CCS

New technology options broaden the scope for carbon capture and storage

How is the global development of carbon capture and storage proceeding? That partly depends on who you ask, writes *Mark Rowe*. Yet several promising new approaches are emerging and there are signs that investors are beginning to trust the technology.

Could CCS prolong the use of fossil fuel-fired power stations, such as this unit in Ashkelon, Israel?

Photo: MinoZig

A technology entwined with fossil fuels that, by the of 2018, boasted 43 large-scale facilities, (18 in commercial operation, five in construction and 20 in development), and which processed almost 40mn t/y of carbon dioxide, is clearly more than a passing fad. Yet proponents of carbon capture and storage (CCS) have asserted for more than 20 years that the technology holds the key to meeting the world's carbon emissions reduction targets. This claim, however, has far from been demonstrated.

In total, 230mn tonnes of carbon dioxide have been injected underground through CCS systems. The world's largest coal-fired power plant with carbon capture technology is Petra Nova, in Houston, US, and it captures about 1.4mn tonnes of carbon dioxide each year.

China has more than 20 CCS facilities at different scales of progressive development and planning. In Saudi Arabia and the United Arab Emirates (UAE), CCS is being embraced by a number of industrial facilities, and in the Netherlands, Norway and the UK, CCS 'hub and cluster' developments are progressing.

A small fraction

Yet the other way of looking at this data is to point out that 40mn t/y represents barely 0.1% of global carbon dioxide emissions.

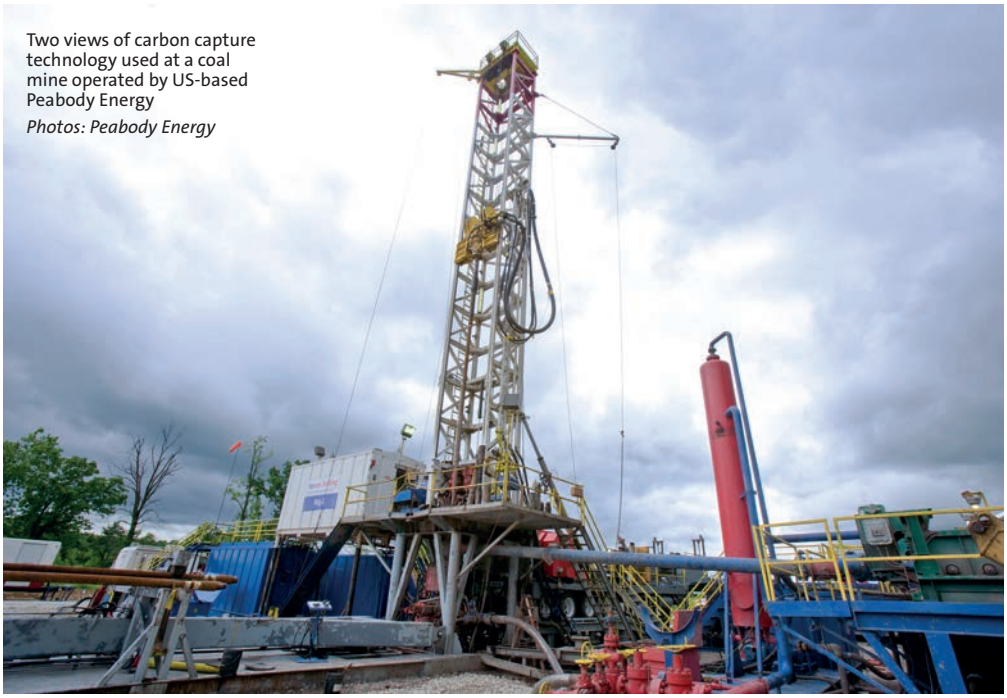
John Scowcroft, Executive Adviser at the Global CCS Institute, is encouraged by the United Nations Framework Convention on Climate Change talks in Katowice, Poland, at the end of 2018. 'The IPCC reports conclude you cannot economically meet the targets without CCS,' he said. 'In Katowice, CCS was not being discussed in the negotiating room but it was there in the side events held by the EU, China and the UK.'

