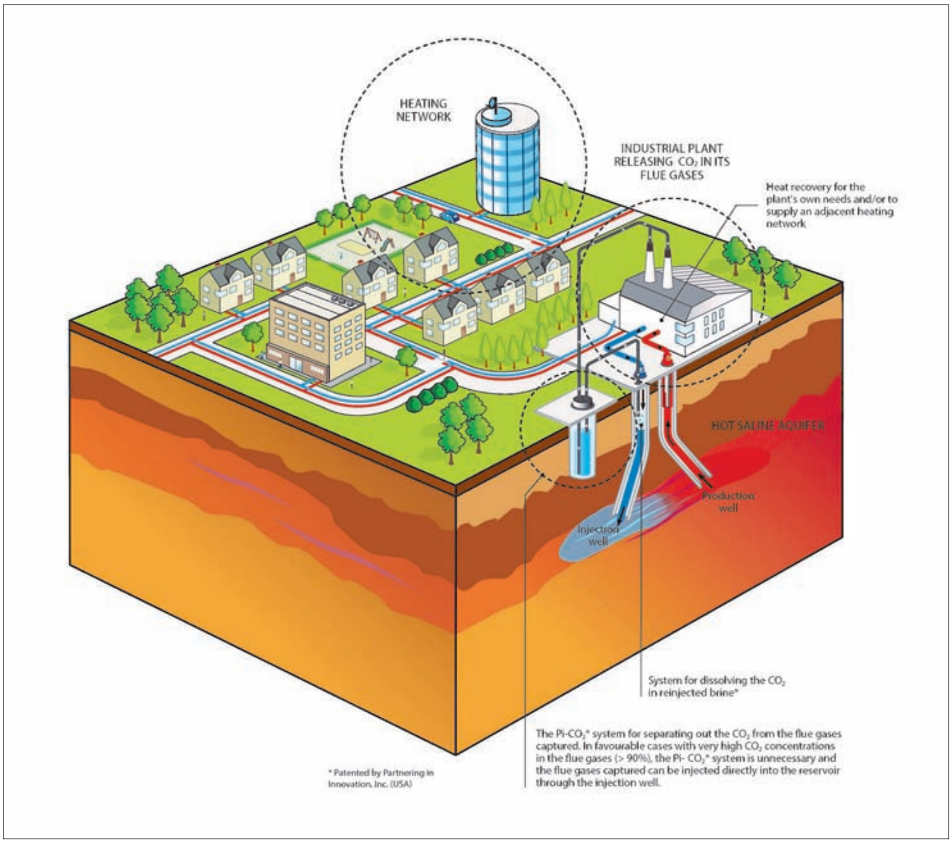

Figure 1 - Schematic diagram showing the CO2-DISSOLVED concept combining local storage of dissolved CO2 and heat recovery through a low-enthalpy geothermal doublet (©BRGM)

Applicability

The CO2-DISSOLVED concept is best-suited to small-to-medium-scale industrial emitters (< 150 kt CO2/y) quite simply because of a physical limitation: the amount of CO2 that can be injected and stored in a dissolved state is limited by both the maximum solubility of CO2 in brine and the maximum possible water flow-rate at the injection well. Based on the typical water flow-rates obtained in geothermal doublets of the Paris basin (200-350 m^3/h), and considering typical downhole pressure, temperature, and salinity conditions in the Dogger aquifer (70°C, 150 bar, 15 g/L, respectively), our calculations reveal that a single doublet could typically dissolve and inject up to 80-150 kt of CO2 per year.

Another basic constraint is of course the existence of suitable aquifers in the right location. The best-case scenario, i.e. combining CO2 storage and heat recovery, would be a 'deep' aquifer (ca. 1,500–2,500 m) with geothermal potential, i.e. temperatures in the region of 60 to 80°C. Nevertheless, a shallower aquifer with lower temperature geothermal resources should not be overlooked as the viability of a CO2-DISSOLVED facility, just like any other standard geothermal plant, should be sized on a case-by-case basis according to the local energy needs.

Urgency and complementarity

While there is no doubt that CO2 Capture and Storage (CCS) has a major role to play in cutting atmospheric greenhouse gas emissions in order to meet the Paris Agreement targets[1], several factors are hindering its deployment in the immediate term, including safety, cost, public perception and regulatory issues.

Although 18 full-scale CCS facilities were in commercial operation in 2018, more than 2,500 will be needed by 2040 to reach the 2°C scenario target[2]. Storing CO2 close to small-scale industrial emission sources could be a complementary option to the 'classic' supercritical CCS approach that generally addresses high-rate emitters. A simple, low-cost and environmentally safe facility injecting small quantities of dissolved CO2 could thus help get the CCS deployment ball rolling.

Whilst at first sight the contribution of a single industrial facility equipped with the CO2-DISSOLVED technology could seem insignificant in terms of climate change impact, things soon escalate when multiplied on a national scale. In France, for example, 650 potentially compatible industrial sites have been identified, accounting for 25% of France's industrial CO2 emissions (Figure 2). Furthermore, let's not overlook the fact that the CO2-DISSOLVED approach brings a decarbonisation solution to an industrial sector that otherwise has few choices for reducing its carbon footprint.

Flexibility

Functions with or without capture

CO2-DISSOLVED can be applied to store CO2 that is either captured elsewhere and transported in by pipeline or tanks or, preferably, captured on-site. In the latter case, although any capture technology is compatible, the proposed CO2 capture technology ('Pi-CO2'[3]) is provided by Partnering in Innovation, Inc., our American partner involved in the project since the start.

The main advantages of this innovative capture solution are twofold: (1) environmental, as the only solvent used is water, and (2) economic, with a cost significantly lower than other post-combustion technologies available on the market due to a cheap and abundantly available solvent (water), an optimized energy consumption, and in-process Sox, Nox, Hg, Se removal (thus avoiding expensive gas pre-treatment).

Functions with or without a favourable geothermal context

Although application of the CO2-DISSOLVED concept is by no means constrained to settings with high geothermal potential, it is particularly well suited to such a synergy where heat recovery is considered an extra bonus. In this case, a CO2-DISSOLVED facility comprises a classic low-enthalpy geothermal doublet from which the warm water (ca. 50-90°C) is extracted, thus enabling energy recovery via a heat exchanger system, and then the cooled brine (ca. 30-40°C) is saturated in dissolved CO2 before being injected back into the aquifer for storage.

How CO2-DISSOLVED can contribute to CCS deployment

Safety and environmental benefits

• Storing CO2 in dissolved form avoids the formation of a gas bubble in the aquifer and therefore the associated risks of buoyancy, causing the gas to rise and leak to the surface. The risk of the injected CO2 escaping to the surface is thus low-to-inexistent as it remains trapped by dissolution in the brine

• Involves relatively small volumes of CO2 (150 kt/y or less)

• No pressure build-up in the aquifer because the amount of injected water is exactly balanced by the amount of pumped water

• No large distance displacement of the in-situ brine since the vicinity impacted is centred around the foot of the wells

• The 'Pi-CO2' CO2 capture system is aqueous based, thus avoiding hazardous solvents

Cost

• Economy of scale: do small-scale, 'low-cost' local storage onshore in an appropriate region and then, once proven, multiply deployment

• Extra revenue sources: energy produced by geothermal heat recovery and CO2 allowances from carbon credits

• Performed locally, thus avoiding the problems related to infrastructure and cost of CO2 transport

• The 'Pi-CO2' CO2 capture system is cost-efficient compared to other technologies on the market

Public perception

• Synergy between safe CO2 storage and a clean and renewable form of energy production

• Support small-scale deployment and involve from the very beginning local stakeholders and population in the industrial pilot and commercial deployment.

Regulations

• Help clarify and detail regulations for the case of storing CO2 in an entirely dissolved state

1. IPCC Special Report ; GCCSI - CCS: A solution to climate change right beneath our feet; IEA – Energy Technology Perspectives 2016
2. Based on a facility with a capture capacity of 1.5 Mt/y of CO2: GCCSI 2018 Status report https://indd.adobe.com/view/2dab1be7-edd0-447d-b020-06242ea2cf3b
3. Carbon Capture Journal March/April issue 68

The journey so far (2013 – 2019) and perspectives

Since the first CO2-DISSOLVED research project launched in 2013, three successive projects have been initiated and a fourth one is in the pipeline (see Table 1 and Figure 3).

The overall objective for the final demonstration stage (last project in Table 1 and red block in Figure 3) is to implement a demonstration pilot at an industrial site. The ground has already been prepared during the 'PILOTE CO2-DISSOLVED' project, and the two current projects, 'CO2-DISSOLVED_INJECTION' and 'GEOCO2', will also contribute to paving the way.

An appropriate site will hopefully be identified during the inventories and pre-feasibility studies. Interestingly, the GEOCO2 project has confirmed a local political support to development of the technology, which is critical to the feasibility of a future demonstrator.

In parallel to these projects, and as a follow-up of the preliminary experimental tests of the first 'Pi-CO2' prototype, a new project is under consideration and design with the objective of running in-well CO2 capture tests at full-scale with a new specifically designed 'Pi-CO2' prototype. Demonstration of the capture prototype in a well setting at high pressure is clearly the missing link to ensure validation of this breakthrough technology. The quality of the international partnership under construction, and the availability of an appropriate experimental site make this project achievable in the relatively short term, compatible with the scheduled launch of a CO2-DISSOLVED demonstration phase.

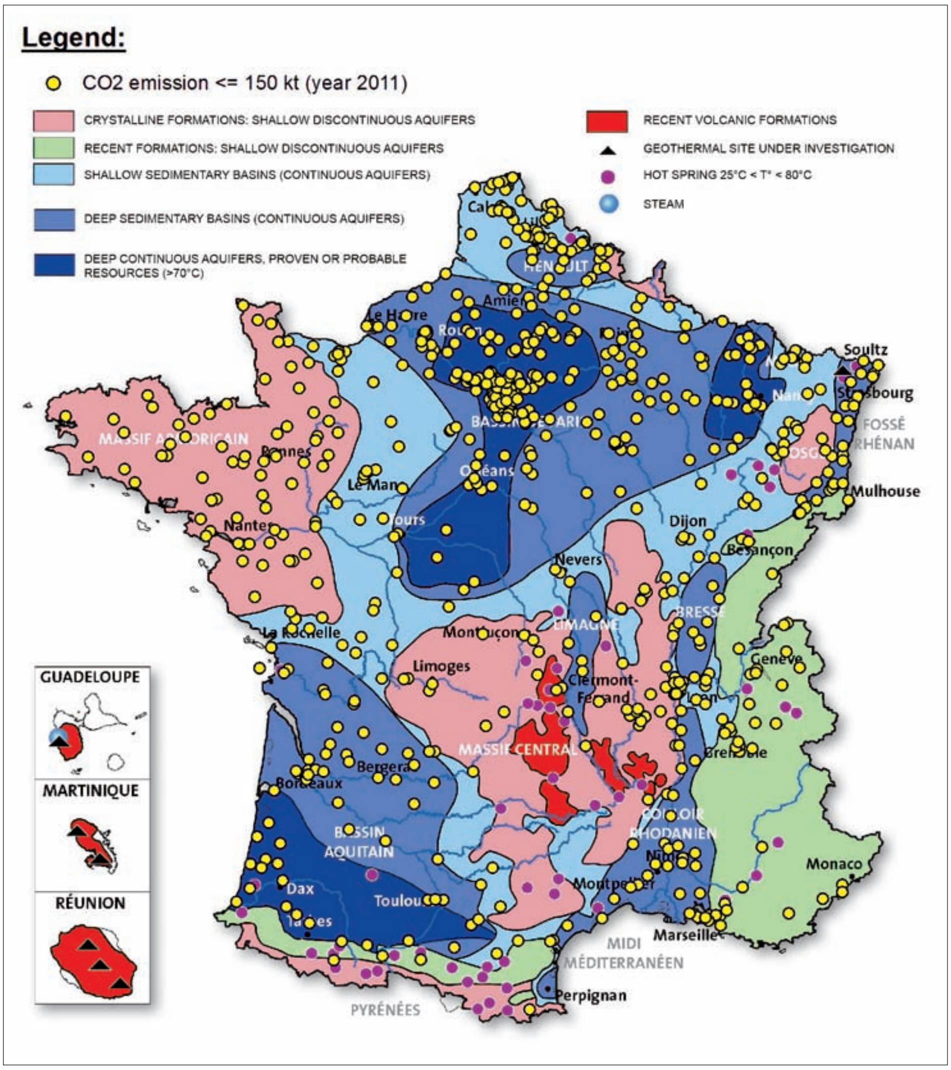

Figure 2 – Location of the small-to-medium industrial emitters on the French metropolitan territory (yellow dots) vs. the most favourable areas for deep geothermal energy resources (dark and medium blue areas) (©BRGM)

The ambitious objective of implementing a commercial demonstration phase in the coming 5-10 years appears feasible as our consortium was recently strengthened by the arrival of major industrial partners and international research institutes.

