Carbon Capture Journal

CCUS in the UK

IEA and UK summit kick-starts a 'new global era' for CCUS

UK plans first integrated CCUS project by mid 2020s and a carbon net-zero heavy industry hub by 2040

Jan / Feb 2019 Issue 67

A Happy New Year for CCUS?

- CATO event - significant progress for Dutch carbon capture
- Cost of capturing CO2 drops 67% for next gen carbon capture plant
- Fluenta: the business of accurately measuring carbon emissions
- Global Status of CCS: 2018 - CCS vital lifeline to beat climate change

Global Status of CCS: 2018 - CCS vital lifeline to beat climate change

Carbon capture and storage is a vital lifeline to beat climate change say a raft of international ambassadors in the Global CCS Institute's flagship report released at the United Nation's 24th Conference of Parties (COP24).

In 2018, according to the Global CCS Institute CO2RE database, there are 23 large-scale CCS facilities in operation or under construction, capturing almost 40 Mtpa of CO2. A further 28 pilot and demonstration-scale facilities are in operation or under construction. Collectively, these capture more than 3 Mtpa of CO2.

Speaking at the launch in Katowice, Poland, the Global CCS Institute said the world is way-off in meeting Paris targets and CCS must be deployed alongside other clean technologies if continued meteorological uncertainty is to be avoided.

"I think it is likely that when we look back in a few years, 2018 may well go down as the year when the stars started to again align for CC," said Global CCS Institute Chief Executive Officer, Brad Page.

"In this past year, and for the first time in quite a long time, we have seen decisive action from a number of governments to include CCS in their armoury."

Grantham Institute Chair, Lord Nicholas Stern, said more and more people are seeing the practicality and importance in deploying CCS as the one technology proven to decarbonize "difficult" sectors such as cement and steel and "locked-in" fossil fuel-based infrastructure.

"Another refreshing development has been the capacity for the private sector, mayors, multinationals, even the media, to start putting their weight behind the technology."

Mr Page said there is now a wealth of evidence to support the need for CCS – from the IEA to the IPCC.

"The IPCC'S 1.5°C report reinforces the role which carbon capture and technology must play in beating climate change. Significantly, it references CCS in three of the four pathways used to reach 1.5°C and is singled out for its ability to play a major role in decarbonizing the high emitting industrial sector."

Mr Page said it was important that everyone working across the climate and energy spheres acknowledged - as the IPCC does - that all clean technologies are necessary.

"It is now irrefutable that Paris targets can only be achieved by embracing a complete cache of clean solutions – of which CCS must be one."

Fatih Birol, Executive Director of the International Energy Agency, pointed out that the IEA has highlighted that as much as 450 Mt of CO2 could be captured, utilised and stored globally with a commercial incentive as low as US$40 per tonne of CO2.

A video by the International Brotherhood of Boilermakers made the case that CCS is central to delivering well-paying jobs, reinvigorating regional communities and providing low-carbon materials and services.

The report says that, significantly, policy confidence has started to materialise.

In the United States a bi-partisan law – the FUTURE Act – was enacted reinvigorating section 45Q tax credits for investment in Carbon Capture Utilisation and Storage (CCUS). This was a significant win for the stimulation of new CCUS projects across the United States and addressed the importance of introducing what is essentially a carbon value to drive investment in energy security and emissions reductions.

In the United Kingdom, Minister of State for Energy and Clean Growth, the Rt Hon Claire Perry, established a dedicated CCUS Council to examine ways of returning the UK to a CCS leadership position as a central plank of the Clean Growth Strategy. I have the honour of sitting on the Council and in a short time the Council and the related Cost Challenge Taskforce have clearly identified the huge clean growth opportunities available to the UK if full-scale industrial hub and cluster projects, which draw on the North Sea's vast storage capacity, are progressed.

In China, where no less than 30 different facilities advanced into various stages of development during the year, commitment to this technology is fast-growing as national, regional and municipal governments embrace CCS and make it part of their long term strategic plans.

Norway and the Netherlands saw Governments recommit to CCS and project proponents are responding. The Norwegian government has committed to advance its large-scale full chain industry-based CCS development and the Port of Rotterdam CCS Backbone Initiative has embarked on the large-scale decarbonisation of refining, power and petrochemical clusters.

"As coal as a fuel source grabs headlines and prompts hot debate, we need to remember that more than 200,000 MW of new coal-fired generation capacity is in construction around the world, none of which will close in a short period and all of which will add very significantly to the climate change challenge," said Mr Page.

"CCS is the only technology that can truly decarbonise these facilities and remains a vital technology for addressing electricity sector emissions. But the big message now is that CCS is the conduit to a new energy economy."

More information

www.globalccsinstitute.com

Carbon Capture Journal

Jan / Feb 2019 Issue 67

Carbon Capture Journal
United House, North Road, London N7 9DP
www.carboncapturejournal.com
Tel +44 (0)208 150 5295

Editor
Keith Forward
editor@carboncapturejournal.com

Publisher
Future Energy Publishing
Karl Jeffery
jeffery@d-e-j.com

Subscriptions
subs@carboncapturejournal.com

Advertising & Sponsorship
David Jeffries
Tel +44 (0)208 150 5293
djeffries@onlymedia.co.uk

Carbon Capture Journal is your one stop information source for new technical developments, opinion, regulatory and research activity with carbon capture, transport and storage.

Carbon Capture Journal is delivered on print and pdf version to a total of 6000 people, all of whom have requested to receive it, including employees of power companies, oil and gas companies, government, engineering companies, consultants, educators, students, and suppliers.

Subscriptions: £250 a year for 6 issues. To subscribe, please contact Karl Jeffery on subs@carboncapturejournal.com Alternatively you can subscribe online at www.d-e-j.com/store

Front cover:

An existing CO2 capture plant at the St Fergus gas processing plant in NE Scotland will be repurposed or rebuilt for the Acorn CCUS project (Image: ©North Sea Midstream Partners)

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

Leaders - CCUS in the UK

Projects and policy

Capture and utilisation

Transport and storage

A Happy New Year for CCUS?

With the turn of the year comes a time for reflection. For CCUS, 2018 might well be remembered as a real pivot point in the journey towards creating a truly commercial industry in the UK. Many of those who have been involved in this journey over the last decade (like some of us at Pale Blue Dot Energy) are growing cautiously optimistic that after several false starts, CCUS might be getting back on track in the UK, with the political support required to help CCUS meet the country's legally binding climate change targets. By Hazel Robertson and Kirsty Lynch, Pale Blue Dot

Throughout this past year and following on from the launch of the Clean Growth Strategy in 2017, the UK Government has put CCUS back on the energy and environment agenda, taking a new and quite different approach from what has been tried in the past.

This time around, Government and Industry are working much more closely together to move CCUS forward. This is something that has been reiterated by UK Energy and Clean Growth Minister Claire Perry throughout the year and was again highlighted at the international Accelerating CCUS conference in November.

It is fair to say that 2018 has seen some serious recommitment to CCUS from both Industry and Government with ongoing collaboration and joint working through the newly established CCUS Council and the intense six-month Cost Challenge Task Force (CCTF). One of the key CCTF recommendations was to bring down the cost of CCUS through deployment and learning by doing.

Pale Blue Dot Energy Managing Director, Alan James – Claire Perry, Minister for Energy and Clean Growth – and Paul Wheelhouse, Scottish Government Minister for Energy – at the Acorn CCS stand of the Accelerating CCUS conference as they put the final pieces in the UK CCUS puzzle (Image: ©Toby Phillips Photography)

Industrial clusters

With Clean Growth as one of the four 'Grand Challenges' of the Industrial Strategy, there also seems to be a deliberate shift in focus from CCUS on power, to dealing with industrial emissions and clustering of carbon intensive industries that have shared geographical infrastructure. This was recently backed up by an early Christmas present to the CCUS industry in the form of a new £170m funding package to develop net-zero carbon industrial hubs.

Here, CCUS can now play a role as one of a range of technologies that will all be required to move industrial regions towards net-zero carbon. This includes the introduction of hydrogen generation with CCS to help unlock some of the particularly hard to decarbonise sectors. CCUS has been reframed in a more positive way as a technology to ensure protection and growth of the UK's industrial regions, rather than an expensive bolt-on to help reduce CO_2 emissions from fossil power generation.

Progressing real projects

A new wave of UK projects is emerging, showing that industry is ready and willing to move forward. Some of these developments look very different from their predecessors; focusing on reducing industrial emissions and hydrogen generation, areas that were not within the scope of previous UK competitions.

One of these is the Acorn CCS Project. As the developer of Acorn, a recognised European Project of Common Interest, the team at Pale Blue Dot Energy has been working in the UK CCS space for well over a decade. Acorn has been designed specifically to learn from the past and be robust for the future – a low-cost option that makes best use of legacy oil and gas infrastructure in order to unlock the very large scale CO_2 storage potential of the UK Central North Sea for the North East coast of the UK and beyond.

2018 saw Acorn become the first ever CCS project to receive funding under the European Commission's Connecting Europe Facility. This funding has been matched by both the UK and Scottish Government, along with Pale Blue Dot Energy and Total and represents a significant milestone for CCS in Europe. The year was topped off with the award of the first ever Lease Option for carbon dioxide storage from Crown Estate Scotland, the first ever carbon dioxide appraisal and storage licence by the Oil and Gas Authority (OGA) and representing UK CCUS at the United Nations 24th Conference of Parties in Poland; it's safe to say it has been a busy year. Early next year will see the Accelerating CCS Technologies (ACT) Acorn feasibility work coming to an end, with the project aiming to be ready to start front end engineering design (FEED) in Q2 2019.

Policy clarity in 2019

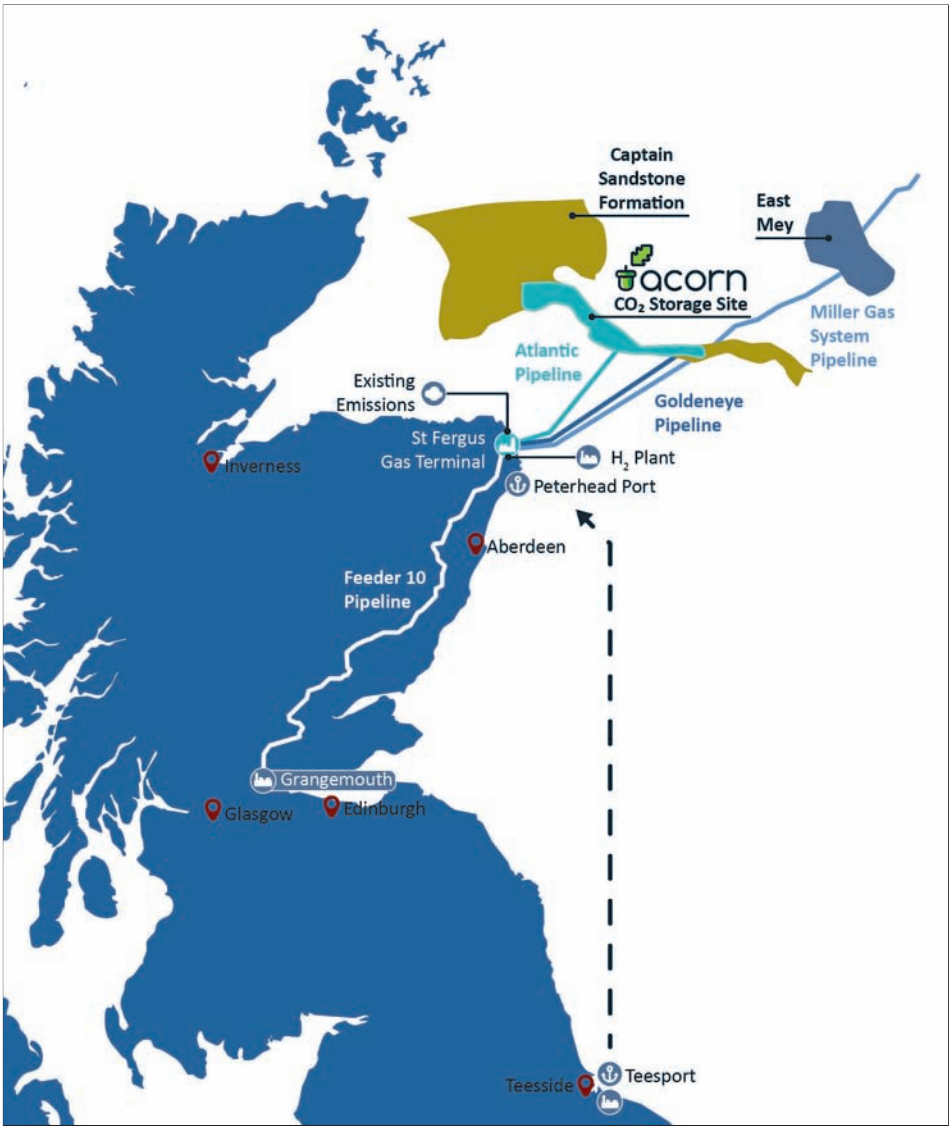
However, for deployment of any CCUS projects in the UK, clear and supportive Government policy must emerge this year. This was a consistent theme throughout 2018, with the Committee on Climate Change (CCC) Progress Report to the UK Government in June sending a strong message that the chopping and changing of strategy around CCUS had to end.