The Paris Agreement was 'a game changer for CCS', noted Luke Warren, Chief Executive of the UK's Carbon Capture and Storage Association (CCSA). 'Until then, carbon targets were always 15 years ahead and involved efficiency and reduction. Paris is about net zero emissions – that is a fundamentally different challenge. CCS keeps cropping up.'

Others believe there are two sides to the coin. 'If you look at all global climate models, CCS is always part of the solution,' said Justin Ong, Carbon Capture Policy Lead for ClearPath, a Washington DC-based organisation that advocates for clean energy. 'But there's a bunch of reasons why carbon capture has not got the same attention as other carbon-reducing technologies such as solar, wind and LED lighting.'

The financial community is less familiar with how to finance CCS projects – many of which are located in different regions, said Ong, so must be tailored to the type of source of carbon dioxide emissions they are taking up. 'It's hard for financial organisations to say it's the same [drop-in] technology they would back when it comes to solar or wind.'

Yet it now seems that the potential for developments, which in turn may yield new business models, is offering hope for



Two views of carbon capture technology used at a coal mine operated by US-based Peabody Energy

Photos: Peabody Energy

advocates of CCS: 'We are starting to see support for CCS come online and trickle through,' said Ong.

Opportunities in the US

In the US, a tax credit – called '45Q' was enacted in 2018, thanks, perhaps unexpectedly, to a budget bill signed by President Donald Trump. Though his agenda was to support fossil fuels and the nuclear industry rather than the potential side-effect of cutting emissions through CCS.

This performance-based tax credit is available to power plants and industrial facilities that capture and store carbon dioxide that would otherwise be emitted into the atmosphere. To receive the credit, the carbon dioxide must be stored geologically or be utilised as a feedstock or component of products.

The move is significant, said Ong, but is also another example of a hurdle not faced by most other carbon emissions reduction technologies. 'You have to verify that the carbon dioxide will stay in the ground, which is a pretty reasonable requirement, but it does add more challenges. It's very likely the carbon dioxide will not leak but it's difficult for scientists to say with 100% certainty that this would be the case.'

A key development is the newer concept of Carbon Capture, Utilisation and Storage (CCUS), whereby the carbon dioxide recovered is re-used rather than merely stored. 'CCUS is definitely needed, it's a business opportunity that can supplement other activities,' said Ong, who cautions this will not of itself be a panacea.

Ong cites the potential for using CCUS to make bricks from locally captured carbon. 'The problem is that there is not a market for making bricks. If you have a coal plant responsible for 90% of local emissions, CCUS for bricks might take out 10% of those.'

However, Ong describes as 'transformational' the potential for NET Power's demonstration combustion power plant at La Porte, Texas, which processes and produces pure and compressed carbon dioxide. A collaboration between Exelon Generation, McDermott, and 8 Rivers Capital and Oxy Low Carbon Ventures (the latter subject to regulatory approval), the company's 50 MW plant operates an oxy-fuel, supercritical carbon dioxide power cycle.

This produces electricity efficiently while eliminating air emissions. The system burns natural gas with oxygen, as opposed to air. Instead of using steam, the cycle uses high-pressure carbon dioxide as a working fluid to turn a combustion turbine.

NET Power says it intends to begin constructing 300 MW class commercial-scale plants by 2021. 'This would drastically reduce the costs of carbon capture and make it competitive with costs of a gas plant,' said Ong, noting this would help with getting the supply chain and financial institutions more comfortable with funding.

Direct capture in Europe

Another area of development is a process known as Direct Air Capture (DAC), whereby carbon dioxide is removed directly from the atmosphere through capture technologies that bind or stick removable substances to carbon dioxide. DAC is operated successfully by Zurich-based Climeworks, which uses filters to capture carbon dioxide emitted from a waste incinerator near the city.