We are currently seeking to enlarge our consortium to include other international funding partners.

The novelty of this concept is not only technical, but also the target in terms of type (industry) and scale (small-to-medium emitters) meaning that it will complement the existing emission-reduction portfolio.

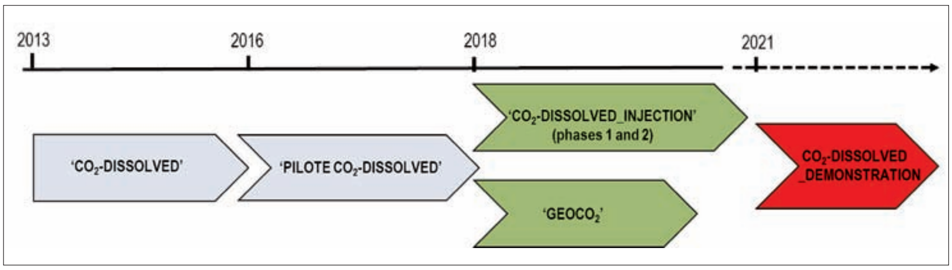

Figure 3 – Past, current, and targeted CO2-DISSOLVED projects: timeline from the first feasibility study to commercial demonstration (©BRGM)

Conclusions and perspectives

Relying on the well-known geothermal doublet technology, CO2-DISSOLVED is a new CCS approach that is simple, low-cost, and environmentally safe as the CO2 is injected and stored in dissolved form and the concept operates with an innovative water-based capture technology.

All results obtained to date through the past and ongoing 'CO2-DISSOLVED' projects confirm the viability of the concept, which has already been proved to be potentially applicable to small-to-medium industrial CO2 emitters (ca. 100 kt/y) in many areas of Europe and the USA (see key references in the bibliography).

Figure 4 – The 'Pi-CO2' water-based CO2 capture technology prototype undergoing testing at BRGM's experimental laboratory (© BRGM – Rowena Stead)

Table 1. CO2-DISSOLVED research projects (past-ongoing-future): from concept to demonstration

Title (and funding)	Duration, Consortium, Aim
CO2-DISSOLVED (ANR: French Research Agency)	• 40 months: January 2013 - May 2016 • 7 partners • Demonstrate the techno-economic feasibility of combining the storage of dissolved CO2 in an aquifer with the extraction of geothermal heat. Assess the techno-economic feasibility of applying the CO2-DISSOLVED technology to a new industrial target, namely 'small' polluters emitting less than 150 kt CO2/y.
PILOTE CO2-DISSOLVED (Investments for the Future Programme (PIA) with Géodénergies)	• 24 months: June 2016 – May 2018 • 9 partners • Seek and select a suitable site where to construct and operate the CO2-DISSOLVED concept and prepare the ground for a future industrial demonstrator phase. Identify an industrial company with an interest in reducing its carbon footprint and recovering geothermal energy. • Start investigations on the social acceptance and regulatory aspects • Set-up and operate first-of-a-kind prototyping tests of the 'Pi-CO2' water-based CO2 capture technology in BRGM's lab (see Figure 4 and issue no. 68 of Carbon Capture Journal).
GEOCO2 (Region Centre – Val de Loire)	• 24 months: September 2018 - August 2020 • 5 partners • Assess the potential of applying CO2-DISSOLVED in the French Centre-Val de Loire Region. Undertake a detailed inventory of the potential of compatible sites and a prefeasibility study of two sites of interest.
CO2-DISSOLVED_INJECTION (Phase 1) (Investments for the Future Programme (PIA) with Géodénergies)	• 18 months: October 2018 – March 2020 • 14 partners • The final objective is to validate the technical feasibility of injecting CO2 in dissolved form, performing on-site injection tests in an 'old' geothermal doublet. • This first preparation phase aims to (1) find an appropriate site in the Paris basin, set-up an agreement with the owner, and obtain the requested permit from the administration, (2) define the detailed experimental programme, (3) organise the communication strategy for the stakeholders and the public.
CO2-DISSOLVED_INJECTION (Phase 2) (funding pending)	• 12-18 months? Expected start by mid/end 2020 • Consortium to be finalised • Perform the CO2 injection test programme as defined in Phase 1. This project is specifically dedicated to the injection process. A CO2 provider will be sought to supply the required amount of CO2 for the tests (ca. 5 kt). • Measure the actual performance of the geothermal doublet while undertaking CO2 co-injection. • Demonstrate to stakeholders, the administration, and the public the safety of CO2 injection operations through an appropriate monitoring plan.
CO2-DISSOLVED_DEMONSTRATION (funding pending)	• 48-60 months? Expected to start from 2022 onwards • Consortium to be defined • Validation of the technical and economic performance of a coupled operation (geothermal + CCS) at industrial scale • Demonstration of risk management and involving local stakeholders in the process

CO2-DISSOLVED could thus bring a turnkey decarbonisation solution to an industrial sector that has little or no other choice of reducing its carbon footprint.

Successful demonstration at this relatively small scale would certainly contribute to convincing the public and decision-makers on the feasibility of underground CO2 storage, and thus help push larger-scale forms of CCS deployment forward.

Short bibliography

C. Castillo, N. C.M. Marty, V. Hamm, C. Kervévan, D. Thiéry, L. de Lary, J.-C. Manceau. Reactive transport modelling of dissolved CO2 injection in a geothermal doublet. Application to the CO2-DISSOLVED concept. Energy Procedia, 114, pp. 4062–4074, 2017.

X. Galiègue, A. Laude. Combining Geothermal Energy and CCS: From the Transformation to the Reconfiguration of a Socio-Technical Regime? Energy Procedia, 114, pp. 7528-7539, 2017.

C. Kervévan, M.-H. Beddelem, X. Galiègue, Y. Le Gallo, F. May, K. O'Neil, J. Sterpenich. Main Results of the CO2-DISSOLVED Project: First Step toward a Future Industrial Pilot Combining Geological Storage of Dissolved CO2 and Geothermal Heat Recovery. Energy Procedia, 114, pp. 4086–4098, 2017.

J. Royer-Adnot, Y. Le Gallo. Economic Analysis of Combined Geothermal and CO2 Storage for Small-Size Emitters. Energy Procedia, 114, pp. 7118–7125, 2017.

A. Randi, J. Sterpenich, D. Thiéry, C. Kervévan, J. Pironon, C. Morlot. Experimental and numerical simulation of the injection of a CO2 saturated solution in a carbonate reservoir: application to the CO2-DISSOLVED concept combining CO2 geological storage and geothermal heat recovery. Energy Procedia, 114, pp. 2942–2956, 2017.

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SINTEF: carbon capture is cheaper than ever

According to a new report, many years of research effort have resulted in significant reductions in the cost of full-scale carbon capture and storage.
By Mona Sprenger, SINTEF

NTNU, SINTEF and their industry partners have together generated the knowledge and developed the methods and technologies needed to make CCS a feasible alternative in the battle to reduce CO2 emissions. This is researcher H. G. Jacob Stang at the CO2-mix rig at SINTEF. Photo: Thor Nielsen

If we are to achieve the two-degree target and meet our commitments as set out in the Paris Agreement, we are entirely dependent on the technology that makes it possible to capture and store CO2.

But it is widely assumed that carbon capture and storage (CCS) is expensive. Very expensive.

However, many technology experts believe that once we start applying CCS, cost reductions will follow a similar trend as those for solar and wind power. According to a new study carried out by SINTEF, CCS technology has already started to be less expensive. The results are reacently published in Elsevier International Journal of Greenhouse Gas Control.

"If the CCS market grows to the extent that we are able to achieve our climate change targets, the savings will be enormous, and the potential for wealth generation in the Norwegian industrial sector is very great," SINTEF researcher Sigmund Størset.

CCS – savings and benefits

During the period 2008 to 2017, the Research Council of Norway (RCN) funded energy research to the tune of NOK 4 billion.

About a quarter of these funds were allocated to CCS. SINTEF has recently been assessing the potential economic benefits accrued from CCS-related innovations linked to the international research centres BIGCCS (the International Research CCS Centre), NCCS (the Norwegian CCS Research Centre) and their antecedents. This work is based on the so-called "Effektstudien" (impact study) that the Norwegian Ministry of Petroleum and Energy has commissioned from the RCN. (Read the fact box)

"We've been looking into seven different innovations in the field of the capture, transport and storage of CO2", says SINTEF researcher Grethe Tangen.

There currently exists no mature market for CCS, which means that it is not so easy to measure the value of this research.

"Our aim is therefore to document that the research carried out in the last ten to twenty years has led to a significant cost reductions throughout the entire value chain", says SINTEF researcher Sigmund Størset.

"If the CCS market grows to the extent that we are able to achieve our climate change targets, the savings will be enormous, and the potential for wealth generation in the Norwegian industrial sector is very great", he says.

Facts

During the period 2008 to 2017, the Research Council of Norway (RCN) funded energy research to the tune of NOK 4 billion. This funding has been a profitable exercise, according to the impact study commissioned from the Research Council of Norway by the Norwegian Ministry of Petroleum and Energy.

A significant portion of these research funds were allocated to CCS. SINTEF has recently published the results of a study assessing the potential economic benefits accrued from CCS-related innovations linked to the international research centres BIGCCS (the International Research CCS Centre), NCCS (the Norwegian CCS Research Centre) and their antecedents.

Ninety different chemical cocktails

In order for CCS to succeed, we must meet the pressing need to establish a full-scale value chain including the capture, transport and storage of CO2. The Norwegian parliament has asked the government to secure funding for at least one carbon capture plant.

At its plant in Brevik in Telemark, cement manufacturers Norcem, a subsidiary of the German Heidelberg Group, are working to establish a full-scale carbon capture plant. Aker Solutions is planning to install technology based on the SOLVit project at the Norcem plant by 2023.

This project has involved the development of new and advanced fluid mixtures that bind the CO2 gas. These mixtures involve relatively low levels of energy consumption and degradation, and are both eco-friendly and non-corrosive. This research was the result of a collaboration between Aker Solutions (formerly Aker Clean Carbon), SINTEF and NTNU.

"We launched the SOLVit project in 2008 with funding from the CLIMIT research programme and from industrial and research sources", says Oscar Graff, who heads Aker Solutions' CCUS department. "And a lot has happened since then.

Our mobile test facility has verified technology for carbon capture from gas- and coal-powered power stations, refineries, waste combustion facilities and cement manufacturing plants. We have tested six pilot facilities in Germany, Scotland, the USA and Norway, and experimented with 90 different chemical cocktails before we identified the best.

We also built a facility at the Mongstad test centre, where we carried out a two-year test programme", says Graff.

Graff believes that the knowledge base and research infrastructure established during the SOLVit project will help towards establishing a commercial, full-scale carbon capture plant outside Norway as well.

"We have advanced the technology and reduced costs significantly by such means as applying a European industrial standard in preference to standards used in the oil and gas sector", says Graff. "The Norcem plant will become even more energy efficient when we go on to exploit waste heat generated by the manufacturing process", he says.

From NOK 50 to 500 million in savings

SINTEF's calculations indicate that potential costs savings resulting from application of the new SOLVit technology in an industrial CCS project will be of the order of between NOK 50 and 500 million.

"This is mainly due to reduced energy requirements linked to the cleaning process", says researcher Grethe Tangen.