At the Accelerating CCUS conference in Edinburgh, several expert panellists reiterated the same call. Allan Baker from Societe General gave the view from the financial sector: a lack of clear government policy is a real issue for financiers. Going forward the financial community will be needed to play a key role in developing a commercial CCUS industry and so this is really a priority for the UK.

Professor Jim Skea, co-chair of Working Group III of the Intergovernmental Panel on Climate Change (IPCC) that led the 1.5C special report, reinforced that to get to the UK's Paris Agreement targets we really need the policy framework for CCS now.

Knowing that a clear policy framework is key to offering confidence to industry, the UK Government launched its CCUS deployment pathway action plan (CCUS Action Plan) which formalised what the Government will be doing next year and beyond to ensure they have the option to deploy CCUS at scale in the 2030s. 2019 looks set to be a very busy year as the Government commences detailed engagement with industry and pulls together the outcomes of several studies that will shape thinking on these policies.

If the Government sticks to these 2019 'New Year's resolutions', by this time next year we should have a great deal more clarity around how CCUS will move forward in the UK.



The UK and Scottish Governments, along with project developer Pale Blue Dot Energy and oil and gas major Total, will provide match funding of the European Commission's Connecting Europe Facilities fund, to progress feasibility work on the UK's Acorn CCS project

A happy new year for CCUS?

The signs are good, but amidst all the inevitable political upheaval in the months ahead, we do need to see a real and serious commitment from the UK Government to keeping its 2019 'New Year's resolutions' and timescales as laid out in the CCUS Action Plan.

From industry, we need to widen out the engagement around CCUS developments and the opportunities it can bring to industrial clusters across the UK, positioning key industrial regions to really take advantage of the decarbonisation opportunities that CCUS infrastructure investment can bring.

By this time next year, we hope to be boasting about that clear policy framework that we have managed to create in the UK – one that will mobilise industry and private finance to kickstart a world-leading UK CCUS sector right here, getting us on track to meeting our climate change targets.

So here's to 2019 building on the momentum of 2018 and working together with Industry and Government to create a very happy new year for CCUS.

More information

www.pale-blu.com

IEA and UK kick-start a new global era for CCUS

The International CCUS Summit, co-chaired by Claire Perry, UK Minister of State for Clean Energy and Growth, and Dr Fatih Birol, the IEA's Executive Director, signalled the 'start of a new era' for CCUS. It was followed by the Accelerating CCUS conference where both gave keynote addresses.

The International Energy Agency and the Government of the United Kingdom held a global summit on carbon capture, utilization and storage (CCUS) in Edinburgh, bringing together global energy leaders, including Ministers and senior representatives from more than a dozen countries, CEOs of major energy companies and the financial community, to identify practical steps to accelerate investment and deployment of CCUS.

The summit emphasised that the private sector is ready and able to deliver CCUS if it can operate within a well-understood fiscal, policy and risk-allocation framework.

Delegates recognised the urgent need to progress CCUS and identify opportunities for early investment. CCUS projects have a typical development time of between four and eight years, meaning investment decisions need to be taken in the coming years for new facilities to be operating globally by the mid-2020s.

"Without CCUS as part of the solution, reaching our international climate goals is practically impossible," said Dr Birol. "CCUS can also enhance energy security and boost economic prosperity. Yet up until now, progress has been muted and if this continues the challenges we face in the energy sector will become infinitely greater. That is why the IEA is bringing together industry, governments and our own technology network – as well as the investment community – to make CCUS a reality."

Delegates recognised the leadership of the IEA in supporting global partnerships and its central role in providing robust analysis to inform policy and investment decisions for CCUS. The meeting also acknowledged that multilateral organisations and initiatives including the Clean Energy Ministerial CCUS Initiative, the Carbon Sequestration Leadership Forum, Mission Innovation, the Oil and Gas Climate Initiative, and the Global CCS Institute are facilitating international CCUS partnerships.

Delegates identified strengthening such initiatives as a priority, and recognised the value of expanding participation from industry, financial services and NGOs, whose support is critical to the accelerated deployment of CCUS.

Dr Birol has challenged participants to report progress by the next IEA Ministerial Meeting, in November 2019, stressing that this is an area the IEA has identified as a major priority and is committed to helping steer forward. The IEA will produce a report on the progress of CCUS investments to underscore the new momentum behind the technology by then. Last year, the IEA held a first international CCUS summit, which was co-chaired by Rick Perry, the US Secretary of Energy, on the sideline of its last ministerial meeting.

The Summit identified priorities and strategies to enable these investment decisions, including:

• **Prioritise competitive investment opportunities**: The IEA has identified that as much as 450 Mt CO2 globally could be captured for CO2 use or storage with an incentive of less than USD 40 per tonne. This CO2 is primarily from industrial facilities such as ethanol production, hydrogen or natural gas processing that otherwise vent relatively pure CO2 into the atmosphere.

Delegates recognised that these early opportunities for CCUS investment could make a substantial contribution to emissions reductions at a competitive cost.

• **Reduce costs through better business models and CCUS "hubs"**: CCUS requires clear commercialisation pathways if investment is to be accelerated. Delegates recognised the need for a swift transition from building stand-alone CCUS facilities with dedicated transport and storage infrastructure, to developing multi-user "hub and cluster" facilities in industrial regions.

This approach can reduce unit costs through economies of scale, while reducing commercial risk and financing costs by separating out the CCUS value-chain. Public-private partnerships are an option to support the development of transport and storage infrastructure.

The Summit underlined the importance of agreeing appropriate risk-sharing arrangements between governments and industry to support the cost-effective deployment of CCUS infrastructure.

• **Develop policy frameworks for investment certainty**: A carbon price or CO2 tax can provide an important long-term investment signal for CCUS, but boosting early investment will require complementary and targeted policy measures.

A range of options including regulatory levers, market based frameworks and measures such as tax credits, grant funding, feed-in tariffs, public procurement, low-carbon product incentives and CCUS obligations and certificates could all play a role depending on national circumstances and preferences.

• **Include CCUS in long-term climate planning:** The deployment of CCUS is critical in all viable pathways to achieving globally-agreed climate goals. The communication and planning of Nationally Determined Contributions (NDCs) and submission of mid-century climate strategies provides an opportunity to identify and articulate the future role for CCUS at a national level.

These can play an important role in informing near-term policy and investment decisions for CCUS while also guiding innovation priorities.

• **Identify and develop "bankable" CO2 storage**: Confidence in the availability of safe, secure and adequate CO2 storage is a prerequisite for investment in both transport and storage infrastructure and capture facilities.

Global CO2 storage resources are considered to be well in excess of likely future requirements. In many regions, however, significant further assessment work is required to convert theoretical storage capacity into "bankable" storage, where capacity, injectivity and containment are well understood.

Regional and interregional collaboration and partnerships are playing an important role in the identification and development of CO2 storage facilities globally and need to be increased.

• **Unlock the value of CO2**: CCUS can be central to a new market for low-carbon and carbon-based products. Innovation in CO2 use – for the production of chemicals, building materials, fuels and products such as low carbon steel and cement – could boost future demand for CO2 as a valuable commodity, driving new markets and providing a commercial incentive for CO2 capture.

Two-thirds of CCUS projects operating today were driven by demand for CO2 for enhanced oil recovery (EOR), and there is significant further potential for EOR-enabled CCUS investment in North America, China and the Middle East. Given the scale of the climate challenge, opportunities for CO2 use are expected to complement the need for geological storage, and the proliferation of projects may help to lower costs of capture and use technology and help unlock the economic value of CCUS to economies, supporting industrial competitiveness.

Research and innovation on both capture and use technologies across a large variety of industrial sectors should continue in parallel to the deployment of available technologies at industrial scale.

Accelerating CCUS

UK Energy and Clean Growth Minister Claire Perry introduced the newly published UK CCUS Action Plan which aims to establish the country's first carbon capture, usage and storage project from the mid 2020s (see following page).

The UK government also announced investment of £175,000 in Project Acorn in St Fergus, Scotland, to develop ways of transporting carbon emissions from where they are captured to storage. This will be matched by the Scottish government, and the European Union Commission will also provide funding.

Another CCUS project is being developed with OGCI Climate Investments which announced its intention to open the first commercial end to end CCUS project in Teesside. The project will use natural gas to generate power, with CO2 then captured and transported by pipeline for storage under the seabed.

Minister Perry said it was time to put a 'rocket booster' under CCUS projects and emphasised the need for government and industry to work together to build the frameworks to enable CCUS to deploy at scale.

UK Minister Claire Perry said it's time to put a 'rocket booster' under CCUS projects at the Accelerating CCUS conference in Edinburgh

The emphasis is now on a cluster based approach with BECCS providing a faster emissions reduction trajectory.

Dr. Fatih Birol said that CCUS was essential to meet climate goals and pointed out that legacy infrastructure already accounted for 95% of emissions to 2040 in a trajectory to meet the Paris Climate targets. "Half of all coal plants are less than 15 years old," he said, "There is no chance of meeting Paris targets without CCS."

He pointed out the disparity in public funding of CCS: in the last 10 years this was just 3% of renewables support in the last year alone.

Scottish Energy Minister Paul Wheelhouse talked about the potential for Scotland to be a hub for transnational storage of CO2.

Vicki Hollub, CEO of Occidental Petroleum, the largest operator of CO2 Enhanced Oil Recovery (EOR) in the U.S., said her company was achieving recovery rates of as much as 70% at one of its conventional Permian reservoirs through EOR, and the company plans to extend CO2 injection to its Permian shale operations.

CO2 sequestration through EOR stores around 40% of the CO2 injected, Ms. Hollub said, meaning overall emissions from a barrel of oil produced is reduced.

Charlotte Morgan from Linklaters and chair of the UK CCUS Cost Challenge Taskforce said that the discussion has moved from standalone projects to a hub concept.

She said getting business models right is key, and warned against a proliferation of models, "keep it simple, investable and well understood. One industry, one voice gets to deployment faster."

Xi Liang of the UK China CCUS Centre talked about the 16 pilot projects being developed in China and the need for knowledge sharing.

Aniruddha Sharma, Co-Founder & CEO, Carbon Clean Solutions talked about enabling 1 billion tonnes of CO2 capture and their subsidy free project in India.

Brad Page, CEO of the Global CCS Institute said it all comes back to long term dependable policies which can bring in investment for any capture technology that works.

Norwegian Minister Björn Haugstad said the key is to foster mutual trust between government and industry and a stable regulatory framework to encourage commercial projects.

Jim Skea from the IPCC talked about different pathways to meeting Paris targets: the more ambitious the target the earlier CCS is .required, especially BECCS.

More information

www.iea.org

www.gov.uk/beis

UK aims for first CCUS project by mid 2020s through industry collaboration

The UK Government's Clean Growth Action Plan aims to make UK a global leader in CCUS and to enable deployment of CCUS at scale during the 2030s subject to costs coming down sufficiently.

The Action Plan is aimed at establishing a cost-effective, investable, and sustainable pathway for CCUS that supports cost reduction and enables commercial deployment in the UK.

Key to this is a focus on collaboration with industry, ensuring there is a business environment that works for all involved in CCUS through identifying the appropriate commercial frameworks to enable investment, innovation and cost reduction.

The Government will work with stakeholders to identify existing infrastructure that could be re-used to support CCUS projects and will develop a policy on re-use of infrastructure for the purpose of CCUS.

The UK will also examine in detail the scope of the opportunity for maximising economies of scale by developing a shared carbon dioxide infrastructure network in an industrial centre, and will report by the end of 2019.

The UK will continue to lead efforts working with other Governments and industry, to accelerate global deployment of CCUS, which will help to drive down costs and expand the emerging market for CCUS technology.

The Goverment also committed to engage with industry through a CCUS Council, co-chaired by the Minister for Energy and Clean Growth and James Smith (formerly chair of the Carbon Trust and Shell UK)

The Council will advise Government on progress against the priorities as set out in the Clean Growth Strategy and in the Action Plan and will also continue to monitor industry capability, CCUS costs, and deployment potential.

The CCUS Council will provide a link between industry and Government in providing advice on industry capability and other CCUS developments during the 2020s.

The plan commits the UK to:

Immediate priorities for action

• Ensuring the business environment works for all involved in CCUS through identifying the appropriate commercial frameworks to enable investment, innovation and cost reduction.

• Ensuring we have the people and the delivery capability to deliver the CCUS infrastructure challenge, enabling deployment at scale in the 2030s, creating high value jobs for people across the UK.

• How best to deploy CCUS infrastructure, subject to cost reduction, in places and regions across the UK.

• Having a strategic approach to ideas, innovation and development, enabling cost reductions.

• Leading international collaboration to accelerate global deployment of CCUS.

• set out how to enable the UK's first CCUS facility in 2019

• invest £20 million in supporting construction of CCUS technologies at industrial sites across the UK, as part of £45 million commitment to innovation

• invest up to £315 million in decarbonising industry, including the potential to use CCUS

• begin work with the Oil and Gas Authority, industry and the Crown Estate and Crown Estate Scotland to identify existing oil and gas infrastructure which could be transformed for CCUS projects

The Government published a number of documents as well as the Action Plan:

• Industrial CCUS: business models

• Industrial CCUS: readiness of UK industrial clusters

• Shipping CO2: UK cost estimation study

• Power CCUS technologies: technical and cost assumptions

Luke Warren, Chief Executive of the CCSA, said, "If we are to have any hope of meeting our existing climate change targets, let alone achieving net zero emissions, we must support the commercialisation of CCUS today."

"The Government's announcement in Edinburgh recognises the need for urgent action, with a commendable commitment to develop the first project by the mid-2020s as a first step towards having the ability to deploy CCUS at scale."

"The Government have today stepped up and shown global leadership by committing to this ambitious and deliverable action plan. We look forward to working with Government over the next year on how to deliver a number of regional CCUS clusters that will be needed to achieve commercial scale deployment."

More information

www.ccsassociation.org.uk

www.gov.uk/beis

UK to develop world-first carbon 'net-zero' hub of heavy industry by 2040

At COP24 climate talks in Poland the UK government has set a world-leading ambition for the first 'net-zero carbon' cluster by 2040 backed by up to £170 million funding.

The UK could have the world's first 'net-zero carbon' cluster of heavy industry by 2040, thanks to up to £170 million of new funding announced at COP24 climate talks in Poland.

Up to £170 million funding for industry will be provided through a competitive process for clusters to research, develop and demonstrate at scale the innovative solutions to lead the way to a decarbonised industrial future, subject to industry entering into partnership with government and providing significant co-investment to this challenge.

These energy intensive clusters include Grangemouth, South Wales, Merseyside, Teesside, Humberside and Southampton. They are recognised as key to the UK economy but also as significant contributors to the UK's emissions.

Energy and Clean Growth Minister Claire Perry announced the ambition alongside plans for at least one low-carbon cluster by 2030 using carbon capture and storage; the UK is aiming to become a world-leader in clean technology and services that will be needed as the world tackles climate change, she said.

Currently, industry accounts for around 25% of all greenhouse gas emissions in the UK, with more than two-thirds of these industrial emissions coming from energy intensive industries which are often located next to each other in clusters.

This new funding of up to £170 million, which is expected to be backed by industry, will help heavy industries like steel, ceramics, cement, chemicals, paper and glass to share expertise and innovative low-carbon solutions.

The government will also be supporting the transformation of foundation industries (steel, glass, ceramics, chemicals) more broadly through providing up to £66 million through the Industrial Strategy Challenge Fund to develop new technologies and establish innovation centres of excellence in these sectors.

Energy and Clean Growth Minister Claire Perry said, "Demonstrating climate action and growing the economy go hand in hand is key to building momentum behind global action on carbon. The UK is a leader in both, cutting our emissions by more than 40% while growing our economy by 2 thirds, but to sustain this track record we need to tackle emissions from energy intensive sectors and bring clean growth to our great industrial centres."

"That's why today I'm launching a mission to create the world's first 'net-zero' carbon cluster by 2040 in the UK with up to £170 million of new government funding. This will help to develop the technologies of the future to transform industry around the world, ensuring the UK seizes the global economic opportunities of moving to greener, cleaner industry – a key part of our modern Industrial Strategy."

The UK Committee on Climate Change welcomed the plan and emphasised the need for low carbon hydrogen deployment and Bioenergy with CCS (BECCS) to make best use of the cluster concept. The CCC said its analysis suggests BECCS could be competitive with other strategies to reduce emissions by 2030.

The Goverenment also announced that the UK-Canada led Powering Past Coal Alliance (PPCA) had celebrated one year of activity, now with over 70 members. As part of this, the UK has committed £20 million for a World Bank programme (ESMAP) to help developing countries move away from coal power and embrace renewable energy and established the Utilities Taskforce to become influential advocates for the PPCA.

The UK and Canada announced new members of the PPCA, committing to eradicating coal power while redirecting resources to renewables. Around 3.5 billion tons of coal are currently burnt globally for power every year, contributing to 45% of the world's emissions.

Dr Luke Warren, Chief Executive of the CCSA, commented:

"The CCSA is delighted to have worked alongside government as part of an industry consortium on the development of this mission over the past year."

"These clusters will utilise technologies which can provide deep decarbonisation in industrial sectors, and CCS is a key part of this effort. The Government has allocated £170 million to this work, and together with matched funding from industry, this will go a long way to laying the groundwork for the creation of low-carbon industrial zones in key UK regions such as Teesside, Merseyside and Scotland."

"Today's announcement represents yet another positive step forward in realising a commercial CCS industry in the UK, which can deliver significant global opportunities for the UK's low carbon economy. The Government recently published its CCUS Deployment Pathway, setting out its plans to deliver the first UK CCUS project by the mid 2020s. Together with the funding announced today, this could help to realise a key recommendation from the CCUS Cost Challenge Taskforce – the establishment of at least two CCUS clusters in the 2020s."

"We are entering into an important and exciting time for CCS in the UK; now is the time for strong industry and Government collaboration, to realise the Government's ambition of deploying CCUS at scale and ensuring the UK steps up its climate ambition to make net-zero emissions a reality."

More information

www.gov.uk/beis

unfccc.int/katowice

First UKCCSRC Early Career Researcher Biannual Meeting

The UKCCSRC funded Early Career Researcher 1st Biannual Meeting took place at the University of Edinburgh on the 6th December bringing together a diverse range of students with a shared interest in all things CCS. By Jonathan Scafidi, University of Edinburgh

Capture engineers, geologists and carbon economists were all in attendance to gain and share knowledge of the latest research in CCS, with talks from Alan James (Managing Director of Pale Blue Dot), Hydra Rodrigues (Heriott Watt), Dr Maarten Verbraeken (University of Edinburgh), Dr Stuart Gilfillan (University of Edinburgh), and Dr Mathieu Lucquiaud (University of Edinburgh).

Alan James opened the talks with a presentation on "Achieving a Paris Compliant Career Path" and discussed the importance of making career decisions based on future needs rather than traditional career paths in the oil and gas sector. In light of the Paris agreement, it is clear that future roles in the energy sector will be very different to previous generations as the energy landscape changes rapidly.

With many governments phasing out new oil and gas exploration, and a public demanding action on climate change, energy companies are beginning to rebrand and diversify away from fossil fuels. Alan's advice to young researchers was to look at the direction in which the sector is shifting and aim to be there when it does.

This point was driven home through two photos of London Picadilly taken 10 years apart in the early 20th Century. The first, taken in 1908, shows streets filled with horse-drawn carriages. The second, from 1918, sees all of the horses gone and replaced instead with buses and cars, a testament to the rapid rise of the internal combustion engine. No point in training up in a redundant industry.

Such a rapid shift should be possible in the coming years for climate change action. Pushing research into a more industry integrated, fast-paced era should be the new target if any of the currently studied technologies are to help achieve the targets of the Paris Agreement. Alan used the Acorn CCS Project, which he is currently working on, as an example of how this can be realised and we all look forward to seeing it successfully operational in 2023.

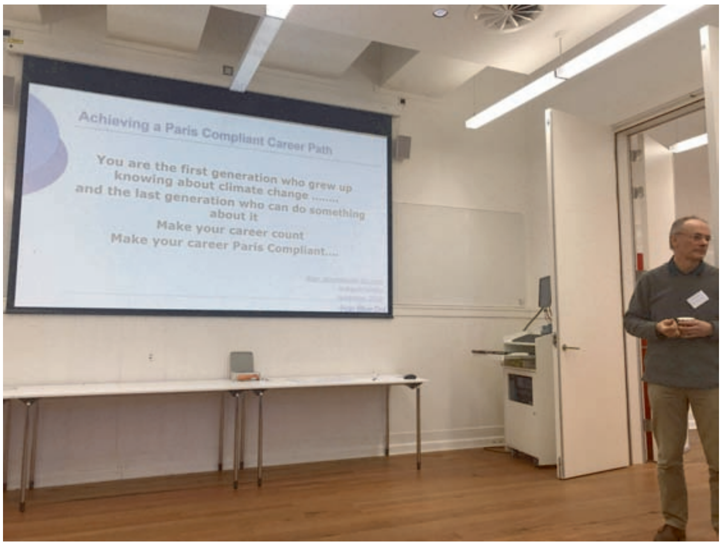


Image: ©Rachel Utley

After Alan's talk a poster session was held to encourage discussions and networking. Work on display included tracing CO2 leakage using noble gas isotopes, assessing potential CO2 reservoir suitability through stress testing core samples, alongside new capture processes and assessments of national carbon transport systems.

After lunch, the talks continued with Hydra Rodrigues presenting her work on modelling the economics of enhanced oil recovery using CO2 injection in a carbonate oil field 300km offshore Brazil. She took the audience through the various stages of building the models and combining them in order to calculate the most cost effective strategy. An engaging Q&A session followed and Hydra was awarded a prize for her talk.

Dr Maarten Verbraeken discussed his work on adsorbents with stepped isotherms and the difficulties in predicting their behaviour. He showed results from the new RALF model his research group has been working on and its vast improvements in predictions.

The final talks of the afternoon came from Dr Stuart Gilfillan and Dr Mathieu Lucquiaud who both spoke about their careers, motivations, and work/life balance. Both talks were of great interest to the audience who were predominantly PhD students, and many questions followed. More than a few were somewhat jealous of Stuart's fieldwork over the years which has taken him from the USA to Australia, looking at real life cases of carbon storage in action, including providing evidence in a legal case.

The meeting culminated in a tour of the engineering labs by Dr Elsa Lasseuguette, the perfect end to a successful day.

The students who attended had a great opportunity to hear about one of the most exciting projects in CCS today from Alan James, which will no doubt inspire them to lead more fulfilling, Paris compliant careers. The depth and insightfulness of the day's questions was testament to the focus and curiosity of the next generation of scientists working on making CCS a reality. Here's hoping they will.

The next UKCCRC Early Career Researcher Biannual Meeting will take place in the summer of 2019.

More information

www.ed.ac.uk

www.ukccsrc.ac.uk

UK CCUS news

Oil & Gas UK report calls for 'essential' CCUS development at scale

www.oilandgasuk.co.uk

The Energy Transition Outlook report, published by industry body Oil & Gas UK, considers the issues and opportunities for the offshore oil and gas sector from the changing energy landscape.

Drawing on existing research carried out by its member organisations and independent consultants and agencies, the 20-page report provides an overview of the key political, economic, technological and social drivers that are influencing the energy mix.

It also highlights the critical importance of industry's drive to maximise production from the UK Continental Shelf to provide security of supply while moving towards achieving climate change ambitions.

It concludes by setting out a policy road map that utilises the UK's world leading expertise in offshore technology to deliver the next phase of the energy transition.

Will Webster, Energy Policy Manager and report author said, "This report demonstrates industry's key role in the energy transition and reinforces that Vision 2035, industry's ambition to add a generation of production to the UK North Sea and double the export opportunity for the supply chain, is critical in achieving the balance between delivering our climate change targets and ensuring security of energy supply."

"As the report shows, despite the rapid advances in lower carbon technologies there is ongoing demand for oil and gas in several key areas including transport and domestic heating. A total of 80% of the UK's 27 million homes are heated by gas, demonstrating the long-term importance of our industry in ensuring security of energy supply."

"A lower carbon future will still require large scale energy distribution networks, undersea engineering and the mass movement and storage of gases and liquids. The role for Carbon Capture and Storage (CCUS) and the development of hydrogen on an industrial scale will also feature in the future as these will be essential elements of any lower carbon environment."

OGCI Climate Investments announces progression of the UK's first commercial full-chain CCUS project

oilandgasclimateinitiative.com

OGCI is entering into a strategic partnership with BP, ENI, Equinor, Occidental Petroleum, Shell and Total to progress the Clean Gas Project, the UK's first commercial full-chain Carbon Capture Utilization and Storage (CCUS) project in Teesside.

The Clean Gas Project could form the heart of the Tees Valley CCUS Cluster that will deploy commercially viable, safe, environmentally responsible CCUS at scale. It will combine CO2 capture from new efficient low-carbon power generation and local industrial emitters in Teesside. The project is a result of collaboration between OGCI Climate Investments, its member companies, central and local government and local industry.

The partnership will support the technical and commercial progression of the Clean Gas Project on to the next stage of development. As the project reaches this important phase, it becomes the anchor project for a decarbonized industrial cluster in Tees Valley, home to British industry.

The partnership will continue to work with the government on commercial terms that support the stakeholders involved, including the Tees Valley Mayor, the Tees Valley Combined Authority (TVCA), local industry, and the community.

The Clean Gas Project will use natural gas to generate power, with CO2 then captured and transported by pipeline for storage in a formation under the Southern North Sea. The infrastructure created would enable industrial clusters in Teesside and elsewhere to capture and store CO2 from their processes. The clean CO2 could also attract CO2-utilization companies, revitalizing the region with new technologies and investment.

As the project progresses, the team will be looking for additional partners across the full value chain. With these additional partners, progress of the project towards actual construction and operations will depend on agreements and approvals of all parties involved. It is anticipated that the project will then progress toward engineering design in 2019.

Drax begins bioenergy carbon capture and storage pilot

www.drax.com

www.c-capture.co.uk

The commissioning of a Bioenergy Carbon Capture and Storage (BECCS) pilot plant at Drax Power Station has started with the first carbon dioxide expected to be captured in the coming weeks.

If successful, the six month pilot project will capture a tonne of CO2 a day from the gases produced when renewable power is generated using biomass at Drax – the UK's biggest power station, near Selby in North Yorkshire.

BECCS is vital to global efforts to combat climate change because the technology will mean the gases that cause global warning can be removed from the atmosphere at the same time as electricity is produced. This means power generation would start to reduce the carbon accumulating in the atmosphere – vital for tackling climate change.

Drax is partnering with Leeds-based C-Capture and is investing £400,000 in what could be the first of several pilot projects undertaken at the power station to deliver a rapid, lower cost demonstration of BECCS.