About 40 per cent of global CO2 emissions are derived from just 4,000 point sources. Many of these are located in low-cost countries such as India, China and Russia.

"The SOLVit technology can be applied in the cement, steel, and waste disposal industries, and in connection with power generation from natural gas and coal", explains Johan Einar Hustad, who is Director of NTNU Energy.

CCS must become a university subject

Hustad emphasises that research will continue to play a crucial role in the work to build a full-scale CO2 treatment plant.

"It will only be when we put a full-scale plant into operation and establish an entire value chain from capture to storage that we will be able to make even greater cost savings", he says. "We have observed this trend in the solar and onshore wind sectors, and the same is happening now in connection with batteries", says Hustad, who is keen to promote education programmes for those wanting to work in the CCS industry.

"We must continue to foster Master's and Ph.D. students", he says. "People who want to work in industry and who can help to establish the expertise that the industry needs. If CCS is to become a technology applied on a large scale, we are dependent on educational provision that is sufficient to meet the industry's future needs", says Hustad.

More information

Article originally appeared in Gemini Research news:

geminiresearchnews.com

Pathways to Net-Zero Emissions from EU Heavy Industry

Achieving net-zero emissions by 2050 for European energy-intensive industries is within reach and multiple pathways can get them there concludes a report by consultancy Material Economics.

If supported by the right policy framework, these industries can contribute their share to the EU's net-zero by 2050 vision, currently under discussion by member states, while remaining competitive and at the forefront of new economic opportunities at the global level.

These are some of the conclusions of a new report – Industrial Transformation 2050 – Pathways to Net-Zero Emissions from EU Heavy Industry – carried out by the consultancy Material Economics with the support of the Wuppertal Institute and the Institute for European Studies, and commissioned by the European Climate Foundation.

A second report, Towards an Industrial Strategy for a Climate Neutral Europe also published today by the Institute for European Studies at the Vrije Universiteit Brussel, spells out a vision of an integrated climate and industrial strategy to support this transition.

Heavy industry is one of the sectors of the EU economy with stagnating CO2 emissions abatement and significant fossil fuel use. Previously perceived as the "hard to abate" industrial sectors, steel, chemicals, and cement account for about 14% of Europe's annual emissions. While other sectors are accelerating their emissions reductions, the share of emissions from heavy industry will increase dramatically under business as usual. As such, industry has a key role to play in the decarbonisation of the European economy to fulfil the EU's commitments under the Paris agreement.

The report concludes that despite the many challenges, there is no question that CCS could provide valuable early emissions reductions and play a role in a fully net-zero production. High capture rates of 90% or more could be combined with bio-based inputs for a truly net zero-CO2 solution. In a stretch case, some 235 Mt of CO2 could be captured from a wide range of sources in the overall materials system.

CCS/U contribution

Carbon capture and storage / use is expeceted to contribute 45–235 Mt CO2 per year by 2050. The main alternative to mobilising new processes is to fit carbon capture and storage or use (CCS/U) to current processes. This can make for less disruptive change: less reliance on processes and feedstocks not yet deployed at scale and continued use of more of current industrial capacity. It also reduces the need for electricity otherwise required for new processes.

However, CCU is viable in a wider net-zero economy only in very particular circumstances, where emissions to the atmosphere are permanently avoided. CCS/U also faces challenges. In steel, the main one is to achieve high rates of carbon capture from current integrated steel plants. Doing so may require cross-sectoral coupling to use end-of-life plastic waste, or else the introduction of new processes such as direct smelting in place of today's blast furnaces.

For chemicals, it would be necessary not just to fit the core steam cracking process with carbon capture, but also to capture CO2 upstream from refining, and downstream from many hundreds of waste incineration plants. Cement production similarly takes place at around 200 geographically dispersed plants, so universal CCS is challenging. Across all sectors, CCS would require public acceptance and access to suitable transport and storage infrastructure. These considerations mean that CCS/U is far from a 'plug and play' solution applicable to all emissions.

Still, it is required to some degree in every pathway explored in this study. High-priority areas could include cement process emissions; the production of hydrogen from natural gas; the incineration of end-of-life plastics; high-temperature heat in cement kilns and crackers in the chemical industry; and potentially the use of off-gases from steel production as feedstock for chemicals.

In a high case, the total amount of CO2 permanently stored could reach 235 Mt per year in 2050, requiring around 3,200 Mt of CO2 storage capacity. However, it also is possible to reach net-zero emissions with CCS/U used mainly for process emissions from cement production. In this case, the amount captured would be around 45 Mt per year.

Key findings

Climate neutrality for heavy industry: From Whether To How

According to the report, there are multiple possible pathways the EU could pursue to achieve the full decarbonisation of its heavy industries by 2050.

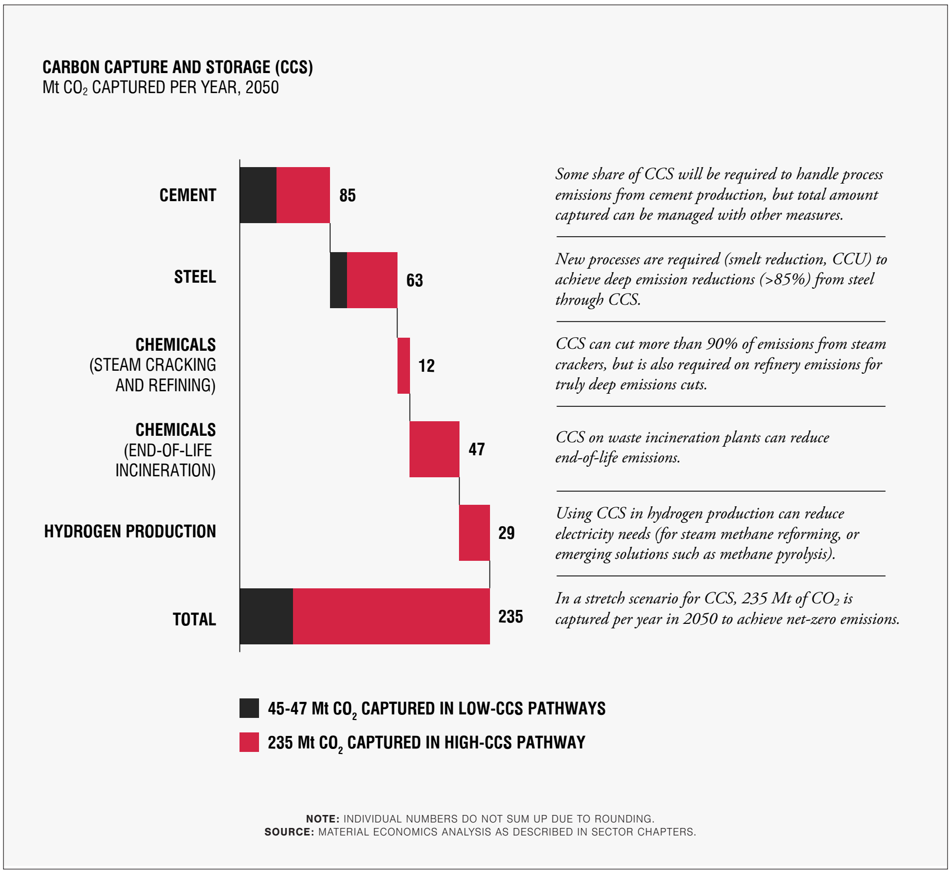
• A more circular economy is a large part of the answer. Increased materials efficiency throughout value chains could cut 58–171 Mt CO2 per year by 2050. 800 kg of steel, cement and chemicals are used per person, per year in the EU. However, it is possible to achieve the same benefits and functionality with less material.

Examples include new manufacturing and construction techniques to reduce waste, co-ordination along value chains for circular product design and end-of-life practices, new circular business models based on sharing and service provision, substitution with highstrength and low-CO2 materials, and less over-use of materials in many large product categories.

• Reusing materials that have already been produced can also result in large emission reductions. By 2050, 70% of steel and plastics could be produced using recycled feedstock. In the case of plastics, using end-of-life plastics as feedstock for new production could significantly reduce the need for fossil fuels to produce new plastics.

• Innovations in new, clean production processes and significant increases in renewable energy production will help enable deeper emission reductions over time. Between 143–241 Mt CO2 per year could be cut by 2050 by deploying new industrial processes. Innovations that would allow the use of electricity to produce high-temperature heat, switching for example from fossil fuels to green hydrogen, are emerging. However, these solutions need to be rapidly developed and deployed if they are to make a significant contribution by 2050.

• Carbon capture and storage/use (CCS/CCU). All pathways developed in the study show that there are cases where not all the emissions can be abated through circular economy and electrification. CCS and CCU will be required to cut between 45 and 235 MtCO2 emissions per year by 2050. However, as the study highlights, these measures are not a 'plug and play' solution and would require access to suitable transport and storage infrastructure.



CCS could be used across a wide range of industrial sources, with 235 Mt CO2 captured by 2050 in a stretch case (from Industrial Transformation 2050 – Pathways to Net-Zero Emissions from EU Heavy Industry

The benefits of decarbonisation

Reaching the full decarbonisation of its heavy industry will create an opportunity for Europe to become one of the key global hotspots for deep decarbonisation. Ten years ago Europe was an undisputed leader in a wide variety of renewable energy and low-carbon products and services. It now has the chance to boost the competitiveness of its industry by developing sustainable solutions that will be needed globally.

Switching from the import of large quantities of fossil fuels and feedstocks to home-grown resources would significantly reduce European industry's dependence on energy imports and will foster Europe's energy trade balance. Steel, cement, and chemicals production together use 8.4 Exajoules (EJ) of mostly imported oil, coal, and natural gas. A major benefit of a more circular economy would be to reduce this need by up to 3.1 EJ per year in 2050.

The costs of the transition

Thanks to a more circular economy and affordable electricity, consumer prices of cars, houses and packaged goods would increase by less than 1%. Overall, the additional costs of achieving zero emissions are around 0.2% of projected EU GDP by 2050.

However, the business-to-business impact can be challenging and must be managed carefully. Therefore, strong policy support will be needed in the near term to ensure companies remain profitable in the transition.

Time is key

EU companies will need to make important investment decisions in the next few years. Changes in value chains and business models will take decades to establish and any delay will hugely complicate the transition. Therefore, national and European policymakers should urgently develop a comprehensive and integrated industrial climate policy strategy that ensures companies remain profitable in the transition to a net-zero and circular industrial future.

Towards an Industrial Strategy for a Climate Neutral Europe puts forward specific policy solutions to be taken into account by EU policymakers as part of their industrial strategy. The suggested policy options range from accelerating research and development, creating lead markets for and safeguarding the competitiveness of low-CO2 solutions, to incentivising and scaling up investments, enabling a fully circular economy as well as facilitating sector coupling and supporting infrastructure.

It suggests that a dedicated governance mechanism for the industrial transition at the EU level must be put in place to guarantee a successful transition.

More information

europeanclimate.org

materialeconomics.com

Europe CCUS news

Europe relaunches CCUS knowledge exchange network

www.ccusnetwork.eu

A Europe-wide knowledge sharing network has received fresh funding from the European Commission to support and inspire major carbon capture, utilisation and storage (CCUS) projects in their efforts to deliver climate action.

The revitalised European CCUS Projects Network will connect industry partners involved in real-life CCUS projects, which have potential to deliver significant carbon emission reductions in Europe's industrial regions.

The network, managed by a secretariat of pooled international expertise, will provide member projects with opportunities for sharing knowledge and best practice alongside guidance on how to increase public awareness and acceptance of CCUS technologies.

The secretariat will ultimately provide advice to the Commission on the most effective way to deliver a commercially viable and technologically sound CCUS network, which will help Europe's member states meet climate targets enshrined in the Paris Agreement.

The project secretariat – which includes project lead Trinomics (Netherlands), Bellona Europa (Belgium), DECHEMA (Germany), Scottish Carbon Capture & Storage (UK), SINTEF (Norway) and TNO (Netherlands) – is keen to contact existing and emerging CCUS projects across Europe, which have significant climate mitigation potential and are close to being ready for operation.