Drax Power Station became the largest decarbonisation project in Europe by upgrading two thirds of its generating units to use biomass instead of coal and, if the BECCS pilot is successful, it will examine options for a similar re-purposing of existing infrastructure to deliver more carbon savings.

The Royal Academy and Royal Society of Engineers have estimated that BECCS could enable us to capture 50 million tonnes of carbon dioxide per year by 2050 – approximately half the nation's emissions target.

Over the summer work was undertaken to ensure the solvent C-Capture has developed is compatible with the biomass flue gas at Drax Power Station. This was completed successfully along with a lab-scale study into the feasibility of re-utilising the flue gas desulphurisation (FGD) absorbers at the power station.

FGD equipment is vital for reducing sulphur emissions from coal, but it is no longer required to control sulphur on four of the generating units at Drax that have been upgraded to use biomass, because the wood pellets used produce minimal levels of sulphur.

The C-Capture team has now proceeded to the second phase of the pilot, with the installation of a demonstration unit. Once commissioned it will isolate the carbon dioxide produced by the biomass combustion.

C-Capture is a spin-out from the Department of Chemistry at the University of Leeds, established through funding from IP Group Plc.

Delaying commercial scale UK deployment of CCUS increases costs

www.eti.co.uk

A report from the Energy Technologies Institute supports extensive research that has consistently demonstrated that Carbon Capture, Usage and Storage (CCUS) deployment is a key component in minimising costs in the transition to a low carbon energy system.

The report supports the analysis that if CCUS is not deployed by 2030 carbon abatement costs in the UK will rise to circa £1 billion a year – and could double before 2050.

The report suggests that gas power stations with CCUS fitted could provide anchor loads for CO2 pipelines and stores that serve emerging CCUS clusters, unlocking a pathway for CCUS to cut emissions in industry and support hydrogen production.

If Carbon Capture, Usage and Storage (CCUS) is not deployed over the next decade, the UK's transition to a low carbon energy system will face increased risk and higher costs says a new report released today by the Energy Technologies Institute (ETI).

'Still in the mix? Understanding the role of Carbon Capture Usage and Storage', was written by the Energy Systems Catapult (ESC) for the ETI, and takes into account recent cost reductions in renewables and the latest ETI modelling on CCUS costs.

The report reaffirms previous ETI work on the importance of CCUS deployment by 2030, without which carbon abatement costs will increase by circa £1billion a year. The research also cements ETI analysis that if CCUS is not developed at all before 2050, the 'national bill' for low carbon energy that year would be circa £35bn higher – equivalent to circa 1% of expected GDP.

The report highlights gas power with CCUS (up to 3GW) as an effective low carbon electricity option that can be deployed cost-effectively before 2030 within an electricity generation mix that meets the 5th carbon budget.

The report concludes that early investment in gas power CCUS in favourable locations for a CCUS industrial cluster represents the most straightforward, deliverable and best value approach to early deployment of the technology.

"We believe that CCUS retains a key role as part of a least cost portfolio of low carbon technologies for the UK and will increase the options for decarbonised electricity, reducing deployment risks for other technologies," said Andrew Haslett, Chief Engineercapture projects in the ground."

Bridge to a cleaner energy future

When considering the options to cut CO_2 emissions and meet the targets of the Paris Agreement, one solution may have slipped below the radar: using CO_2 as a commercial commodity instead of treating it as waste. Technologies exist to do this today. By Thomas Weber, Jupiter Oxygen Corporation USA

The solution is especially appealing to emerging economies, where the use of fossil fuels will continue, and likely increase, for decades – despite ambitious climate policies. One case in point is India. With 18% of the global population (1.3 billion people), India uses just 6% of the world's primary energy, and some 240 million people still have no access to electricity. Limited availability of energy is a major obstacle to India's development.

The government's primary goal is to boost economic growth, which at the same time will increase energy consumption. The International Energy Agency (IEA) projects that India's energy demand will more than double by 2040.

But while per capita CO_2 emissions are lower than those of China and significantly lower than the US, India is already the fourth largest carbon emitter. How to try to meet energy needs while keeping CO_2 in check? India plans to significantly increase renewable energy – for example, with the 100 GW solar power initiative as announced at COP 21 in Paris. However, the pace of economic change is too fast for renewables to take over an energy system where three quarters of energy demand are met by fossil fuels and where coal is the backbone of the Indian power sector, accounting for over 70% of generation.

Coal is abundant in the country, and cheap; the government will necessarily keep investing in this resource and it is expected that the share of coal in the primary energy mix will even increase between now and 2040. Any climate and energy policy will have to consider that reality. This is where Carbon Capture, Utilisation and Storage (CCUS), today – and the reuse of carbon (CCU) at scale in the near future – come in to play.

For example, one strategy has been developed to capture, utilise and store CO_2, using oxygen combustion to capture CO_2 from industrial facilities and power plants in order to inject it at high pressure into coal seams. This approach is a game-changer as it combines several attributes that support the effective and environmentally responsible use of fossil fuels.

First, the use of high flame-temperature oxy-combustion (burning fossil fuels in a boiler with nearly pure oxygen) maximises fuel efficiency and enables cost-effective carbon capture.

Second, this oxy-combustion process produces both CO_2 and nitrogen, which, when injected at high pressure (and permanently stored) into deep, unminable coal seams, significantly increases unconventional domestic gas production. The freed coal-bed methane is collected and used, acting as an important bridge fuel in the transition to clean energy. (The process is referred to as Enhanced Coal-Bed Methane "ECBM" recovery, and has been field tested in the USA, Canada and China).

Third, the synergy of oxy-combustion, carbon capture and utilisation creates significant additional revenue streams. The greatest obstacle to date for the implementation of carbon capture technology at power plants has been reduced operating efficiency and consequently higher electricity costs. Having a viable CBM/ECBM market available, where the captured CO_2 and nitrogen can be sold to ECBM-recovery operators, creates an immediate business case for the implementation of oxy-combustion-based carbon capture technology at coal fired power plants.

Revenues from the sale of CO_2, nitrogen and other by-products will offset the higher costs of operating power plants with CCUS. In addition, co-benefits of this advanced coal power plant operation are 95% of CO_2 emission reduction, air pollutant control (SO_x, NO_x, PM and mercury removal), as well as heat recovery (which increases the efficiency of the process) and water recovery (a particularly valuable scarce resource in India.)

Tapping the potential

Jupiter Oxygen Corporation (JOC), a pioneer in oxy-combustion technology, has commenced an initial commercial CCUS project in Xinjiang Province (western China), which includes retrofitting a 55MWe coal-fired power plant with JOC's high flame temperature oxy-combustion and CO_2 capture technologies. In addition, JOC is pursuing demonstration project development in West Bengal, India, potentially including collaboration between JOC and the Indian Institute of Technology Bombay.

In India the potential for this technology is substantial. The country has large coal reserves, but not much natural gas. There are estimated to be 70 to 90 trillion cubic feet (2.0 to 2.6 trillion cubic metres) of coal bed methane in place, of which 20 trillion cubic feet (0.57 trillion cubic metres) are recoverable with conventional CBM. Almost the same volume again is potentially recoverable with ECBM. And exploiting the full potential of ECBM in India could deliver several billion metric tons of CO_2 storage capacity. As CBM projects come into existence and expand, infrastructure and expertise will grow, enabling identification of the business opportunities that take advantage of proximity between the unminable coal seams and CO_2 'source' facilities. Some of these opportunities have already been identified for India in a recent study commissioned by JOC (ARI, 2015).

In essence, this is a sector where India can demonstrate leadership. India's Nationally Determined Contribution (NDC) to the Paris Agreement calls for technological solutions and international collaboration on clean coal. India's NDC also promises to reduce carbon intensity by 33-35% by 2030 relative to 2005 levels, a goal that is hard to reach without addressing fossil fuel emissions. But it's not just India. The IEA says that 70% of all carbon capture and storage in 2050 will need to be in non-OECD countries, where energy demand is growing and fossil fuels remain an important resource. As a complement to renewables and energy efficiency, CCUS and CCU offer an important bridge to a cleaner energy future, allowing us to be smarter about fossil fuels.

More information

Adopted from Climate 2020 article:
www.climate2020.org.uk/bridge-cleaner-energy-future

Reaching net-zero carbon emissions from harder-to-abate sectors by 2050

The Mission Possible report by the Energy Transitions Commission shows that reaching net-zero carbon emissions from heavy industry and heavy-duty transport can be done through ambitious policy, accelerated innovation and investment, with minimal cost to the global economy.

Reaching net-zero carbon emissions from heavy industry and heavy-duty transport sectors is technically and financially possible by 2060 and earlier in developed economies and could cost less than 0.5% of global GDP, according to a report by the Energy Transitions Commission (ETC).

The report Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century outlines the possible routes to fully decarbonize cement, steel, plastics, trucking, shipping and aviation – which together represent 30% of energy emissions today and could increase to 60% by mid-century as other sectors lower their emissions.

The "Mission Possible" report was developed with contributions from over 200 industry experts over a 6- month consultation process. Its findings show that full decarbonization is technically feasible with technologies that already exist, although several still need to reach commercial readiness.

The total cost to the global economy would be less than 0.5% of GDP by mid-century, and could be reduced even further by improving energy efficiency, by making better use of carbon-intensive materials (through greater materials efficiency and recycling) and by limiting demand growth for carbon-intensive transport (through greater logistics efficiency and modal shift).

The report also shows that this would have only a minor impact on the cost of end consumer products. For example:

• Green steel use would add approximately US$180 on the price of a car.

• Green shipping would add less than 1% to the price of an imported pair of jeans.

• Low-carbon plastics would add 1 US cent on the price of a bottle of soda.

Key policy levers

• Tightening carbon-intensity mandates on industrial processes, heavy-duty transport and the carbon content of consumer products.

• Introducing adequate carbon pricing, strongly pursuing the ideal objective of internationally agreed and comprehensive pricing systems, but recognizing the potential also to use prices which are differentiated by sector, applied to downstream consumer products and defined in advance.

• Encouraging the shift from a linear to a circular economy through appropriate regulation on materials efficiency and recycling.

• Investing in the green industry, through R&D support, deployment support, and the use of public procurement to create initial demand for "green" products and services.

• Accelerating public-private collaboration to build necessary energy and transport infrastructure.

Reaching full decarbonization will require a portfolio of decarbonization technologies, and the optimal route to net-zero carbon will vary across location depending on local resources.

Direct and indirect electrification (through hydrogen) will likely play a significant role in most sectors of industry and transport, leading to a sharp increase in power demand – growing 4-6 times from today's 20,000 TWh to reach around 100,000 TWh by mid-century).

Hydrogen use will almost certainly increase dramatically (7-11 times by mid-century), with two routes to zero-carbon hydrogen: electrolysis, which will likely dominate in the long term, and steam methane reforming plus carbon capture and storage.

Bioenergy and bio-feedstock will be required in several sectors, but will need to be tightly regulated to avoid adverse environmental impact (such as deforestation), and its use should be focused on priority sectors where alternatives are least available or more costly, such as aviation and plastics feedstocks.

Carbon capture (combined with use or storage) will likely be required to capture process emissions from cement and may also be the most cost-competitive decarbonization option for other sectors in several geographies. However, it does not need to play a major role in power generation, with the storage needs required could be less than many scenarios suggest. Tight regulation of storage is essential to ensure safety and permanence.

Adair Turner, co-chair of the ETC said, "This report sets out an optimistic but completely realistic message – we can build a zero-carbon economy with a minor cost to economic growth. We should now commit to achieving this by 2060 at the latest, and put in place the policies and investments required to deliver it."

More information

www.energy-transitions.org

The business of carbon emissions: managing and reducing in 2019

Waste gases and other pollutants must be measured accurately as a matter of best business practice for oil and gas providers to demonstrate their awareness of the need for a global, carbon crackdown and to abide by new legislation. By Alex Keys, Marketing Director, Fluenta

With international initiatives to reduce global carbon dioxide (CO_2) emissions gaining momentum, the pressure on companies to reduce their impact on the environment is mounting. Companies can harness advances in connected measurement technology to drive new revenue streams during the necessary transition from waste to capture of CO_2.

Precise measurement of waste gases produced by gas flaring can only be properly managed with the use of accurate measurement technology, an application that forms the backbone of an effective energy management scheme.

One of the best solutions available to evolve the carbon neutral agenda is carbon capture technology. The methods required to capture carbon effectively are already in use, but these practices are rendered largely redundant if the companies do not have an accurate assessment of how much CO_2 is produced as a result of flaring. This is why an accurate measurement of CO_2 emissions produced in flaring could enable companies to make a case for investment in carbon capture technology and revenue generation through schemes like carbon pricing.

The role of government

An International Energy Agency (IEA) report, 'CO_2 Emissions from Fuel Combustion Highlights 2015' estimated more than 40% of CO_2 emissions come from the power sector, with a further 20% resulting from large-scale industrial processes such as chemicals production.

In a more recent report, the body found that between 2013 and 2018, energy-related CO_2 emissions from advanced economies fell by 3% or 400 million tonnes. However, the same report found the total carbon footprint of the U.S., Asia and Europe will have increased by 0.5% year-on-year as a result of countries moving away from coal.

The Conference of Parties 24 (COP 24) on climate change - which took place in Katowice, Poland - saw all but a few world governments denouncing reliance on coal as an energy source. Indeed, both this years' summit and IEA reports are calling for an almost immediate reduction in CO_2 emissions - the largest contributing factor to global warming. Both have called for a revised reduction in warming of the globe from 2C to 1.5C.

Reaching boiling point

Policy makers are now committed to enforcing reductions of CO_2 and other harmful gases as a matter of urgency. It is likely that companies will be subject to rigorous and stringent legislature that will require oil and gas companies to be more accountable than ever before in 2019.

Oil and gas industries operate thousands of gas flares around the globe. They burn approximately 140 billion cubic meters of natural gas annually, causing more than 300 million tons of CO_2 to be emitted to the atmosphere.

Zero Flaring by 2030 (ZRF) – an initiative introduced by the World Bank - brings together governments, oil companies, and development institutions that recognise the flaring situation in oil and gas production is unsustainable.

ZRF brought these groups together to cooperate and eliminate routine flaring no later than 2030. In this initiative governments incentivise oil and gas companies to invest in reducing waste from flaring. Oil and gas companies pledge to create new oil fields that will not require routine flaring and both governments report on flaring-produced CO_2 on an annual basis.

Based on current legislation and projected plans for 2019, companies that do not engage with the carbon reduction agenda and take steps to significantly reduce emissions will face financial consequences. Reduced funding and incentives from the government and reputational risk are just some of the potential outcomes of failing to comply.

To avoid significant penalties and make accurate reports to legislators, oil and gas companies must employ every technological advantage they can. When reporting on emissions created during gas production processes in flaring for example, the use of accurate measuring devices will be vital.

Supply and demand – the carbon capture market

Companies need to work towards eliminating routine flaring within existing operations and ensuring new developments incorporate gas utilisation solutions. Ultrasonic flow meters have a significant part to play in this. Accurate flow measurement is vital in managing flaring reduction and ensuring compliance with any associated regulation but will also help to inform strategy and planning once widespread gas capture and storage solutions are in place. If companies fail to accurately measure flaring, effective management is impossible.

Many companies responsible for flaring simply estimate emissions based on factors such as pipe size and pressure levels. If routine flaring is to be effectively eliminated, high flaring countries must give more focus to accurate measurement.

Economic moves

If companies invest in new technologies to measure, monitor, and capture excess gas, gas flaring operations can be monetised. In doing so, companies will be well positioned to meet changes in the global regulatory landscape. By making flare gas capture more economical, companies can increase their revenues and maximise their profitability, while at the same time significantly reducing carbon emissions.

Methane capture is far more cost-effective than it was and offers operators the opportunity to create solid energy management schemes, including re-directing excess gas to power operations instead of burning it. Developments in mobile gas capture technology have enabled gas capture to be used at smaller sites. This is particularly relevant with the huge growth in hydraulic fracturing operations (fracking), which are often smaller and more short term.

While long-term gas capture technology generally includes the installation of permanent gas pipelines, there are gas processing firms using mobile gas capture and natural gas extraction units – about the size of a semi-trailer – which can be deployed quickly and easily in remote locations. One firm recently installed 15 of these units at oil well sites in North Dakota - one of the highest gas flaring regions in the world that falls under 'economic' reasoning.

The mobile gas capture units are gathering around 35,000 gallons of natural gas liquids every day and the positive impact on the environment has already been significant. Capturing the gas instead of flaring, the 15 mobile units have prevented the release into the atmosphere of almost 55,900 tonnes of carbon dioxide and 17,100 tonnes of volatile organic compounds.

Accurate measurement technology is the first step towards the large-scale capture of gas. Many sites still estimate emissions and this level of inaccuracy cannot support the implementation of gas capture technology – whether mobile or fixed. When excess gas is being flared or diverted to a capture mechanism it is crucial the operator knows exactly how much gas it is releasing.

The unpredictable nature of gas extraction means flow measurement needs to manage wide fluctuations in the velocity of gas, as well as different atmospheric conditions and changing compositions.

Smarter operations

Advances in connected infrastructure or the Internet of Things (IoT) – mean operators can now collect and analyse emissions data remotely. Where previously engineers would need to be present on-site to physically download data, connected meters offer far greater visibility, cost savings and enable better management and optimisation of emissions in large scale operations.

When real-time data is fed into cloud-based software such as a continuous emission monitoring system (CEMS), organisations can collect, record and report data remotely and in real-time. The software is run on the central server of the business and it is therefore not necessary to store and run software on-site.

This reduces cost and the necessity of having a human operator on-site to manage hardware and associated data. Additionally, the information is stored securely on a remote server and is not dependent on the health and reliability of an on-site machine.

The operator can then access and analyse the data using a variety of devices, providing they are connected to the internet. With internet connectivity available almost everywhere, businesses can access the real-time data feeds of remote assets from multiple devices, anywhere in the world.

The combination of accurate, real-time information on remote assets and cloud technology can have a significant positive impact on moving high-flaring industries from a monitoring to management approach. It enables companies to access information on extreme fluctuations in emissions, and make strategic decisions based on historic data.

By using cloud technology to record gas flaring, companies can build a better picture of trends over time and utilise this information to derive valuable insight to inform business strategy.

Real-time data can also be used to create a competitive advantage. Data retrieved from different sites can be compared to more effectively manage the flaring process – site to site, country to country, or process to process – enabling continuous improvement over time. Best practice can be taken from top performing (low emission) sites and implemented across the entire business operation.

New year resolutions

To meet emission requirements, make a case for investment in new technology and update policies, oil and gas companies will need to gather accurate and comprehensive data on flare emissions. CO_2 reductions and carbon footprints will still dominate the conversation around the industry in 2019, but companies should consider implementing high-accuracy measurement devices and IoT solutions as a matter of urgency.

For minimising reputational risk, reporting will be critical. Oil and gas companies may have a negative reputation in terms of their impact on the environment, but taking responsibility for unnecessary emissions by measuring and reporting emissions information, may help to address this.

As such, companies will also have a vested interested in disseminating data on their emissions at the beginning of the year in order to demonstrate reduced emissions publicly by the end of 2019.

Accuracy is key

While a complete reduction in CO_2 emissions and a comprehensive carbon capture programme is an unrealistic goal for the start of 2019, the ground work for implementing these changes should begin as soon as possible. New legislation, governmental and institutional pressures are enough to warrant the accurate measurement and presentation of data, but the fiscal benefits for oil and gas companies makes a case for itself.

The cost savings generated by cloud-based measurement and data capture are readily apparent. The value this data type offers in making a case to stakeholders for carbon capture implementation is significant. Devices employed in the measurement of gas flaring are also making the autonomous operation of facilities a more concrete reality.

Should the future of gas flaring be intrinsically tied to a carbon capture economy, the only way to plot a road map for the industry is through accurate measurement of emissions. As 2019 approaches, so too does the need for oil and gas companies to start building a picture of what the new carbon economy may look like.

More information

www.fluenta.com

COP24 Side Event: CCS as an enabler for effective climate action globally

Bellona, together with CCSA, the IEAGHG, the International CCS Knowledge Centre, and the University of Texas hosted an official side event on December 6th during the COP24 to discuss how CCS can help Poland and similar countries to decarbonize industry.

"To limit global warming, we need impressive changes and transformations of all sectors."

With these words, Thelma Krug, Vice Chair of the IPCC, began her remarks on the findings of the most recent IPCC Report on 1.5°C. The points she raised during the UNFCC Side Event at the COP24 in Katowice, Poland, culminated in the powerful message that CCS is crucial to retain a chance at meeting the well-below 2°C target, and naturally even more so for the 1.5°C.

Indeed, to achieve net-zero emissions in the energy intensive industry, CCS would be essential to complement other measures, such as efficiency, fuel switching, materials substitution and increased recycling.

Bellona, together with CCSA, the IEAGHG, the International CCS Knowledge Centre, and the University of Texas had hosted this official side event on December 6th during the COP24 to discuss how CCS can help Poland and similar countries to decarbonize industry. Following introductory remarks by Tim Dixon of the IEAGHG and Ms Krug, a large panel of experts from industry, civil society, and academia discussed varying motivations, approaches and experiences surrounding the CCS technology.

From visions how CCS can help a developing nation, such as Trinidad and Tobago, to the experiences of the planning and implementation of the world's first capture project in the cement industry in Norway, as well as the learnings from having already begun capturing CO2 from a coal power plant in Canada, the panel combined a breadth of knowledge that showcased the necessity, requirements and feasibility of CCS as a crucial climate action tool.

Ms Krug had stressed that CO2 capture in industry was more feasible than in coal plants or from biomass, as retrofitting CCS on existing industrial plants would leave industry sites relatively untouched. A point Manuela Ojan from HeidelbergCement (HC) supported, by presenting her company's capture project at Brevik, Norway, that by the mid-2020s will be capturing and storing about half a million tonnes of CO2 deep underneath the Norwegian seabed. At the same time, HC was investing millions into new technologies that could more than halve the CO2 capture costs, with the overall goal to create a net-zero cement industry by 2050.

"Carbon capture and storage learnings in one sector can be applied to other industries. Please come see CCS in practice at Boundary Dam" – Mike Monea, International CCS Knowledge Centre

Following up with his own CCS project, Mike Monea, from the International CCS Knowledge Centre, described how his experience of implementing a capture project had allowed him to improve the new generation technology significantly. A technology and expertise, he was now sharing with interested parties willing to finally begin cutting CO2 emissions from major point sources, for example, China.

As industry is not merely a major source of emissions but also a major provider of jobs and economic growth, Brian Kohler from the global industry unions association, IndustriALL, outlined why in the absence of a silver bullet solution, all climate mitigation technologies – including CCS – would need to be deployed to safeguard employment, wealth and development.

"The best and most just transition for workers requires making existing industries green" – Brian Kohler, IndustriALL

Bellona's own Jonas Helseth, Director of the Brussels office, linked several of the mentioned points of the panel, noting industry's growing vulnerabilities without adequate emission reduction options in a world where other sectors are already transitioning towards net-zero. He presented Bellona's vision of an open and shared CO2 network of transport hubs, pipelines and ships for northern Europe as an option to overcome the financial and infrastructural hurdles of CCS. Such a network would effectively become a public good to society, not unlike sewage systems. Its benefits would not only break the current inertia, but also allow industry to deeply decarbonise, provide society with low-carbon goods, and drive innovation globally.

Before the Rt. Hon Mark Field, Minister of State for HM Foreign and Commonwealth Office, held the final keynote speech, Prof. Andrew Jupiter of the University of the West Indies outlined in-depth how his country, Trinidad and Tobago, was already suffering severely from the effects of a changing climate, yet struggling to reduce emissions particularly in power generation and from the domestic chemical industry.

CCS was one of the key technologies that would allow a small nation in the south of the Caribbean to do its part in the global fight against global warming. The Rt. Hon Mark Field, in his closing remarks, consequently stressed the importance of international cooperation and mutual support.

He noted the first global CCUS summit was held in Edinburgh the week before and expressed his hope that the summit together with the COP would mark a turning point in the deployment of the CCS technology that will be essential to reach the world's climate ambitions.

More information

www.bellona.org

CATO event - progress for Dutch carbon capture

The Dutch are making big steps with industrial carbon capture and storage, we learned at a CATO forum in Utrecht, with a new project for the Port of Rotterdam taking CO2 offshore, another project capturing CO2 from steel, three pilot projects to gather CO2 from waste plants.

The Dutch are making big steps with industrial carbon capture, storage and utilisation, we learned at the CATO "Meet the Projects" event in Utrecht, Netherlands, on December 4.

Projects include the PORTHOS plan to build a CO2 transport hub in the Port of Rotterdam, projects to both reduce and capture CO2 at Tata Steel, and a project to build a gas to power with CCS system entirely offshore.

There are planned CO2 capture pilots at waste-to-energy plants run by companies AVR, HVC and Twence, research into inland shipping of liquid CO2, projects to build on existing CO2 sales to greenhouses for fertilising tomatoes and peppers. All three of these projects connect together.

Delegates heard about the latest developments in The Netherlands at the CATO event in Utrecht

CATO stands for "CO2 Afvang, Transport en Opslag", in English CO2 capture, transport and storage. CATO ran its own research projects from 2004 to 2014, and subsequently worked on CCS programs funded under other Dutch reseach schemes. It hopes to get a CATO-3 program running shortly.

PORTHOS – with timescale

The PORTHOS project is perhaps the most exciting development, to build a CO2 pipeline along the Port of Rotterdam connecting multiple CO2 emitters, and then take the CO2 to offshore storage.

The project now has a timescale, with concept selection during 2019, basic engineering by mid-2019, final investment decision in early 2020, detailed engineering in mid-2020, procurement and construction to start in late 2020, with commissioning mid-2023. The system is designed to carry 5,000 tonnes of CO2 per year.

The project is run by the Port of Rotterdam Authority; Gasunie, a Dutch natural gas infrastructure and transportation company; and EBN, a natural gas exploration and production company.

There are various decisions still to make, including the best location for the compressor station, the routing of the pipeline, and the transport and storage fee which will be charged to emitters. Two different storage fields are under consideration

PORTHOS could be considered a follow-up to the ROAD project, which planned to build a carbon capture plant and offshore storage around the Port of Rotterdam. The project was mothballed in 2014 due to funding constraints.

There will be a 36 inch pipeline running 33km along the port, then a compressor on the Maasvlaakte industrial complex at the coast, then an 18 inch offshore pipeline carrying higher pressure gas to offshore empty gas fields.