Projects being considered as network members will have a focus on carbon capture and storage (CCS) and/or CO_2 utilisation (CCU), and will need to demonstrate substantial overall CO_2 emissions reduction in their lifecycle analysis as well as a commitment to building a European CCUS industry through knowledge sharing.

Hans Bolscher, project coordinator, Trinomics, said: "The knowledge-sharing component of the CCUS Projects Network is a crucial step towards promoting an environment in which stakeholders can work together and learn from each other, while identifying areas to address in the CCUS domain. It also presents an excellent opportunity to develop an approach to disseminate knowledge to the wider public. By increasing public acceptance of CCUS projects in the EU and beyond, confidence and trust can be drawn to such technologies."

The revitalised network replaces the European CCS Demonstration Project Network, established by the Commission in 2009 to accelerate the deployment of safe, large-scale and commercially viable CCS projects.

Aker Solutions Signs Carbon Capture Contract With Twence

www.akersolutions.com

www.twence.nl

Aker Solutions has signed an agreement for delivery of carbon capture and liquefaction at Twence's waste-to-energy plant in Hengelo in the Netherlands.

The solution that will capture Twence's CO_2 emissions is called Just Catch, a modular carbon capture system developed by Aker Solutions to be as simple, low-cost and environmentally friendly as possible.

Twence converts 1 million tons of waste to energy every year, from households and other sources. A majority of the waste comes from bio materials. To contribute to the Netherlands' progress towards the goals set in the Paris climate agreement in 2015, Twence ran a public procurement process to find a carbon capture, utilization and storage (CCUS) provider. Major determining factors for winning the competition were price, time to implement and environmental attributes. Aker Solutions has gained the experience necessary to meet these requirements through a long-term commitment to CCUS.

Trusted Technology

"To eliminate our impact on the environment, we needed an easy, inexpensive and time-efficient solution to capture the carbon we produce," said Dr. Marc Kapteijn, managing director of Twence. "We also needed to be able to trust the technology and process to be as environmentally friendly, robust and effective as possible. Just Catch satisfies all our requirements."

"Twence's confidence in us proves that we are producing an attractive solution for the market," said Luis Araujo, chief executive officer of Aker Solutions. "We have focused on cutting costs and simplifying CCUS technology. Our goal is to make carbon capture accessible and affordable. CCUS is one of the three main pillars in Aker Solutions' decarbonization strategy. The other two are decarbonization of oil and gas facilities and offshore floating wind."

Aker Solutions has previously gained one year operational data collection and experience from carbon capture at a waste to energy plant similar to Twence. The Just Catch and liquefaction plant at Twence's facilities has a capacity of 100,000 tons of CO_2 per annum (TPA) and is planned to be in operation by 2021. Once the CO_2 is captured and liquefied, it will be supplied by road tankers to users such as nearby greenhouses, where it will increase the yields of plants and vegetables. This supply replaces emissions from the traditional method of producing CO_2 for greenhouses: burning fossil fuels.

Standardized Modules

Just Catch is standardized and can be delivered in several different sizes, ranging currently from 10,000 to 100,000 TPA. Just Catch can therefore meet the needs of different-sized operations, for example waste-to-

The Preem wet gas facility and refinery at Lysekil. Photo: Preem

energy, fossil power plants or cement factories. It will help customers realize their carbon capture ambitions with predictable costs, implementation time and physical footprint. Once the system is fabricated, Aker Solutions can deliver the four process container modules by trucks, in a single shipment.

"Aker Solutions was part of the world's first large-scale carbon capture and storage project in 1996, at the Sleipner field offshore Norway," said Oscar Graff, vice president and head of CCUS at Aker Solutions.

"During the last couple of years we have seen a significant uptake in the interest from several market segments and we are now engaged in numerous tenders and projects globally. One of them being the CCS FEED for the Norcem cement factory in Norway that develops a large 400,000 TPA capture and liquefaction facility for permanent CO2 storage."

"In parallel, we have developed Just Catch, an innovative standardized and modular product that is winning international CCUS bids," said Graff. "Our engineers have made a ground-breaking job in the development of Just Catch. It has reduced the capture plant footprint by about 90 percent and thereby reduced the cost of materials and fabrication significantly. With our proprietary technology and solvent which absorbs the CO2 from the flue gas, we have the most efficient, robust and environmentally friendly CCUS technology on the market."

Researchers aim to store Swedish CO2 on the Norwegian shelf

www.geminiresearchnews.com

A Swedish-Norwegian research project will be looking into the possibilities and costs of transporting CO2 captured in Sweden for storage on the Norwegian shelf.

This is the first project ever to look into this possibility. “This can bring Sweden closer to its target of achieving climate neutrality by 2045”, says Research Manager Kristin Jordal at SINTEF.

The aim is to investigate the possibilities of establishing a full-scale facility for the capture and transport of CO2 from the Preem refinery and wet gas plant at Lysekil. Such a project would reduce CO2 emissions by up to 500,000 tons per year, and the demonstration plant represents a step towards establishing a full-scale facility by 2025.

“Preem’s CCS project provides a unique opportunity for Norway and Sweden to showcase the synergies between CO2 capture from Swedish emissions sources and the Norwegian full-scale CCS project”, says Project Manager Stefania Gardarsdottir at SINTEF.

SINTEF’s contribution will be research work on all aspects of the CCS value chain, from the development of compact heat exchangers (for WHP from the refinery), to the capture of CO2 and assessments of the potential for transporting CO2 to sequestration sites in the North Sea. The project will also incorporate business models for the integration of the work carried out at the Preem facility into the Norwegian full-scale project.

“Norway is a leading player in the development of carbon sequestration technology, and in Sweden there are many industrial companies with a keen interest in CO2 capture as a means of reducing emissions”, says CEO Petter Holland at Preem. “Collaboration in this project will enable us to create the optimal conditions for achieving a large-scale CCS capture facility”, he says.

The project is a joint effort involving Preem, Chalmers University of Technology, SINTEF Energy Research, Equinor and Aker Solutions. It is being funded with NOK 9.5 million from Gassnova (within the CLIMIT programme framework), and SEK 7.7 million from the Swedish Energy Agency. The project was launched in February in 2019 and will continue until 2021.

Making CCS add up

The lack of support for CCS and record of cancellation of major projects has happened because the figures aren't right, argues Dr Dawid Hanak, Assistant Professor in Clean Energy at Cranfield

Dr Hanak has developed an economic analysis method closer to reality, based around the idea of 'net present value', taking into account the scale factor of equipment, taxes, interest and depreciation. Using this tool he's shown how some of the latest CCS technologies used with conventional power plants can reduce carbon capture costs by 25% - transforming the picture in terms of the economic viability of using CCS, particularly in the context of carbon taxes.

In the past two years, six major Carbon Capture Storage projects in the UK have been shelved. There's a similar picture of a collapse in support for CCS in other parts of the world. Meanwhile, all the potential for carbon emission reductions from the use of CCS - in the power generation and carbon intensive industries like steel and cement in particular - are being lost due to a lack of action.

The problems are rooted in the basic and limited figures used to understand performance. And these can be misleading. In recent years there has been significant progress in reducing the energy intensity of CCS. But the standard calculations being referred to still show an efficiency penalty of at least 7% points compared with conventional power plants without CCS, increasing the cost of electricity by at least 60%. While CCS processes are designed to remove 90% of CO2 from the flue gas, the use of established CCS approaches on fossil-fuel-fired power plants will reduce their CO2 emissions by only 60-80% over the life-time of the process due to the falls in efficiency caused by implementation of CCS. It's a negative spiral. To achieve the same level of power output with CCS, larger plants are needed, more fuel, more emissions.

Unfair comparisons are then being made with renewable power generation, when the actual whole-life cost of moving to renewables isn't being taken into account. Importantly, in the decarbonisation scenarios put together by the Global CCS Institute suggest that if CCS is not implemented the cost of achieving the emission reduction targets would increase by up to 140%, due to considerably higher costs of alternative clean energy technologies such as geothermal power plants and offshore wind farms. To achieve the same levels of carbon reduction, the additional costs of investment to achieve the needed high penetration levels of renewable energy sources might reach at least £3.5 billion by 2050. This is due to the staggering costs for the integration of renewables that can account for more than 50% of the generation cost. It's worrying, then, that the total global investment in research and development of CCS technologies was only £15 billion between 2006 and 2015 – a figure which is two orders of magnitude lower than the total investment in development of other renewable energy sources, mostly renewables, in that period.

It is a common misconception that CCS and renewables are competing technologies, whereas both are being deployed to achieve the same goal – reduce the anthropogenic CO2 emissions in a fight to mitigate climate change. Therefore, we need to develop hybrid technologies that will exploit synergy between renewable energy sources and low-carbon fossil fuel power generation that leads to both reduced curtailment of renewable energy sources and reduced economic penalties of CCS. As some CCS technologies have an inherent energy storage capability, these can reduce the need for fought-for lithium resources, which are not sufficient for deployment of the battery storage at a scale, and subjugate the intermittence of the renewables, increasing their penetration in the energy portfolio.

We are in a critical transition phase between 'black' and 'green' technologies. To get to the low-carbon world we all need to be part of, there has to be realism about the practicalities involved. What's needed is more sophisticated assessments of feasibility in order for more clear-sighted decisions to be made on CCS, and its role in decarbonising economies in the transition to 100% renewable energy generation. It's a fantasy that the UK, as well as many other nations, can avoid carbon emissions in the near term. While decommissioning coal-fired power stations has made an instant impact on CO2 figures, other future emissions reductions will be much more difficult to achieve without CCS. Renewables are the future, but we need to find practical, sustainable ways to get there first.

CCS technologies are becoming more sophisticated, with enhanced forms of calcium looping in particular having the potential to reduce the efficiency penalties. Calcium looping is a process where carbon dioxide can be separated from other gases - and so captured and stored away - through reversible reaction with metal oxides, such as lime, to form metal carbonates.

Work at Cranfield has identified opportunities for using new methods that improve a less effective aspect of calcium looping, the need for both high-purity oxygen production to support regeneration of the sorbent at high temperature and for efficient heat utilisation, by using indirectly heated reactors and an advanced supercritical CO2 power cycle. Yet the data supporting the commercial viability of calcium looping at an industrial scale is still not sufficient to drive further development and adoption. So other high-potential CCS methods, like new forms of calcium looping, have become overlooked and more time is lost.

Our work at Cranfield has looked at developing an evidence base for governments and industry that will support commercial deployment of CCS. We have developed new concepts for power generation systems based on calcium looping combustion process and evaluated their economic performance using commercial tools. We believe this will not only provide more accurate and reliable data, but will also directly speak to decision makers and will support further investment in CCS.

In contrast to levelised cost of electricity, which is commonly used in the CCS community, we have employed the net present value approach that, in addition to the investment costs, also takes into account the scale factor of equipment, taxes, interest and depreciation, so cash flows during construction and operation years of the power generation system. Moreover, we have derived correlations for the capital costs for each piece of equipment allows for a bottom-up cost estimation that is closer to the industrial practice.

To identify the benefits of new power generation concepts based on calcium looping combustion process, we have compared their key performance indicators, such as the break-even electricity price and the efficiency penalty, with a conventional coal-fired power plant without CCS and more mature CCS technologies.

Our analysis confirmed that a more mature CCS technology, the established approach of amine scrubbing results in an efficiency penalty of 9.4% points when retrofitted to a coal-fired power plant; the penalty in terms of electricity price is €36.80 per Megawatt generated per hour (MWh), assuming there is no carbon tax. Comparatively, the new calcium looping combustion process with advanced supercritical CO2 power cycle shows no efficiency penalty with an electricity price penalty of around 11.5 €/MWh. Importantly, we estimated that the lowest cost of CO2 avoided, which corresponds to the minimum market value of carbon tax at which there will be no electricity price penalty associated with CCS, for the new calcium looping combustion process will be 16.3 € per tonne of CO2.

As this is below the current market values of carbon tax of 18–25 €/tCO2, our analysis confirms there are economic incentives for the government and industry to implement CCS at a larger scale. This is in addition to the environmental benefits. While a coal-fired station pours out more than 796 kg of CO2 for every MWh, this is reduced dramatically to around 91.5 kg/MWh, allowing the energy industry and other sectors to work more effectively to hitting carbon emission reduction targets.