The pipeline pressure will be up to 35 bar onshore, then compressed to 85 to 120 bar for the offshore part. By the time the gas reaches the bottom of the well, the additional gravity force will increase the pressure to around 200 bar, where it is injected into the reservoir.

One of the main technical issues is flow assurance, making sure that the CO2 does not freeze and block the pipeline. This could happen if there is a sudden drop in pressure, because gas cools as it expands. For example if the pressure at the bottom of the well is much greater than the reservoir pressure, gas will expand quickly.

Further information is at https://rotterdamccus.nl/en/

Jacob Limbeek of OCAP, a system to collect CO2 from a Shell refinery and beer fermenting facility, and pipe it to greenhouses to speed up plant growth, said greenhouse operators would typically pay Eur 55 to 60 per tonne for CO2 acquired through combusting natural gas, so could pay an equivalent amount

There were some hints dropped about a similar scheme around the Port of Amsterdam called ATHOS, but no further details provided.

Tata Steel

Tata Steel is involved in two CO2 related research projects, “HIsarna,” to make the process of reducing iron ore to iron more efficient and CCS ready, and EVEREST to capture carbon from a standard steelmaking process and make it easier to convert the gaseous products of the blast furnace into useful products.

In a conventional steelmaking process, iron oxide (iron ore) is reacted with coke (containing carbon), to make iron, carbon dioxide and carbon monoxide. The carbon dioxide is vented to the atmosphere. This is why steelmaking has such high CO2 emissions.

The HISarna process sees iron ore reacted directly with oxygen in a cyclone converter furnace. This is more efficient, and means that the reaction product has a higher concentration of CO2, so needs less further separation before going to a CO2 storage facility.

The greater efficiency means that 20 per cent less CO2 is produced (with no carbon capture). The project aims to demonstrate a 35 per cent reduction.

The HIsarna project is run by ULCOS, “Ultra-Low CO2 Steelmaking”, a consortium of 48 European companies and organisations from 15 European countries. Around Eur 75m has been invested in reducing CO2 emissions from steelmaking over 10 years.

The environmental performance can be improved by using biomass for fuel, and adding scrap metal to the furnace.

A first “campaign” in 2011 showed the feasibility of the process, producing the first liquid metal. In 2013 it achieved its productivity target. Over 2015-17 there was a major upgrade to the pilot plant with Eur 25m invested. In 2017 it started an “endurance test”, and the plant is still running.

There are studies looking at whether the CO2 could be cleaned to become ‘food grade’ and so used for fizzy drinks, or if it could be used for enhanced oil recovery.

The group would like to build an industrial size demonstration plant, handling 0.5 to 1m tonnes of hot metal per year, but that would need Euro 300m to 350m investment, some of which would probably need to come from public sources, said Jan van der Stel of Tata Steel.

Steel with carbon capture

Tata is also involved in a project to trial carbon capture on steel making, and also see if the by-products from steelmaking can be used to make napthta and other useful chemicals.

The project is called EVEREST (“Enhancing Value by Emissions Re-use and Emissions Storage”). The main target is to reduce Tata’s CO2 emissions by 4m tonnes per year.

To make it possible to make naphtha, hydrogen would be added to the blast furnace, so the gases flowing out would be a mixture of hydrogen, carbon monoxide and carbon dioxide, or ‘syngas’, the ingredients for the Fischer Tropsch process to create naphtha, a liquid fuel.

This process could also make methanol, acetic acid, kerosene, ammonia or methane. For the overall environmental performance, it would be better if the chemicals were used to make products which are not ultimately combusted, so used for plastics rather than fuels, said Hans van Zutphen of Tata Steel.

For the conventional carbon capture plant, an amine solvent has been chosen. One challenge is that the plant should operate at a high pressure, around 16 bar, because the blast furnace (input gas) is at high pressure, and the destination (perhaps the forthcoming ‘ATHOS’ CO2 pipeline network) will also be at high pressure. It would be wasteful to depressurise the gas for carbon capture, only to have to compress it again for the pipeline.

Two big challenges are the flows of nitrogen and sulphur compounds in the blast furnace gas, and also the erratic gas flows out of the blast furnace, which could make it hard to connect it to a chemical process which requires a steady flow.

The time scale is to start basic engineering for the carbon capture plant in Q2 2019, open a pilot operation in Gent in Q2 2020, and a second pilot operation in IJmuiden Q4 2021. A separate pilot for the Fischer Tropsch project would start in Q2 2020, with proof of concept in Q3 2021 and basic engineering for the full scale project at the same time, leading to full commercial operation in Q2 2027.

The project partners in the Fischer Tropsch pilot plant are Dow Chemical, Arcelor Mittal, ISPT, University of Gent, ECN and Tata Steel.

CO2 for greenhouses

The Dutch are perhaps already a world leader in CO_2 utilisation, with the "OCAP" system to collect CO_2 from a Shell refinery and beer fermenting facility, and pipe it to greenhouses, to speed up plant growth. OCAP stands for 'Organic CO_2 for Assimilation by Plants'.

Jacob Limbeek of OCAP, the organisation which runs the pipeline, says that the Netherlands has the highest production of tomatoes, peppers and cucumbers per square kilometre in the world, with its highly optimised greenhouses.

OCAP is a joint venture by gas company Linde and construction company VolkerWessels. It carries around 400,000 tonnes of CO_2 per year, to over 580 greenhouses. Some deliveries are made by truck.

The greenhouse operators burn gas for heating in the winter, and the CO_2 from that is used as a fertiliser. So their main demand for CO_2 from external sources is during the summer. Without a CO_2 supply, they burn gas purely for its CO_2.

Greenhouse operators would typically pay Eur 55 to 60 per tonne for CO_2 acquired through combusting natural gas, so could pay an equivalent amount for CO_2 to be supplied to them, Mr Limbeek said.

The CO_2 in the pipeline from Shell's refinery is still counted as "emitted" under the Emission Trading Scheme, on the basis that the CO_2 will enter the environment eventually.

CO2 by barge

A research project is underway to explore transport of liquefied CO_2 to greenhouses by barge, since there are many greenhouses close to inland waterways, but not connected to the CO_2 pipeline.

Organisations involved in the research project are Linde Gas, RINA Netherlands, HVC Alkmaar, LTO Glaskracht, Noord BV, Noord-Holland Noord, and Shipco Consultancy.

One approach is to take a vessel for carrying coal (which is no longer needed, due to phasing out of coal power), and convert it to carry CO_2 by installing tanks. The CO_2 will probably be carried at 20 bars pressure and minus 50 degrees C.

Leen Schipper of Shipco said that many more greenhouse operators expressed interest in receiving CO_2 while the research was going on, so the target transportation volume increased from 30,000 tonnes a year to 870,000 tonnes.

One question is why companies don't use intermodal refrigerated tank containers for the CO_2, since there is already an infrastructure to transport them. Mr Schipper replied that the cost would probably be more expensive than using tanks.

Greenhouses typically have a storage tank capable of carrying 300 tonnes, and 250 tonnes can be delivered at once by vessel, thus filling a storage tank which is nearly empty but still with a little CO_2 in reserve.

CO2 from waste incineration

Three Dutch energy-from-waste companies, AVR, HVC and Twence, are looking for way that CO_2 can be captured from the waste combustion process, and then sold to greenhouses.

AVR has had a pilot project running with Dutch research organisation TNO since 2016, with a carbon capture plant connected to a waste incineration facility. The CO_2 is then sold to gases company Air Liquide.

The carbon capture plant includes a flue gas condensing column, an absorber (amine scrubber) and a stripper. The CO_2 will be cooled to a liquid by air cooled condensers, so it can be easily carried by truck, to customers across the Netherlands. There are and then 4 x 250 tonne CO_2 storage tanks.

Generic MEA solvent will be used, to maintain maximum flexibility in choice of supplier and minimise the number of variables.

Meanwhile energy from waste company HVC has three projects called Ambience, Ambition and Amazing.

The "Ambience" project ("Alkmaar biomass energy carbon capture use) and "Ambition" projects (Alkmaar Bio-Co2 Liquefaction for Greenhouses) run together.

It involves a CO_2 capture plant, built in November 2018, in the BEC Alkmaar waste incineration facility, planning to start operation in January 2019, with a measurement program running until November 2019. It will capture 0.5 tonnes per hour of CO_2 (4,000 tonnes per year).

The absorber and stripper has 12m high columns, and are placed in an existing building for equipment for cleaning flue gas. The CO_2 will be liquefied.

The "Amazing" project ("Alkmaar haalbaarheidsstudie grootschalige demo zuiver CO_2 afvang en vervloeiing") will build a larger scale CO_2 capture plant, producing 75,000 tonnes of liquid CO_2 annually. Currently it is at the feasibility study stage, but with a plan to complete in 2019.

Twence, a third waste processing company in Eastern Netherlands, is planning to build a CO_2 utilisation demonstration plant. The project schedule is for engineering in Q4 2018, procurement in Q1 2019, construction in Q2 2019, and testing the amine solvent in Q3 2019.

The idea is that it can lead to a large scale CO_2 utilisation plant in operation by the second quarter of 2021, said project engineer Andy Roeloffzen.

Reducing solvent degradation

The "Plant One" research project at TNO is looking for ways to reduce the rate of carbon capture amine solvent degradation.

The degradation of the solvent is linked to the amount of oxygen dissolved in the solvent. So by removing dissolved oxygen, the degradation rate can be reduced. Theoretically, no dissolved oxygen means no solvent degradation, said Juliana Monteiro, scientific researcher at TNO.

Higher levels of oxygen are linked to the formation of ammonia in the amine, and increased corrosivity, reduced effectiveness of the solvent and increased waste disposal.

Dutch government perspective

Joëlle Rekers, Senior Policy Advisor Energy with the Dutch Ministry of Economic Affairs, said that there has been a renewed interest in CCS in government over the past few months. The question under consideration is what role government should say in encouraging CCS to be taken forward.

In 2019, the Netherlands plans to spend Eur 10m on CCUS feasibility studies and pilots, she said.

Ms Rekers said that the government's focus is on carbon capture for industry, not carbon capture for electricity, because in the electricity sector renewables have more public support.

In power, "we see CCS as a temporary solution," she said. "It should not stand in the way of more sustainable solutions. She noted that "CCS is still a sensitive topic with NGOs and other partners."

Arnold Groot, Founder of Circular Energy, calculates that the cost of the project could work out at Eur 6 per tonne of CO2 stored, so within the current carbon price

BECCS

There was some discussion about BECCS ("Bioenergy with carbon capture and storage"), a topic of growing interest as a way to make fuel and remove CO2 from the atmosphere at the same time.

Tom Mikunda, Energy Policy Consultant, TNO, said that BECCS is sometimes talked about as an entirely different technology to CCS, when it is just CCS "with a different fuel". Perhaps some people are keen to differentiate them because they think BECCS is good and CCS is bad, he suggested.

Jon Gibbins, Centre Director of the UK Carbon Capture and Storage Research Centre said that coal plants could be used for burning biomass without any adaption at all. If we envisage a future with a great deal of BECCS, it would make sense to try to keep coal plants open rather than close them down, he said.

One of the biggest problems with biomass projects so far has been getting a large, reliable supply of it, he said.

Circular Energy

Circular Energy (www.circular-energy.nl) is a Dutch start-up company seeking to operate an offshore gas field, combusting the gas to make power offshore and separating CO2 from the flue gas for immediate sequestration.

Founder Arnold Groot, a former planning and economics practice lead at Shell, calculates that the cost of the project could work out at Eur 6 per tonne of CO2 stored, so within the current carbon price.

The project could run on a gas field which is too small to run economically otherwise (and so there is less competition to buy the license to operate it). The gas field would ideally be close to an offshore wind farm, so the power cable to take power to shore is already in place.

The project could then provide back-up to the wind power, only operating when there is a demand for power and the wind farm is unable to operate due to low wind (thereby utilising existing capacity in the power cable).

One challenge is that the CO2 would be injected into producing reservoirs, which would already be at higher pressure than a depleted gas field or aquifer. The CO2 would need to be compressed to around 200 bar for it to be injected into the reservoir

By replacing produced methane with injected CO2, the reservoir pressure could be kept high.

Building a carbon capture plant offshore would be more expensive and complex than building it onshore.

But on the other hand, there would be no need for a long CO2 pipeline to a sequestration site.

Also there would be advantages to an operator combusting its own gas – it would not need to process the gas to pipeline specification, and there could be taxation advantages, if the tax is calculated based on the gas sales price. In this case, the gas is not sold directly.

The placement of the wells would be critical, to try to avoid CO2 breakthrough to the production well.

Mr Groot calculates that the weight of the power plant and carbon capture facility would be around 6,000 tonnes, equivalent to the topsides on a typical central Central North Sea platform.

The size of the plant might be more of a challenge than the weight. He envisages using modularised equipment as far as possible to keep the costs down.

More information

Presentations from the event can be downloaded at:

http://bit.ly/CATO18

Projects and policy news

DNV GL research sees long-term expansion of hydrogen use for energy

dnvgl.com/hydrogenenergycarrier

Hydrogen can play a significant role in decarbonizing world energy supply to mitigate climate change, according to a new research paper by DNV GL.

Hydrogen as an energy carrier predicts demand for hydrogen for heating residential and commercial space, heat for industry, and transport to reach between 39 and 161 million tonnes of hydrogen per annum (Mtpa) in 2050, under various modelled scenarios. Currently, only about 1,000 tonnes of hydrogen production is for energy each year, mostly for hydrogen fuel-cell electric vehicles.

This estimated rising demand for hydrogen for energy comes after the UN Environment Emissions Gap Report revealed on November 27 that atmospheric levels of the greenhouse gas carbon dioxide rose for the first time in four years in 2017.

The UN Environment Programme warned that if the gap between target and actual emissions is not closed by 2030, it is extremely unlikely that the 2°C upper limit on warming agreed as a target by almost all the world's nations can still be reached.

Carbon capture and storage is important to hydrogen's role in decarbonizing energy because, however it is made, it must be low-carbon across its entire value chain. DNV GL's research paper suggests that policymakers need to consider the requirement for large-scale carbon capture and storage when incentivizing low-carbon hydrogen production for heating residential and commercial space.

The paper analyses prospects for two types of low-carbon hydrogen production. Blue hydrogen is produced from fossil fuels (by either steam methane reforming or coal gasification) with carbon capture and storage to reduce the carbon footprint. It will be used largely to heat buildings and for industrial processes. Green hydrogen is made using an electricity mix with low greenhouse gas emissions to power electrolysis of water. It will principally be used for mobility.

Hydrogen as an energy carrier forecasts that green hydrogen may achieve cost parity with blue hydrogen in around 2030 in some regions.

The paper asserts that green hydrogen can create value by harnessing surplus electricity from variable renewable energy sources such as wind and solar photovoltaic farms. It also proposes a viable business concept for producing transportable, blue hydrogen by reforming natural gas with carbon capture and storage on platforms more than 300 kilometres from shore.

DNV GL's research sees Australia, Canada, the Netherlands, the UK and the US as nations most likely to view hydrogen as an attractive option for decarbonizing the heating of residential and commercial buildings at significant scale.

“Natural gas currently provides a high proportion of the energy for such heating in these countries, and their existing gas infrastructure can be adapted to hydrogen distribution and storage. Importantly, they also have large-scale carbon capture and storage operations, or are beyond early stages of developing these,” explained the paper's lead author, Dr Jørg Aarnes, senior principal engineer, DNV GL - Group Technology & Research.

The research paper also expects hydrogen-fuelled heating to be established by 2050 among decarbonization measures in industries such as cement and aluminium. It sees no substantial hydrogen use for industrial process heating by 2030. The research points to more refuelling infrastructure and cheaper green hydrogen boosting uptake of hydrogen fuel-cell electric vehicles. It estimates that more than 80% of hydrogen demand for mobility in 2050 will be for buses, trucks and other heavy vehicles.

“This research paper reaffirms the exciting potential for hydrogen as an energy carrier. It could play a significant role in decarbonizing the gas that will be delivered to our homes and businesses, while transforming the carbon footprint of mobility,” said Liv A. Hovem, CEO, DNV GL - Oil & Gas.

“As our industry sharpens focus on decarbonization for the long-term supply of sustainable and affordable energy, DNV GL continues to work in close partnership with our clients to make hydrogen a safe and cost-effective contributor to the world energy mix,” she added.

EU Long Term Strategy highlights important role of CCS

europa.eu

www.zeroemissionsplatform.eu

The European Zero Emissions Technology & Innovation Platform (ZEP) has welcomed the publication of the EU Long Term Strategy for Greenhouse Gas Emissions Reduction.

The Strategy sets out a number of options to deliver long-term emissions reductions, including options to achieve the Paris Agreement goal of 1.5°C (net-zero emissions).

Commenting on the announcement, Dr. Graeme Sweeney, Chairman of ZEP, said, "We are delighted to see that the Commission has recognised the importance of CCS – a critical technology for delivering net-zero emissions across industry, heat and power. Indeed, all scenarios in the Strategy include CCS, and those that achieve the Paris Agreement 1.5°C goal, rely heavily on CCS – in particular to enable deep decarbonisation across industry and to unlock negative emissions.”

“This is consistent with the recent IPCC report on delivering 1.5°C, which concludes that industry will be unable to achieve the Paris Agreement goal without CCS."

"Whilst today's Strategy and ambition are a welcome and important step towards meeting Europe's contribution to the Paris Agreement, it is now vital that this ambition is translated into reality – particularly as we transition to a new Commission next year."

"To enable CCS to fulfil its role in delivering this long-term Strategy, action must begin now. Support mechanisms such as the Innovation Fund, Connecting Europe Facility and InvestEU programme, will all be critical for delivering the first EU CCS clusters.”

“It is therefore extremely important that these mechanisms are consistent and appropriately designed to support CCS, particularly to enable the development of CO2 transport and storage infrastructure, which will provide the backbone for low-carbon industrial hubs across Europe”.

Cost of capturing CO2 drops 67% for next gen carbon capture plant

The International CCS Knowledge Centre report shows a deep capital cost reductions of 67% per tonne of captured CO2.

The study showed that compared to the Boundary Dam 3 CCS project (BD3), a CCS system at Shand could see capture capital cost reductions of 67% per tonne of CO2 captured as well as 92% in potential savings to power plant integration capital cost.

Based on the model, the levelized cost of captured CO2 is calculated at $45US/tonne.

The Shand CCS Feasibility Study is based on an independent study of the construction and design of SaskPower's Boundary Dam 3 CCS project. In addition to cost reductions, key outcomes of the Shand CCS Feasibility Study include:

• A design that ensures improved responsiveness to fluctuating customer demand for power, which is increasingly necessary in power systems that exhibit increasing levels of variable renewable energy such as wind and solar;

• A design that minimizes water requirements; and

• A meaningful reduction in process complexity, allowing efficiency gains to be maximized.

"This innovative study destroys the myth, once and for all, that Carbon Capture Utilization and Storage in the power sector is not a cost-effective mitigation option. The study clearly demonstrates that CCUS on coal can be competitive with natural gas even with the very low gas prices in North America." said John Gale, General Manager, IEAGHG.

An illustrated rendering of the Shand Power Station with appended carbon capture facility

Key Technical Findings

Shand Power Station is a single unit plant located 12 km from Boundary Dam. With a gross output of 305 MW, Shand's current capacity is approximately twice that of BD3. Shand was originally designed with provisions for a second unit that was never built, and therefore has the space to house a carbon capture facility. Commissioned in 1992, Shand is also SaskPower's newest coal-fired power plant and is thought to be the best candidate for a CCS retrofit if SaskPower were to consider another CCS Project.

The larger Shand CCS facility would also offer lower operating costs compared with BD3. The anticipated cost of capture from the Shand CCS Facility would be $45US/tonne of CO2, assuming a 30-year sustained runtime of the power plant and purchasing of lost power at costs consistent with new Natural Gas Combined Cycle (NGCC) power projects.

The requirement for power generation flexibility, to accommodate variable renewables, was coupled with the ability to maintain the capture facility capacity such that the CCS plant increases its capture rate when the load is reduced. While 90% CO2 capture is expected at a full power plant load, more than 96% CO2 capture could be achievable at 62% electrical load.

Water supply at Shand is limited and additional water draw for the capture facility would be a regulatory hurdle, if possible at all. As a result, the system was designed without the requirement for additional water. The proposed heat-rejection design would eliminate this burden by only requiring the use of water that has been condensed from the flue gas.

The BD3 design was optimized to run at full load of its power unit. The Shand capture facility would overcome this limitation through a design that could follow the normal power output variation that has been historically required from Shand.

Potential project risks for increased operating costs and barriers to project approval have been mitigated. Proactive measures to evaluate amine maintenance costs, which are of most concern for effective management of ongoing operating costs, would be realized by executing pilot testing at SaskPower's Carbon Capture Test Facility (CCTF).

More information

www.ccsknowledge.com

Microcapsule technology for post-combustion carbon capture

Research led by the University of Pittsburgh and Lawrence Livermore National Laboratory (LLNL) uses microcapsule technology that may make post-combustion carbon capture cheaper, safer, and more efficient.

"Our approach is very different than the traditional method of capturing carbon dioxide at a power plant," said Katherine Hornbostel, assistant professor of mechanical engineering at Pitt's Swanson School of Engineering. "Instead of flowing a chemical solvent down a tower (like water down a waterfall), we are putting the solvent into tiny microcapsules."

Similar to containing liquid medicine in a pill, microencapsulation is a process in which liquids are surrounded by a solid coating.

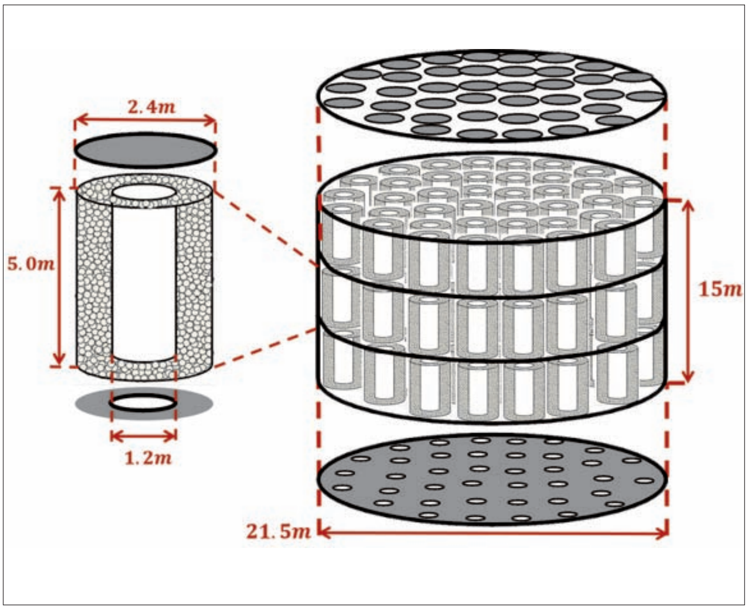
"In our proposed design of a carbon capture reactor, we pack a bunch of microcapsules into a container and flow the power plant exhaust gas through that," said Hornbostel.

"The heat required for conventional reactors is high, which translates to higher plant operating costs. Our design will be a smaller structure and require less electricity to operate, thereby lowering costs."

Conventional designs also use a harsh amine solvent that is expensive and can be dangerous to the environment. The microcapsule design created by Hornbostel and her collaborators at LLNL uses a solution that is made from a common household item.

"We're using baking soda dissolved in water as our solvent," said Hornbostel.

It's cheaper, better for the environment, and more abundant than conventional solvents. Cost and abundance are critical factors when you're talking about 20 or more meter-wide reactors installed at hundreds of power plants."



Proposed design of a carbon capture reactor filled with baking soda capsules for a 500 MW coal power plant. Power plant exhaust is sent to hundreds of cylinders packed together (shown on right). Each cylinder (shown on left) is a hollow cylinder that lets exhaust gas flow through the core, then out through a packed bed of capsules

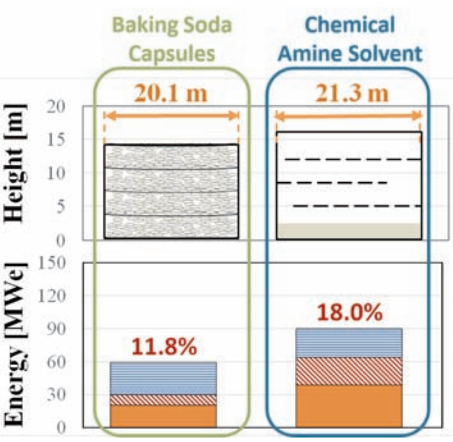
Hornbostel explained that the small size of the microcapsule gives the solvent a large surface area for a given volume. This high surface area makes the solvent absorb carbon dioxide faster, which means that slower absorbing solvents can be used.

"This is good news," says Hornbostel, "because it gives cheaper solvents like baking soda solution a fighting chance to compete with more expensive and corrosive solvents."

Hornbostel detailed her model in a recent paper in Applied Energy, "Packed and fluidized bed absorber modeling for carbon capture with micro-encapsulated sodium carbonate solution".

"Our proposed microcapsule technology and design are promising for post-combustion carbon capture because they help make slow-reacting solvents more efficient," said Hornbostel.

"We believe that the decreased solvent cost combined with a smaller structure and lower operating cost may help coal and natural gas power plants maintain profits long-term without harming the environment."



Model results for carbon capture system for a 500 MW coal power plant. The sizes (top row) and energy penalty (bottom row) are compared between the baking soda capsule design (left) and the traditional amine solvent design (right). The baking soda capsule reactor is smaller and requires a lot less energy than the traditional reactor design

More information

www.engineering.pitt.edu
10.1016/j.apenergy.2018.11.027

Harvard scientist develops process to convert CO2 into industrial fuels

Rowland Institute Fellow Haotian Wang and colleagues have developed an improved system to use renewable electricity to reduce carbon dioxide into carbon monoxide (CO) — a key commodity used in a number of industrial processes.

"The most promising idea may be to connect these devices with coal-fired power plants or other industry that produces a lot of CO2," Wang said. "About 20 percent of those gases are CO2, so if you can pump them into this cell … and combine it with clean electricity, then we can potentially produce useful chemicals out of these wastes in a sustainable way, and even close part of that CO2 cycle."

The new system, Wang said, represents a dramatic step forward from the one he and colleagues first described in a 2017 paper in Chem.

The old system was barely the size of a cellphone and relied on two electrolyte-filled chambers, each of which held an electrode. The new system is cheaper and relies on high concentrations of CO2 gas and water vapor to operate more efficiently. Just one 10-by-10-centimeter cell can produce as much as four liters of CO per hour, said Wang.

The new system addresses the two main challenges — cost and scalability — that were seen as limiting the initial approach, he said.