Overall, our work at Cranfield has shown how some of the emerging CCS technologies can reduce carbon capture costs compared with more traditional methods by more than 25% - transforming the picture in terms of the economic viability of using CCS.

More information
www.cranfield.ac.uk

UK Government should 'green light' carbon capture technology, say MPs

The Government needs to move away from vague and ambiguous targets and give a clear policy direction to ensure the UK seizes the industrial and decarbonisation benefits of carbon capture usage and storage (CCUS).

A Business, Energy and Industrial Strategy (BEIS) Committee report, "Carbon Capture Usage and Storage: third time lucky?" says CCUS is necessary to meet national and international climate change targets at least cost and argues the technology could play a significant role in supporting productivity growth outside London and the South East.

The UK is considered to have one of the most favourable environments globally for CCUS, but the technology has suffered from 15 years of turbulent policy support, including the cancellation of two major competitions at a late stage. No commercial-scale plant has yet been constructed in the UK.

What will happen if CCUS is not deployed?

The report notes that in the UK, failure to deploy CCUS could double the cost of meeting our targets under the Climate Change Act 2008, rising from approximately 1% to 2% of GDP per annum in 2050.

Failure to deploy CCUS would also mean the UK could not credibly adopt a 'net zero emissions' target in line with the Paris Agreement's 1.5°C aspiration. This latter target is a more ambitious policy on which the Committee on Climate Change will set out whether the Government should commit to a net-zero target and the date to achieve it.

The report recognises the Energy Minister's personal commitment and support for CCUS but finds there is a lack of clarity concerning the Government's ambitions for CCUS, both in terms of time-scale for deployment of CCUS and the level of costs reductions the Government is demanding from the technology before it gives it support.

Government should provide clarity

Rather than seeking unspecified cost reductions, the report says the Government should kick-start CCUS by aiming to bring forwards projects at least cost. The report also says the ambition to "deploy CCUS at scale during the 2030s" is so broad as to be meaningless, and asks the Government provide clarity by adopting specific targets in line with the Committee on Climate Change's recommendation.

The Government has set a target to commission the first CCUS facility by the mid-2020s. Five clusters - Teesside, Humberside, Merseyside, South Wales, North East Scotland – have been identified as well suited to early CCUS deployment. The report recommends this ambition is raised to target the development of first CCUS projects in at least three clusters by 2025.

The report also recommends that the Government consider an alternative to running a third competition for funding and urgently consult on approaches to allocate funding for CCUS industry clusters, to ensure that the approach selected promotes collaboration and benefits CCUS development across the UK.

CCUS wider benefits

The report recommends that the forthcoming Comprehensive Spending Review take account not only of CCUS' costs, but also its wider benefits – notably to extend the lifetime of heavy industries which will otherwise need to close under the requirements of the Climate Change Act. It also recommends the Government task the National Instructure

Commission – or a third party – to conduct a cost benefit analysis of the potential role of CCUS to decarbonise industrial emissions and that the results of this assessment should be taken into account during decision-making on spending for national infrastructure.

The report recognises CCUS as a particularly useful technology in tackling carbon emissions, with its potential application to many different areas of the economy. For example, carbon capture technology can decarbonise waste gases from power stations and industrial facilities; help to produce clean hydrogen fuel from natural gas; and remove greenhouse gas emissions from the atmosphere via bioenergy with CCS (BECCS) or direct air CCS (DACCS).

As part of this inquiry, the BEIS Committee held an evidence hearing in Teesside where it questioned representatives from the five key areas for CCUS industry clusters (Teesside, Humberside, Merseyside, South Wales, North East Scotland).

Stuart Haszeldine, Professor of CCS at the University of Edinburgh and SCCS Director, said, "We are pleased to see the Committee focusing on the 'how' rather than the 'why' of CCS. It has been shown time and again that CCS is not just the lowest cost way of decarbonising the UK economy. It will be essential if the world is to achieve the climate ambitions of the Paris Agreement."

"There are five potential CCUS clusters of high-emitting industries, which want to reduce their emissions by capturing and permanently storing the CO2 they emit. Each cluster has different and complementary strengths, and the UK Government needs to support them to collaborate, not pit them against each other in a competitive arena."

"There is still the question of how development of carbon storage will be paid for, and how networks of networks of pipes to transport the CO2 will be funded. It's clear that a new business needs to be created, with CO2 as its subject."

"The appetite for rapid change to tackle CO2 emissions is clear, but the vagueness of government policy, and the lack of dedicated funding for CCS, continues to act as a brake on these ambitions. We could be well on our way to decarbonising the whole economy in 2023, if the UK Government takes the Committee's recommendations on board."

More information

www.parliament.uk

Reports say net zero emissions are UK business opportunity

Two new reports from the Aldersgate Group argue for policies that seek to accelerate the innovation at scale of critical technologies such as carbon capture and storage and hydrogen.

Businesses are positive about a UK net zero emissions target but it must come with bold innovation support say the two reports based on extensive business engagement and new research from Vivid Economics and the UK Energy Research Centre,.

They argue that a net zero emissions target could provide a significant industrial opportunity for UK businesses as long as it is accompanied by a much bolder innovation policy and ambitious market creation measures that are informed by a clear understanding of lifecycle emissions. These policies should seek to accelerate the innovation at scale of critical technologies such as carbon capture and storage and hydrogen, and rapidly grow the demand for ultra-low carbon infrastructure, products and services.

The first report, Accelerating innovation towards net zero, from Vivid Economics and the UK Energy Research Centre (UKERC) commissioned by the Aldersgate Group, sets out key recommendations to accelerate innovation. These recommendations come from a review of past case studies of rapid innovations relevant to decarbonisation from the banking, manufacturing and energy sectors.

The second report, Zeroing in: capturing the opportunities from a UK net zero emission target, from the Aldersgate Group, establishes key policy measures that should accompany a UK net zero emissions target to maximise industrial opportunities for UK businesses and avoid unintended consequences. It features innovative case studies from the energy, steel, aviation, manufacturing, ICT and cement sectors showing how businesses are already taking action towards net zero emissions.

Key messages to government

1. Urgently accelerate efforts to meet current carbon budgets to provide a credible foundation from which to achieve net zero emissions. The UK is currently not on track to meet the fourth and fifth carbon budgets. To rectify this and put the UK on a credible and cost-effective pathway to achieve net zero emissions, government must urgently pursue low-regret policy options. These include significantly improving energy efficiency in buildings through the introduction of binding regulatory standards and fiscal incentives and accelerating the roll-out of zero emission vehicles through tightening emission standards in the 2020s and guaranteed plug-in vehicle grants.

2. Provide long-term visibility to businesses by setting a net zero target as soon as possible after the CCC publishes its advice. Long-term clarity is essential to inform cost-effective business investment decisions in the new business models and high capital cost infrastructure required to achieve net zero emissions. Government should work with industry to set sector-based decarbonisation roadmaps underpinning this target, following the example of the Swedish fossil free industry roadmaps.

3. The Government's innovation policy should overcome the fear of failure and be focused on demonstrating the viability of critical technologies and systems at scale, including through public-private funding arrangements. This should include supporting at scale demonstration of Carbon Capture and Storage (CCS), the use of hydrogen in heating, Direct Air Capture technology and continued innovation in offshore wind. Government – and its stakeholders – should recognise that successful and unsuccessful trials provide equally valuable lessons to inform good policymaking.

4. Market creation policies based on an understanding of lifecycle emissions are essential to accelerate innovation and deploy new low carbon infrastructure, goods and services at scale. Market standards informed by lifecycle emissions can help grow the market for critical infrastructure and products such as ultra-low carbon building materials, guarantee a level playing field for business and avoid offshoring emissions. Stable revenue policies such as through incentives for fossil fuel using industries to store their carbon emissions can provide a market for CCS.

5. Mandate new or existing institutions to accelerate innovation and co-ordinate the early stage deployment of complex technologies such as low carbon heat and CCS. Past innovations show that third party institutions can accelerate knowledge sharing between businesses and sectors and co-ordinate the efficient deployment of complex infrastructure. For example, government-backed organisations in the UK and Denmark ensured that successful wind energy designs proliferated more quickly, whilst the Gas Council in the UK played an essential role in the late 1960s in developing bulk gas supplies, rolling out a gas network and supporting the rapid customer take-up of gas boilers and central heating in homes.

6. Support the UK's workforce so it can benefit from the economic opportunities that a net zero target could provide. This requires developing a cross-departmental education and training strategy to ensure the workforce is equipped with the skills required by the net zero transition, working with industry to understand future needs. Government should also work with businesses and Local Enterprise Partnerships to encourage low carbon supply chain investment decisions to be made in parts of the country facing high unemployment risks and where similar skill sets can be found.

7. Use the UK's diplomatic reach and new trade policy to promote the adoption of net zero targets globally. Through its extensive diplomatic network of climate attachés, the UK can play an influential role in encouraging the adoption of net zero targets globally in the run-up to the COP26 climate summit in December 2020. The UK's future trade policy after Brexit should support the delivery of its net zero target and promote growing trade in low carbon goods and services.

Recommendation	Application to UK innovation agenda
Increase ambition in demonstrating complex and high capital cost technologies and systems.	1. At-scale investment commitment is needed in the 2020s for CCUS (including in combination with bioenergy). 2. Large scale demonstrations are also required to understand the feasibility of repurposing a significant section of the gas network to use hydrogen. 3. Show how industrial clusters can achieve net zero emissions through energy and resource efficiency and the use of low-carbon energy 4. Funding for demonstrations of Direct Air Capture.
Create new markets to catalyse early deployment and move towards widespread commercialisation.	1. Market creation mechanisms to be considered include CfDs for power sector CCUS and obligations or incentives for fossil fuel using industries to sequester their CO_2 emissions. 2. A clear strategy and a public organisation to develop capture and storage infrastructure. 3. Market creation mechanisms and regulatory drivers to complete the full decarbonisation of the power sector, grow the market for zero emission vehicles and the market for energy efficiency in buildings.
Use concurrent innovations such as those happening in the digital sector to improve system efficiency and make new products more accessible and attractive to customers.	1. Government should co-ordinate the roll-out of new low-carbon technologies with new digital services, through providing data controls and platforms, and trialling "energy as a service" business models at scale. 2. Business models should focus on providing *smart* heating which is both low-carbon and a better experience for the customer. 3. Consumers should be given incentives to transition to these technologies. For example, time of use pricing for electricity will create cost benefits for consumers who shift demand to off-peak periods. Stronger regulations on efficiency can help drive rapid improvements in the efficiency of our housing stock.
Use existing or new organisations (cross-industry associations or public-private collaborations) to accelerate innovation in critical areas and co-ordinate early stage deployment.	1. The low-carbon heat transition requires coordination of energy supply and new infrastructure. 2. Electrification and decarbonisation of transport needs to be carefully co-ordinated with power sector decarbonisation, grid reinforcement, storage innovation and smart heating roll-out. 3. In CCUS, new CO_2 transport infrastructure (or repurposing of existing infrastructure) needs coordination with the development of CO_2 stores and rollout of capture plant. The recommendation of the Parliamentary advisory group on CCS for a new public delivery body is one way to achieve this.
Harness trusted voices to build consumer acceptance, through information sharing and rapid responses to concerns.	1. The use of trusted organisations, for example expanding the role of Ofgem or the Energy Savings Trust, could be used to share information on technologies and respond rapidly to concerns. 2. Where technologies are very novel, such as with CCUS and DACCS, government should commit to early, genuine, open and transparent public engagement.
Align innovation policy in such a way that it strengthens the UK's industrial advantages and increases knowledge spillovers between businesses and sectors.	1. Government should take actions to prioritise innovation in sectors with positive technology spillovers such as CCUS, heating, ventilation and air conditioning (HVAC), biofuels and wind.