"In that earlier work, we had discovered the single nickel atom catalysts which are very selective for reducing CO2 to CO … but one of the challenges we faced was that the materials were expensive to synthesize," Wang said. "The support we were using to anchor single nickel atoms was based on graphene, which made it very difficult to scale up if you wanted to produce it at gram or even kilogram scale for practical use in the future."

To address that problem, he said, his team turned to a commercial product that's thousands of times cheaper than graphene as an alternative support — carbon black.

Using a process similar to electrostatic attraction, Wang and colleagues are able to absorb single nickel atoms (positively charged) into defects (negatively charged) in carbon black nanoparticles, with the resulting material being both low-cost and highly selective for CO2 reduction.

"Right now, the best we can produce is grams, but previously we could only produce milligrams per batch," Wang said. "But this is only limited by the synthesis equipment we have; if you had a larger tank, you could make kilograms or even tons of this catalyst."

The other challenge Wang and colleagues had to overcome was tied to the fact that the original system only worked in a liquid solution.

The initial system worked by using an electrode in one chamber to split water molecules into oxygen and protons. As the oxygen bubbled away, protons conducted through the liquid solution would move into the second chamber, where — with the help of the nickel catalyst — they would bind with CO2 and break the molecule apart, leaving CO and water. That water could then be fed back into the first chamber, where it would again be split, and the process would start again.

"The problem was that the CO2 we can reduce in that system are only those dissolved in water; most of the molecules surrounding the catalyst were water," he said. "There was only a trace amount of CO2, so it was pretty inefficient."

While it may be tempting to simply increase the voltage applied on the catalyst to increase the reaction rate, that can have the unintended consequence of splitting water, not reducing CO2, Wang said.

"If you deplete the CO2 that's close to the electrode, other molecules have to diffuse to the electrode, and that takes time," Wang said. "But if you're increasing the voltage, it's more likely that the surrounding water will take that opportunity to react and split into hydrogen and oxygen."

The solution proved to be relatively simple — to avoid splitting water, the team took the catalyst out of solution.

"We replace that liquid water with water vapor, and feed in high-concentration CO2 gas," he said. "So if the old system was more than 99 percent water and less than 1 percent CO2, now we can completely reverse that, and pump 97 percent CO2 gas and only 3 percent water vapor into this system. Before those, liquid water also functioned as ion conductors in the system, and now we use ion exchange membranes instead to help ions move around without liquid water.

"The impact is that we can deliver an order of magnitude higher current density," he continued. "Previously, we were operating at about 10 milliamps-per-centimeter squared, but today we can easily ramp up to 100 milliamps."

Going forward, Wang said, the system still has challenges to overcome — particularly related to stability.

"If you want to use this to make an economic or environmental impact, it needs to have a continuous operation of thousands of hours," he said. "Right now, we can do this for tens of hours, so there's still a big gap, but I believe those problems can be addressed with more detailed analysis of both the CO2reduction catalyst and the water oxidation catalyst."

Ultimately, Wang said, the day may come when industry will be able to capture the CO2 that is now released into the atmosphere and transform it into useful products.

"Carbon monoxide is not a particularly high-value chemical product," Wang said. "To explore more possibilities, my group has also developed several copper-based catalysts that can further reduce CO2 into products that are much more valuable."

More information

www2.rowland.harvard.edu

Capture and utilisation news

Direct electrocatalytic reduction of carbon dioxide from low concentration sources

www.titech.ac.jp

Tokyo Institute of Technology has developed a method that is capable of reducing low-concentration carbon dioxide (even 1 percent) with high selectivity and durability.

It is a new potential technology which could enable direct utilization of CO_2 in exhaust gases from heavy industries.

A study led by Osamu Ishitani of the Department of Chemistry, Tokyo Tech now demonstrates the advantages of applying electrocatalysis to capture low-concentration CO_2.

In their study published in Chemical Science, Ishitani and colleagues including Hiromu Kumagai and Tetsuya Nishikawa drew on decades of work on honing the capabilities of a rhenium-based catalyst, and demonstrated its ability to reduce low-concentration CO_2 in the presence of a chemical called triethanolamine (TEOA).

Compared to many previous studies that have focused on reducing pure CO_2, few have explored how to improve direct capture of low-concentration CO_2 -- a topic that warrants further investigation, considering that plants harness low concentrations of CO_2 (about 400 ppm, that is 0.04% of the atmosphere) and exhaust gases from heavy industries typically contain low levels of CO_2 (around 3-13%).

By avoiding the need for additional energy-consuming condensation processes, their strategy, if scaled up, could provide a more viable, environmentally friendly solution to CO_2 capture in many settings.

In a series of experiments to assess electrocatalytic activity, the researchers found that at a CO_2 concentration of 1%, the rhenium-based catalyst showed very high selectivity (94%) towards carbon monoxide (CO) formation.

A likely reason behind the high performance, the researchers say, is the efficient insertion of CO_2 into the rhenium-oxygen bond.

West Virginia University to capture CO2, sell baking soda

www.wvu.edu

Research at West Virginia University will focus on turning carbon dioxide in power plant flue gas into commercial-quality sodium bicarbonate, aiming to use product sales to lower the cost of carbon capture technology.

Current techniques can increase the cost of the cleanest coal-fired ultrasupercritical power plants by more than 50 percent, according to data in the annual technology baseline report by the National Renewable Energy Laboratory.

The $1 million project is being funded by the U.S. Department of Energy Office of Fossil Energy through the National Energy Technology Laboratory. The collaborators are providing 20 percent matching funding.

WVU Orthopaedics professor Bingyun Li, a nanomaterials science expert and the project's leader, will conduct laboratory experiments to test the effects of other gases in power plant flue gas on the process. Along with carbon dioxide, emitted flue gas contains mostly nitrogen, water vapor, and oxygen plus, if controlled, trace pollutants such as sulfur dioxide and nitrogen oxides.

Chemical engineering professor Badie Morsi of the University of Pittsburgh will develop a commercial-scale system based on the process while WVU Davis College of Agriculture, Natural Resources and Design professor Jingxin Wang will evaluate the process' costs. Longview Power, LLC, who operates one of the country's cleanest coal-fired power plant located in Maidsville, will help create a technology-to-market strategy.

Li's preliminary studies revealed two amino acids, glycine (Gly) and alanine (Ala), with the ability to capture and convert carbon dioxide into bicarbonate nanofibers or 'flowers' of nanowires.

Because amino acids are the building blocks of proteins in living things, the process is safe for the environment. The patent-pending process works faster and absorbs three times more carbon dioxide than the current leading post-combustion carbon capture technology, he said.

"Dr. Li's unique innovation has the potential to overcome the very high equipment costs of current carbon capture and storage technologies. Having a particularly well-run power plant nearby with strong management interested in working with us is important for gaining the design and installation knowledge needed for commercialization," said WVU Energy Institute Interim Director James Wood.

"This is an excellent example of a university's ability to foster cross-cutting research and an example of why WVU is an R1 ranked research institution."

"The release of carbon dioxide from power plants impacts our daily life and also the coal industry. We are very happy to lend our expertise in nanotechnology to solve an important environmental and energy problem, and we are fortunate to be able to support the coal industry in our state and worldwide," Li said. "We may also explore some new markets for the nano-baking soda we convert from the carbon dioxide."

Sodium bicarbonate is a 5.7-million-tons-per-year market and growing. Global Market Insights predicts that the market will be worth $9 billion by 2024. The chemical is used in everything from baked goods to cleaning products to pharmaceuticals. The unusual shape of the nano- particles produced by WVU's patented process opens the possibility for new applications such as the manufacture of encapsulated drugs.

Li observed that solvents produced a never-before-reported clear separation of a CO_2-lean phase and a CO_2-rich phase, making it easier to separate the baking soda particles from the solvent and recycle the solvent to capture more carbon dioxide and make more particles.

The CO_2-rich phase contained 73.5 weight percent sodium bicarbonate, nearly the same as the Solvay process, the current commercial method for making baking soda. Researchers are targeting making a 99.8 percent pure product with the WVU process.

"The WVU technology is simple, with the potential to generate a useful byproduct right at the power plant site," Li said. "The system that can be retrofitted into existing power plants and added to new power plants."

Transport and storage news

ETI report on brine production and its Impact on UK CO2 storage

www.eti.co.uk

The report concludes the savings to the UK from deploying brine production as part of a UK CCS rollout would be at least £2 billion.

The Energy Technoligies Institute report looks at how brine production could help to develop the capacity to deploy CCUS at commercial scale.

Based on the analysis summarised in this report the savings to the UK from deploying brine production as part of a UK CCS rollout implementation strategy in line with that needed to deliver lowest-cost decarbonisation pathways would be at least £2 billion, but would most likely be more.

This cost benefit is derived from a combination of in-store cost reduction from economies of scale by enabling significantly increased storage capacity to reduce unit storage costs (in one example studied this was worth £1 billion over the life of the store - a 33% reduction); and enhancing the capacity of cheaper stores, thereby obviating the need to appraise and develop more expensive stores (for the limited examples studied this was valued at another £1 billion).

UK Oil and Gas Authority awards first CCS license to Acorn project

www.ogauthority.co.uk

The award has been made to Pale Blue Dot Energy (Acorn) Ltd (PBD) for the Acorn Carbon Capture and Storage Project.

PBD has been awarded an 'Initial Term' CO2 Storage Licence for a four year period. The licence grants authorisation for offshore exploration for the purposes of selecting a site for CO2 storage. Under the terms of the licence, the company would need to submit and be awarded a Storage Permit before CO2 injection could begin. The Storage Permit also sets out the requirements that the Developer must follow during operations.

The project seeks to re-use existing oil and gas infrastructure for transporting and storing carbon; and to repurpose or rebuild an existing CO2 capture facility based at the St Fergus Gas Terminal.

Dr Andy Samuel, Chief Executive of the OGA said: "We welcome the government's recently-announced Action Plan to develop the UK's first carbon capture, usage and storage projects and are continuing our close working with the government and others to identify existing UKCS infrastructure which could be re-used. We are also looking closely where else we can play a role, including the role of gas as a transition fuel; reducing emissions in flaring and venting; considering CO2 opportunities for EOR; and where suitable bringing attention to energy integration with renewables, including gas-to-wire.

The SCCS partnership welcomed the news, which follows Crown Estate Scotland last week issuing its first ever CO2 lease option to Acorn, underlining the requirement for carbon capture, utilisation and storage (CCUS) projects to secure a number of permissions and consents before they can access a CO2 storage site.

Prof Stuart Haszeldine, SCCS Director, said, "The recent announcement from OGA heralds a new future for the North Sea. The Acorn site could launch a new multi-billion offshore industry, which progressively and systematically takes the place of oil and gas extraction as fields end production from now to the 2030s. By unlocking access for re-use of existing oil and gas infrastructure, this allows the first CO2 storage projects to reduce capital costs by 20-50%."

"We are now witnessing a resurgence in optimism for the CO2 storage industry and this comes coupled to the announcement from Crown Estate Scotland last week of their first lease option for the Acorn project to use porespace offshore Scotland for long-term CO2 storage. There is now a need for the UK Government to maintain the momentum boosted by last week's international summit on accelerating CCUS to support rapidly emerging CCUS projects around the UK."

Scientists identify new minerals for carbon capture

www.ualberta.ca

Geologists at the University of Alberta show hydrotalcites are capable of carbon sequestration beneath the surface of mine tailings.

Research confirms new minerals are capturing and storing carbon in a new paper by University of Alberta geologists and their collaborators. The minerals, members of the hydrotalcite group, are the first outside of the carbonate family to naturally capture atmospheric CO2 in mine waste, important as society continues to forge ways to lower our carbon emissions and combat climate change.

"This research confirmed that hydrotalcites are capable of sequestering atmospheric CO2 in mine waste," said Connor Turvey, who conducted this research during his PhD studies under the supervision of Sasha Wilson. "Hydrotalcites are trapping the CO2 deeper into the tailings where carbonate minerals were unable to form."

Mine tailings are composed of the waste minerals removed from the ground in the mining process. As these minerals are exposed to the atmosphere and to rain water, they can react to form new minerals that trap CO2 from the atmosphere.

The research highlights the potential for improving carbon capture one to two metres beneath the surface of mining wastes, where most sequestration usually occurs. "One thing that this indicates is that the capacity for carbon sequestration at this depth could be improved by providing a more plentiful source of carbon to those depths," added Wilson, associate professor in the Department of Earth and Atmospheric Sciences and expert in economic geology.

The study was conducted at Woodsreef Asbestos Mine in New South Wales, Australia. Carbon capture, utilization, and storage in minerals is of growing importance for both academia and industry. This discovery points to the potential to use mineral waste from mines to sequester carbon more effectively, supporting remediation efforts.

"Merely going carbon neutral is no longer going to be enough to prevent climate change from occurring," said Turvey. "What is now needed is for our world to become carbon negative."

This means that industry must both reduce carbon emissions while simultaneously exploring carbon sequestration to actively draw excess CO2 from the atmosphere—making discoveries like this one more important than ever.


MAN
Economy or ecology? We have the energy for both.
MAN Energy Solutions
Future in the making
We are investing all of our energy into creating solutions for sustainable prosperity. That's why we have changed our name from MAN Diesel & Turbo to MAN Energy Solutions.
Step by step, we advance marine, power, and industry solutions. This is future in the making. For customers, stakeholders, and society.
www.man-es.com