Key recommendations from 'Accelerating innovation towards net zero'

Nick Molho, Executive Director, Aldersgate Group, said, "UK businesses are ready to take up the challenge of delivering a net zero emissions target but bold innovation and market creation policies will be essential to give them the support they need. Businesses want to see the government's innovation policy move beyond the 'fear of failure' and trial critical technologies such as CCS and hydrogen at scale in order to inform key policy decisions in areas such as heat and industrial decarbonisation."

"Support for innovation must be combined with measures informed by lifecycle emissions, such as markets standards, to grow the demand for ultra-low carbon infrastructure, products and services and set a market level playing field in the process."

More information

www.aldersgategroup.org.uk

UK can phase out greenhouse gas emissions by 2050

The UK can end its contribution to global warming within 30 years by setting an ambitious new target to reduce its greenhouse gas emissions to zero by 2050, and CCS is essential to this ambition finds the Committee on Climate Change (CCC) in its latest report.

Carbon capture and storage is essential says the report, "Net Zero – The UK's contribution to stopping global warming."

The CCC previously recommended that the first CCS cluster should be operational by 2026, with two clusters, capturing at least 10MtCO2, operating by 2030. The new report finds that for a net-zero target it is very likely that more will be needed. At least one of the clusters should involve substantial production of low-carbon hydrogen. The Government will need to take a lead on infrastructure development, with long-term contracts to reward carbon capture plants and encourage investment.

Main findings

Falls in cost for some of the key zero-carbon technologies mean that achieving net-zero is now possible within the economic cost that Parliament originally accepted when it passed the Climate Change Act in 2008. The Committee's report, requested by the UK, Scottish and Welsh Governments in light of the Paris Agreement and the IPCC's Special Report in 2018, finds that:

• The foundations are in place throughout the UK and the policies required to deliver key pillars of a net-zero economy are already active or in development. These include: a supply of low-carbon electricity (which will need to quadruple by 2050), efficient buildings and low-carbon heating (required throughout the UK's building stock), electric vehicles (which should be the only option from 2035 or earlier), developing carbon capture and storage technology and low-carbon hydrogen (which are a necessity not an option), stopping biodegradable waste going to landfill, phasing-out potent fluorinated gases, increasing tree planting, and measures to reduce emissions on farms. However, these policies must be urgently strengthened and must deliver tangible emissions reductions – current policy is not enough even for existing targets.

• Policies will have to ramp up significantly for a 'net-zero' emissions target to be credible, given that most sectors of the economy will need to cut their emissions to zero by 2050. The Committee's conclusion that the UK can achieve a net-zero GHG target by 2050 and at acceptable cost is entirely contingent on the introduction without delay of clear, stable and well-designed policies across the emitting sectors of the economy. Government must set the direction and provide the urgency. The public will need to be engaged if the transition is to succeed. Serious plans are needed to clean up the UK's heating systems, to deliver the infrastructure for carbon capture and storage technology and to drive transformational change in how we use our land.

• The overall costs of the transition to a net-zero economy are manageable but they must be fairly distributed. Rapid cost reductions in essential technologies such as offshore wind and batteries for electric vehicles mean that a net-zero greenhouse gas target can be met at an annual cost of up to 1-2% of GDP to 2050. However, the costs of the transition must be fair, and must be perceived as such by workers and energy bill payers. The Committee recommends that the Treasury reviews how the remaining costs of achieving net- zero can be managed in a fair way for consumers and businesses.

There are multiple benefits of the transition to a zero-carbon economy, the Committee's report shows. These include benefits to people's health from better air quality, less noise thanks to quieter vehicles, more active travel thanks to increased rates of cycling and walking, healthier diets, and increased recreational benefits from changes to land use.

In addition, the UK could receive an industrial boost as it leads the way in low-carbon products and services including electric vehicles, finance and engineering, carbon capture and storage and hydrogen technologies with potential benefits for exports, productivity and jobs.

CCS in the report

The Committee says it has consistently stressed the importance of CCS in achieving the current 2050 target for an 80% reduction at lowest cost and as an enabler of deeper emissions reductions beyond that. The Clean Growth Strategy stated an ambition to deploy carbon capture usage and storage (CCUS) at scale during the 2030s, subject to costs coming down sufficiently. Given its strategic importance in achieving deep decarbonisation, CCS is a necessity for a net-zero target.

By 2050, CCS has a large potential role to play in multiple applications. Our Further Ambition scenario requires annual CO2 capture volumes of up to 175 MtCO2 by 2050, across industry, greenhouse gas removals (GGR), hydrogen production and power generation. While the amount of CCS for energy generation from fossil fuels could be significantly lower than we have assumed, we stress that all currently credible pathways through which the UK could reach net-zero emissions domestically all involve a significant role for CCS, especially for industry and GGR.

The evidence base (for example Pöyry and Element Energy - Potential CCS Cost Reduction Mechanisms; CCSA - Lowest cost decarbonisation for the UK: The critical role of CCS) is clear that UK deployment of CCS is required to unlock the greatest opportunities for cost reduction:

• The UK has some of the most advantageous CO2 storage potential of any country in the world, and will need a large contribution from CCS by 2050. The CO2 transport and storage infrastructure required for CCS is capital intensive and is also subject to large economies of scale – costs can be reduced significantly compared to one-off projects through sharing of large-scale infrastructure between projects. The earlier CO2 infrastructure is deployed at such scale in the UK, the earlier CCS can be deployed cost-effectively.

• Reductions in cost of capital can be achieved by proving the technology and business model in the UK. It is clear that a significant part of the reductions in the strike prices for offshore wind following deployment at scale in the UK has resulted from reductions in the cost of capital, as the technology becomes more established, and supply chains and business models develop. While technology costs can be reduced via global deployment, reductions in the cost of capital for CCS in the UK will require UK deployment.

The CCC's assessment is that delivery of CCS requires action on CO2 infrastructure, development of the hydrogen option and policy frameworks across energy generation, industry and greenhouse gas removals:

• CO2 infrastructure. An approach to CO2 infrastructure development and funding is needed that is separate from that for individual projects. CO2 infrastructure roll-out and initial projects should lead to multiple CCS clusters being operational by the mid-2020s, and all major clusters having CO2 infrastructure by around 2030.

• Development of the hydrogen option. Given the importance of hydrogen in our net-zero scenarios, especially in industry, and the importance of CCS to its production at large scale,hydrogen production should start at scale by 2030 at each of the industrial CCS clusters.

• Policy frameworks. Delivery of CCS projects across the range of applications requires a policy framework that covers energy generation, industry and greenhouse gas removals. In addition to supporting infrastructure development, a framework to support decarbonisation of heavy industry should be developed and implemented by the end of 2022. Initial industry projects could require a support mechanism prior to this. Given the scale of BECCS that might be required by 2050, the Government should aim to have an initial BECCS project at scale early on (e.g. by around 2030).

Given the lack of progress to date on CCS and its greater role as ambition goes beyond an 80% reduction by 2050, progress in deploying CCS in the 2020s is a crucial enabler to putting the UK on track to meeting a net-zero target.

More information

www.theccc.org.uk

Strathclyde highlights job security potential of CCS

A report produced by the Centre for Energy Policy at the University of strathclyde examines some of the potential economic opportunities for Scotland in the further development of CCS.

www.strath.ac.uk

New research highlights the potential of Carbon Capture and Storage (CCS) to help sustain jobs and build supply chain, helping the shift to a low carbon economy.

The research represents a step towards understanding how the industry could become an increasingly valuable part of Scotland's drive of growing the blue economy.

Blue economy

The 'Blue Economy' is an emerging concept which encourages better stewardship of our ocean or 'blue' resources.

This new report highlights the potential for CCS to play an important role in helping to sustain around 44,000 direct and indirect Scottish jobs currently linked to oil and gas and other related industrial sectors.

It also suggests a new approach to measuring societal value of the CCS sector, and that value to the Scottish economy could be delivered via developing carbon transport and storage infrastructure and service delivery.

Professor Karen Turner, Director of the Centre for Energy Policy at the University of Strathclyde, said: "Our research shows that CCS could benefit jobs in a wide range of sectors across the Scottish economy, not just in the oil and gas industry.

Reduce emissions

Large-scale development of CCS could help reduce emissions from industrial sectors that are hard to decarbonise, as well as create opportunities for a skilled oil and gas and support industry workforce to transition to work in low carbon infrastructure.

It could also offer major industries such as oil and gas the ability to decarbonise and respond to the climate change ambitions set out by The Scottish Government.

Crown Estate Scotland plays a key part in future development of CCS as it manages leasing rights to carbon and gas storage out to 200 nautical miles.

Colin Palmer, Head of Marine for Crown Estate Scotland, said: "This work helps us to understand the potential economic and environmental value to Scotland of large-scale CCS. In our role as enabler, we want to work with the sector in the coming years to make the most of Scotland's natural assets – workers and the climate will both benefit."

The nature of the geology deep below the Central North Sea means Scotland has the potential to host around 75 per cent of the UK's capacity of CO2 emissions, helping meet both UK and Scottish climate change targets.

Last year Crown Estate Scotland signed its first ever lease agreement for carbon dioxide (CO2) storage, Acorn CCS, to be based at the St Fergus Gas Terminal on the Aberdeenshire coast.

Projects and policy news

EFI California Energy Study identifies CCUS as major contributor

energyfuturesinitiative.org

The Energy Futures Initiative (EFI), a not-for-profit think tank dedicated to driving innovation in energy technology, policy, and business models, published the full findings of a study outlining how the state of California can maintain its global leadership in forging a low-carbon energy economy.

The study, Optionality, Flexibility & Innovation: Pathways for Deep Decarbonization in California, examines 33 clean energy pathways and technology options that California policymakers must consider as it plans and executes an unprecedented transformation of its energy system.

It identifies CCUS as a major contributor in reducing industrial emissions and from the electricity sector.

California has committed to reducing its greenhouse gas emissions to 80 percent or more below 1990 levels by 2050, with an ambitious interim target of 40 percent below 1990 levels by 2030. The high-level outcome of the study is that California can indeed meet its aggressive 2030 and mid-century targets.

However, doing so will require success across multiple sectors of the economy, with multiple technologies contributing to each. Meeting the goals and managing costs will require a strong focus on innovation and maximum optionality.

"To get to 80 percent cuts and beyond, breakthrough innovation will be needed," said Alex Kizer, EFI's Director of Strategic Research. "At the same time, the innovation pathways must minimize the disruptions to the state's existing energy sector and find ways to accelerate the development of clean energy technologies, which potentially can provide hundreds of thousands more new jobs."

EFI explored two separate but overlapping policy streams: a pathway to achieve the 2030 intermediate decarbonization goal as well a major effort to achieve deep decarbonization by mid-century, in line with California's 2018 SB 100 legislation, which mandates net-zero emissions in Electricity by 2045. The 2030 pathways are established by sector: Agriculture, Buildings, Electricity, Industry, and Transportation.

It further identifies key policies and technologies that currently contribute to the state's ability to meet its 2030 goals and where technology innovation and policies need support. It also sets forth an innovation-centered approach to meeting the 2050 goal.

The study identified multiple technological innovations domains that need to be aggressively pursued in order to successfully meet deep decarbonization targets, including Carbon Management (Direct Air Capture & CCUS)

Scottish Government should use "all levers at their disposal" to advance CCS

www.sccs.org.uk

Scottish Parliament's Environment, Climate Change and Land Reform (ECCLR) Committee released a reporting recommending urgent action on CCS.

Scottish Carbon Capture & Storage (SCCS) welcomed the report by the Scottish Parliament's Environment, Climate Change and Land Reform (ECCLR) Committee on Scotland's new Climate Change Bill and said it is pleased to see its support for carbon capture and storage (CCS).

Witnesses who provided evidence to the committee's inquiry emphasised the need for urgent action on climate change, and this message appears to have been heard loud and clear, said SCCS.

We are glad to see the committee recognise the crucial role of CCS in reducing Scotland's emissions in line with the ambitions of the Paris Agreement. CCS technologies are already operational across the world, and Scotland is in the enviable position of having extensive offshore geology that is well suited to the secure and permanent storage of CO2.

Scientists from SCCS partner institutions are carrying out world-leading research to develop and improve CCS technologies further. Together with the SCCS Team, they have also been key partners in the ACT Acorn project, which aims to develop the UK's first full-chain CCS project in north-east Scotland.

The accelerated delivery of CCS worldwide will be essential if we are to keep global average temperatures below 1.5°C; however, it is not a magic bullet, and it needs to be part of a mix of approaches, including renewable electricity generation, energy efficiency and behaviour change. Support from government is needed for all these approaches, and they should not be pitted against each other. CCS will require investment in new infrastructure for Scotland – although costs can be reduced by re-purposing legacy infrastructure from the oil and gas industry.

The sooner we start to deploy CCS, the sooner we can start making deep emissions reductions in industry, a sector which has so far shown slow progress in reducing its climate impact. Industrial emissions are an area where renewable electricity can have only a limited impact – most CO2 emissions come either from the process itself, or from a high demand for heat that can currently only be met by fossil fuels. This means that CCS is the only option for high-emitting industries to decarbonise – other than ceasing production, which would be catastrophic for jobs and the economy.

Once CCS infrastructure is in place we can start to produce low-carbon hydrogen in bulk from methane, which opens up new routes to displacing fossil fuels in heat and transport – two other sectors where significant progress on reducing emissions is needed.

CCS infrastructure will also mean that we can start achieving "negative emissions" by applying CCS to biogenic sources of CO2, compensating for emissions which cannot be eliminated. Research shows that the earlier negative emissions technologies are deployed, the less they will be needed in future, which means a lower impact on land use.

CCS has a crucial role to play in a just transition to a low-carbon economy – retaining manufacturing jobs; replacing oil and gas jobs with low-carbon activities; and supporting the construction industry by providing low-carbon cement and steel. CCS helps to provide a viable future for communities currently dependent on a fossil fuel-based economy.

We urge the Scottish Government to continue to work with the ECCLR Committee and other stakeholders to make sure that Scotland has all the tools it needs to play its part in tackling climate change.

C2ES and RITE recommendations for international CCUS collaboration

The Center for Climate and Energy Solutions (C2ES) and the Research Institute of Innovative Technology for the Earth (RITE) today forwarded recommendations to the government of Japan on ways to strengthen international collaboration on carbon capture use and storage (CCUS) technologies during Japan's G20 Presidency.

The recommendations emerge from an international roundtable in Washington, D.C., organized by C2ES and RITE with support from Japan's Ministry of Economy, Trade and Industry (METI). They will be presented to G20 governments this month at a preparatory meeting for an upcoming meeting of G20 energy and environment ministers in Karuizawa, Japan.

During the roundtable, participants discussed policy, finance and technology issues, including lessons learned from existing collaborative efforts and the role of CCUS in long-term energy and climate strategies. These issues are reviewed in detail in a background paper.

Key recommendations

Integrating CCUS into Action Plans

Mechanisms available to energy and environment ministers to advance shared G20 objectives include the adoption of joint action plans and the initiation of national action plans by individual Member countries. Such action plans should give full consideration to the potential of CCUS technologies to contribute to collective and national goals. In particular:

• Ministers, as part of a broader energy and environment action plan, should initiate the development of a joint CCUS action plan to be adopted by the G20 in 2020. This CCUS action plan should identify the specific areas where additional collaborative efforts can best capitalize on and complement existing international initiatives. The development of this action plan should be a joint undertaking of the Japan and Saudi G20 Presidencies.

• In their national planning, Member countries should consider undertaking national readiness assessments, including an analysis of measures needed to facilitate commercial deployment of largescale CO2 storage, and of other domestic policies that could incentivize CCUS on a level playing field with other clean energy technologies. Member countries should further consider ways that CCUS can contribute to their long-term low greenhouse gas emission development strategies and their future nationally determined contributions under the Paris Agreement.

Promoting Carbon Recycling

CCUS efforts to date have focused most heavily on technologies to capture CO2 emissions from power plants and industrial facilities and to transport and safely store those CO2 emissions. One promising area that deserves stronger attention is the development of processes and technologies enabling the productive utilization of captured CO2, or "carbon recycling." Potential uses include building materials, polymers and plastics, fuels and other high value-added materials. In addition to sequestering CO2 from the atmosphere, the creation of additional commercial uses for captured carbon can provide stronger incentive for investment in CCUS technologies and infrastructure. Toward these ends:

• Energy and environment Ministers should consider, as part of a joint G20 action plan, the establishment of a working group to develop a "carbon recycling" action plan for adoption by the G20 in 2020.

• This working group should include business participation from relevant sectors and should examine the potential for large-scale CCUS chains, including cross-border projects, to facilitate markets and supply chains for "carbon recycling" products.

Other Recommendations

The roundtable considered a wide array of other options to strengthen international collaboration on CCUS. Further recommendations include:

• Engaging financial institutions and encouraging stronger public and private sector investment in CCUS, including through contributions to the CCS Trust Funds of the World Bank and the Asian Development Bank, which provide critical support in developing countries.

• Facilitating large-scale CCUS chains and encouraging the ratification of the export amendment of the London Protocol to allow the export of CO2 for offshore storage.

• Pledging stronger support for collaborative efforts highlighted in the 2017 Roadmap of the Carbon Sequestration Leadership Forum, including the International Test Centre Network and the CO2 Storage Data Consortium.

• Organizing side events at the G20 Summit to highlight recent CCUS successes, build stronger understanding of these technologies and their multiple benefits, and identify opportunities for their advancement.

"Building and developing a robust set of solutions and technologies for action on climate change is a global priority," said C2ES President Bob Perciasepe. "CCUS technologies should be essential elements of the global agenda because they can help achieve multiple objectives at once - from reducing emissions to preserving industrial regions to expanding energy access. The G20 nations have a great opportunity to strengthen collaboration to advance deployment of CCUS at the Osaka summit."

More information

www.c2es.org

New separation technique could lead to reduced carbon dioxide emissions

A Washington State University research team has developed a new way to separate carbon dioxide out of industrial processes using porous nano rods.

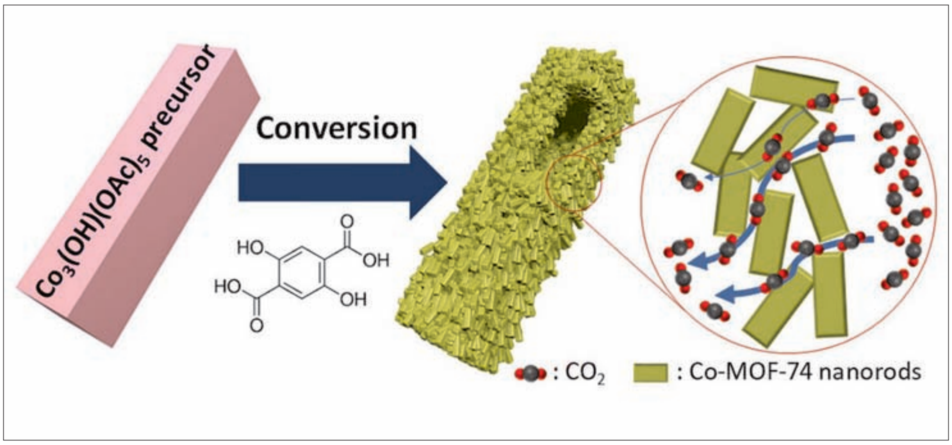
Led by Min-Kyu Song, assistant professor in the School of Mechanical and Materials Engineering, and Ph.D. student Xiahui Zhang, the researchers developed a way to create hollow, nanorod-shaped porous materials made of cobalt metal ions and organic molecules to separate the carbon dioxide in a way that works under real-life conditions.

They recently published their work in the journal, ACS Applied Materials and Interfaces. The work also includes researchers from Nanyang Technological University in Singapore.

Because of concerns about global warming and climate change, researchers have been working to develop ways to capture, store and use the carbon dioxide that fossil fuel industries emit during energy production.

Carbon capture systems have to be able to selectively grab carbon dioxide out of the exhaust gases under the dynamic conditions that exist in a power plant. At the same time, such systems need to be inexpensive and energy efficient.

Microporous materials, known as metal-organic frameworks, hold great promise for carbon capture because the large surface area of the tiny particles offer a large number of accessible sites to interact with carbon dioxide. The nanomaterials do a good job of taking up carbon dioxide under carefully controlled, equilibrium conditions, but fail in realistic operating conditions.



Min-Kyu Song and Xiahui Zhang have developed a method to selectively grab carbon dioxide out of the exhaust gases under real-life conditions

n their work, the WSU research team improved the performance under a dynamic flow condition by designing a novel structure of materials. They developed a new architecture for the crystals, shortening the distance that gas molecules have to travel and creating a hollow nano-sized rod that allows carbon dioxide to enter and get to a reaction site more easily.

The synthesized materials with the unique architecture continued working successfully through 10 cycles, which is a "pretty good lab-scale demonstration," said Song.

Their novel materials processing represents a simple, general strategy for controlling the nanostructure to enhance similar separation processes, which could also be applied to other fields, such as in water treatment.

"What really matters are their high performance under dynamic conditions," he said. "Our separation process has much better applicability in practical systems."

The next step in their research is to demonstrate the scalability of the process. They are also continuing to study other types of metal-organic crystals. While their research is an important first step in realizing practical gas separation technologies, "there are still significant research challenges in efficiently collecting and storing carbon dioxide at a low cost," said Song.

More information

www.wsu.edu

Capture and utilisation news

International collaboration on tool to find best CO2 utilisation technology

www.globalco2initiative.org/research

A tool to identify promising carbon dioxide utilization technologies will be expanded and advanced through a $1.5 million project funded by the Global CO2 Initiative at the University of Michigan (GCI-UM) and Climate-KIC, the European Institute of Innovation and Technology's Climate Knowledge & Innovation Community.

The Techno-Economic and Life Cycle Assessment (TEA/LCA) Guidelines for CO2 utilization technologies tool is one-of-a-kind in scope and designed to evaluate various approaches to this strategy to mitigate climate change.

The new project, 'CO2nsistent', will run for three years, fund a team of researchers, and seek to deepen and broaden a first generation of guidelines that were established by the initial project partners in 2018. It will also continue to support current industries and researchers developing these new technologies and applications.

"We have an opportunity to accelerate the development and deployment of CO2 utilization technologies. This requires well-informed decisions and for that we need to have harmonized, robust assessments to guide research, investment, and policymaking. We must know upfront, before deployment, that new technologies will be carbon negative and dollar positive," stated Volker Sick, Director of the Global CO2 Initiative at the University of Michigan.

The joint announcement was made at a workshop that was organized and conducted in partnership with National Energy Technology Laboratory, National Renewable Energy Laboratory, and Volans. The workshop was attended by over 100 CO2 utilization technology experts, industry representatives, policymakers, and members of the public. Participants set out to explore next-generation needs to inform future metrics, best practices, validation, and other steps toward building a harmonized global toolkit for measuring and reporting on carbon dioxide utilization or removal.

Comprehensive, consistent, and transparent TEA/LCA assessments, integrated into the policy landscape, will accelerate funding decisions and promote sustainability-driven technology development. Currently, no standardized TEA and LCA methods have been adopted, so studies cannot easily be compared, risking sub-optimal decisions.

"The 'CO2nsistent' project builds on research and innovations previously funded by EIT Climate-KIC. It reflects the need for making existing knowledge and methodologies broadly accessible beyond Europe. Enabling comparability and transparency of a diverse set of solutions at the global scale through factual information will be crucial for regulatory processes, public acceptance and to direct investments to applications with the highest climate change mitigation impact," said Climate-KIC's Sira Saccani, Director of Sustainable Production Systems.

As this nascent technology space continues to rapidly gain momentum among academia, industry, and governments seeking solutions to reduce carbon emissions and create new circular business opportunities, these Guidelines aim to harmonize approaches to measure further investments and commercialization.

An anticipated end-user and industry supporter of the toolkit, Christoph Gürtler of Covestro, a world-leading manufacturer of high-tech polymer materials, said, "It is my belief that a timely analysis of potentially new processes e.g. on CO2 utilization using an aligned and harmonized TEA/LCA approach is the key for making the most of given R&D resources – leveraging value and avoiding costly detours."

The guideline documents the CO2nsistent project produces will be open access, as will a series of example studies. Stakeholders and practitioners will be involved throughout the project in a range of workshops and webinars.

CO2 Solutions begins commissioning at pulp mill

www.co2solutions.com

The project involves the deployment of a 30-tonne per day (tpd) CO2 capture unit and ancillary equipment at Resolute's pulp mill in Saint-Félicien, Quebec and the commercial reuse of the captured CO2 by the adjacent Toundra Greenhouse complex.

The start of the commissioning of the CO2 capture unit officially took place on March 14, 2019. This start-up was preceded by the successful pre-operation verifications of each of the capture unit's systems, after which the unit was put into operation and the first tonnes of CO2 were captured. The company now expects to ramp up the overall capture rate to validate the unit's nominal capacity of 30 tonnes of CO2 per day.

The construction of the Saint-Félicien CO2 capture unit was partly financed with investments from Sustainable Development Technology Canada (SDTC) and the Technoclimat program of the Quebec government as well as a loan from Canada Economic Development (CED).

"With the start-up of the Saint-Félicien capture unit, CO2 Solutions has achieved an exciting milestone, not only for the Corporation but also for the carbon capture industry," stated Richard Surprenant, CO2 Solutions' Chief Technology Officer. "This unit, a 3x scale-up from our currently operating 10-tpd unit in Montreal-East, confirms the position of our proprietary enzymatic technology as the world's most advanced second-generation carbon capture technology. We have demonstrated once again the dependability and simplicity of our enzymatic technology."

Once the Saint-Félicien capture unit reaches its nominal capacity of 30 tonnes of CO2 per day, a six-month demonstration period will begin, after which the commercial phase will begin and the company will generate revenues from the sale of the CO2 to Toundra Greenhouse. This unit, the company's second operating CO2 capture unit, is a first-of-a-kind commercial unit and, as a result, it confirms the enzymatic technology's attainment of Technology Readiness Level (TRL) 8.

It will provide several benefits to its stakeholders, from generating revenues for CO2 Solutions, to reducing the Resolute pulp mill's CO2 emissions and enhancing the growth of Toundra Greenhouse's production with a non-fossil source of CO2.

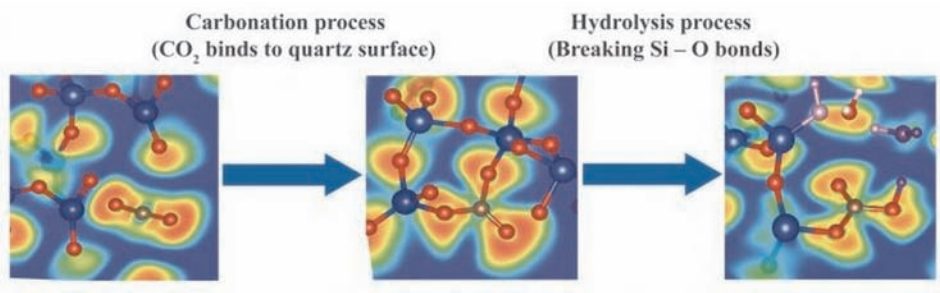
Of particular note is that, unlike CO2 capture processes that use toxic amine chemicals, the company's enzymatic technology produces no toxic emissions or wastes, making it a clean-tech process that is clean, a rarity among known CO2 capture technologies.

CO2 mineralization in geologically common rocks for carbon storage

Kyushu University-led researchers ran computer simulations of CO2 reacting with rock surfaces to form carbonate minerals, showing how 'mineral trapping' can be used for carbon storage.

Geological trapping can play a major role here. Our planet's underground rocks and sediments offer a vast potential space for long-term carbon storage. To support this, a recent computational study from a Japanese-led international group at Kyushu University shows how trapped carbon dioxide can be converted into harmless minerals.

The rocks beneath the earth's surface are highly porous, and trapping involves injecting CO2 into the pores after collecting it from its emission source. Although CO2 is usually considered too stable to react chemically with rock, it can bind tightly to the surface by physical adsorption. Eventually it dissolves in water, forming carbonic acid, which can react with aqueous metals to form carbonate minerals.



The red color denotes that the occurrence probability of valence electrons is 100 percent, the blue color means that no electrons exist in the area, and the green color means free electron-gas indicating the border of covalent bonds. Red, blue and brown balls represent oxygen, silicon and carbon atoms, respectively. Credit: International Institute for Carbon-Neutral Energy Research (I^2CNER), Kyushu University

"Mineralization is the most stable method of long-term CO2 storage, locking CO2 into a completely secure form that can't be re-emitted," explains Jihui Jia of the International Institute for Carbon-Neutral Energy Research (I2CNER), Kyushu University, first author of the study. "This was once thought to take thousands of years, but that view is rapidly changing. The chemical reactions are not fully understood because they're so hard to reproduce in the lab. This is where modeling comes in."

As reported in The Journal of Physical Chemistry C, simulations were initially run to predict what happens when carbon dioxide collides with a cleaved quartz surface--quartz (SiO2) being abundant in the earth's crust. When the simulation trajectories were played back, the CO2 molecules were seen bending from their linear O=C=O shape to form trigonal CO3 units bonded with the quartz.

In a second round of simulations, H2O molecules were added to mimic the "formation water" that is often present beneath oil and gas drilling sites. Intriguingly, the H2O molecules spontaneously attacked the reactive CO3 structures, breaking the Si-O bonds to produce carbonate ions. Just like carbonic acid, carbonate ions can react with dissolved metal cations (such as Mg2+, Ca2+, and Fe2+) to bind carbon permanently into mineral form.

Together, the simulations show that both steps of CO2 mineralization--carbonation (binding to rock) and hydrolysis (reacting with water)--are favorable. Moreover, free carbonate ions can be made by hydrolysis, not just by dissociation of carbonic acid as was once assumed. These insights relied on a sophisticated form of molecular dynamics that models not just the physical collisions between atoms, but electron transfer, the essence of chemistry.

"Our results suggest some ways to improve geological trapping," says study lead author Takeshi Tsuji. "For quartz to capture CO2, it must be a cleaved surface, so the silicon and oxygen atoms have reactive 'dangling' bonds. In real life, however, the surface might be protected by hydrogen bonding and cations, which would prevent mineralization. We need a way to strip off those cations or dehydrogenate the surface."

Evidence is growing that captured CO2 can mineralize much faster than previously believed. While this is exciting, the Kyushu paper underlines how complex and delicate the chemistry can be. For now, the group recommends further studies on other abundant rocks, like basalt, to map out the role that geochemical trapping can play in the greatest technical challenge facing civilization.

More information

Jihui Jia et al, Ab Initio Molecular Dynamics Study of Carbonation and Hydrolysis Reactions on Cleaved Quartz (001) Surface, The Journal of Physical Chemistry C (2019). DOI:
10.1021/acs.jpcc.8b12089
pubs.acs.org/journal/jpccck
i2cner.kyushu-u.ac.jp

USGS review of carbon mineralization

Following an assessment of geologic carbon storage potential in sedimentary rocks, the USGS has published a comprehensive review of potential carbon storage in igneous and metamorphic rocks through a process known as carbon mineralization.

In 2013, USGS released the first-ever comprehensive national assessment of geologic carbon dioxide storage potential in sedimentary basins. According to this assessment, the United States could store up to 3,000 metric gigatons of carbon dioxide. Now, the USGS has published a comprehensive review of another type of geologic carbon storage: carbon mineralization.

Carbon mineralization is the process by which carbon dioxide becomes a solid mineral, such as a carbonate. It is a chemical reaction that happens when certain rocks are exposed to carbon dioxide. The biggest advantage of carbon mineralization is that the carbon cannot escape back to the atmosphere. It happens naturally, but the process can be sped up artificially. Most of the rocks that have the potential for carbon mineralization are igneous or metamorphic, as opposed to porous sedimentary reservoirs.

The primary difference between carbon storage in sedimentary reservoirs and carbon mineralization is that in the sedimentary reservoirs, the injected carbon dioxide dissolves into deep saline groundwaters. However, in carbon mineralization, chemical reactions form a new carbonate mineral within the rocks it is meant to be stored in, preventing possible escape later.

There are two primary types of geologic carbon mineralization: injection of CO_2 into rock formations deep underground, or exposure to broken pieces of rock at the surface, such as leftovers from mining, called mine tailings.

Injecting Carbon Deep Underground

This method of carbon mineralization is most similar to geologic carbon storage in sedimentary basins. The carbon dioxide is injected into wells that go deep underground to igneous or metamorphic rock formations that have the potential for carbon mineralization.

The two primary rock types that have the potential for carbon mineralization through injection are basalt and a broad category of rocks called ultramafic, meaning they have extremely high amounts of magnesium and iron. Laboratory studies have shown that ultramafic rocks have the fastest reaction times, and pilot studies have shown that injection of carbon dioxide into basalt can lead to mineralization in under two years.

Mineralizing Carbon with Crushed Rocks

Meanwhile, back at the surface, the other method of carbon mineralization involves exposing carbon dioxide to ultramafic rocks or basalt at the surface. Often these rocks are in the form of crushed mining waste, such as asbestos mine tailings. Carbon mineralization of asbestos mine tailings would have the added benefit of reducing the risks associated with exposed asbestos.

Carbon mineralization of mine waste can be a much faster process than injecting the carbon underground for mineralization, since there is more surface area on the crushed rocks for the carbon to form minerals. However, there is not nearly as much rock that can be mineralized on the surface as there is underground, so the overall amount of carbon storage is higher for underground injection than exposing carbon dioxide to crushed rock on the surface. Likely the best use for this method would be close to industrial sites with carbon dioxide emissions, where the carbon could be captured before it goes into the atmosphere and immediately mineralized onsite.

Carbon Cost Comparisons

Carbon mineralization is but one method of geologic carbon storage, and which method gets chosen for each situation will depend on a variety of factors. One of the most important factors, though, will be the cost per ton to store that carbon.

Currently, storing carbon in sedimentary basins is the most cost-effective method, assuming the amount of pressure in the basin does not reduce the storage space that would otherwise be available. Storage in brine-filled sedimentary reservoirs could cost about $7-13 per metric ton of carbon dioxide. However, conditions tend to vary significantly throughout sedimentary basins, and some management of pressure and water is likely to be required, which could increase the cost to around $20-80 per metric ton of carbon dioxide.

Meanwhile, carbon mineralization of crushed rocks at the surface, such as mine tailings or industrial waste, has been estimated to cost around $8 per metric ton of carbon dioxide. However, this is only cost-effective at the local scale and for already mined materials. If mining is required, the cost increases significantly.

Based on limited results from a few pilot projects, carbon mineralization in deep underground basaltic formations could be around $30 per metric ton of carbon dioxide. No estimates have been made yet for storage in ultramafic rock formations. The cost benefit analysis suggests that perhaps the most effective use for carbon mineralization is as an option to complement sedimentary brine carbon storage.

All Across America

Just as with the geologic carbon storage in sedimentary basins studied previously, the potential for carbon storage through mineralization is spread throughout the United States, though in markedly different locations. There are a few hot spots that deserve special mention.

The biggest hot spot is in the Pacific Northwest. The Columbia River Basalts within Idaho, Oregon and Washington have a large amount of potential, both at the surface and underground.

Another region with abundant basalts, though most are underground and are of uncertain quality, is the midcontinent from Minnesota, Wisconsin, and Michigan, all the way down to Oklahoma and Texas.

More information

www.usgs.gov

CCT 2019 HOUSTON
TEXAS, USA 3-7 JUNE

The IEA Clean Coal Centre's 9th International **Conference on Clean Coal Technologies**

CCT 2019 comes to the USA for the first time on 3-7 June, 2019. The city of Houston plays host to this leading forum for innovation in the coal industry, giving delegates the opportunity to visit the **Petra Nova** project – the world's largest CCS facility on coal power, and **NET Power's** pioneering demonstration of the 'Allam Cycle' capture process.

Featuring three days of technical sessions, panel discussion and keynotes from leading figures in the industry, CCT 2019 will cover the research, demonstration and deployment of cleaner coal technologies and next-generation carbon capture systems.

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