Filters on the roof of the waste plant are aided by fans to suck in ambient air. The air with reduced carbon dioxide content is blown out again, while the filters are saturated with carbon dioxide within a few hours. The saturated filter is heated to about 100°C by using waste heat from the plant. The high purity carbon dioxide is isolated and transferred to industrial greenhouses via gas pipelines, where it is used as fertiliser.

Ong describes a combination of amine and membrane technology as: 'the next phase' of such technologies: 'Currently, amine sees you spray and latch onto the carbon dioxide and filter it out at a later stage. With membrane technology added to that you have surfaces that allow the carbon dioxide to pass through.'

Ong sees DAC having longevity, partly because he feels the wider public will buy into the idea, which will encourage investors who are wary of being accused of supporting a technology that perpetuates the use of fossil fuels. 'It's taking carbon dioxide direct from the air and it's on a modular scale that is similar to wind and solar technology. It can be financed on a smaller scale.' Ong believes that DAC can bring costs of CCS down by between 50% and 80%.

When it comes to the prospects for DAC, long-sightedness is another virtue, according to Scowcroft, who cites the experience of the costs of solar. 'The cost of DAC is put at about €330 of carbon per tonne – look at the cost of solar 30 years ago and the costs were similar. The costs will come down – and companies

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will take the view that they have to decarbonise and use the technology at some point. That's why prices dropped for renewables.'

BECCS, CV2 to the fore

Another option is 'Bioenergy with CCS' (BECCS), whereby carbon dioxide emissions are removed from the atmosphere through the application of CCS to the transformation of trees and crops into energy fuels. This is then applied to ethanol plants and to carbon dioxide storage in enhanced oil recovery (EOR).

At its factory in Illinois, US, the giant agribusiness Archer Daniels Midland captures emissions from its ethanol plant and traps them in the layer of sandstone that lies beneath the Illinois corn belt; in addition, the process captures carbon dioxide from the atmosphere at the same time as it captures emissions released by fermenting corn. This, says Scowcroft, makes the process 'carbon negative'. However, he argues there are still environmental challenges with BECCS around competing for land resources and wood.

This means that Scowcroft is also wary of another development, C2V, or 'Carbon to Value'. In this process, carbon dioxide is used to manufacture new products, including fertiliser feedstock (for instance SABIC, in Saudi Arabia), soda ash (Carbon Clean Solutions, in India), foams used in mattresses and upholstered furniture (Covestro in Germany) and bricks and cement (Australia's Mineral Carbonation International).

In the SABIC programme, carbon dioxide is captured and purified from an existing ethylene glycol production facility located in Jubail, on the Gulf. It is subsequently transported via pipeline, for utilisation, mainly as a feedstock for production of methanol, urea, oxy-alcohols, and polycarbonates.

Scowcroft is wary of a technology that effectively offsets the pumping of carbon dioxide into the atmosphere. 'If carbon goes back into the atmosphere then we are not solving anything,' he claimed. 'We have to address the permanent removal of carbon.'

Others in the industry are wary of CCUS and innovative technologies that may come under its umbrella. Warren believes that DAC may play a small part in CCS's future but that the key focus must be on storing carbon, rather than recycling it: to be carbon negative rather than carbon neutral. 'The caveat [with DAC] is that we need to be storing millions of tonnes of carbon. These technologies are not scalable to the extent that is required.'

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When it comes to performance loss, new technologies may not even be necessary in order to strengthen the case for CCS, argues Scowcroft. Only two of the world's major 18 CCS projects are at power stations. The rest are places where it is fairly easy to capture or remove the carbon dioxide, he noted.

He cited the example of SaskPower's Boundary Dam 160 MW CCS project, in Saskatchewan, Canada, which uses CCS to cap emissions from cheap coal reserves nearby. Energy losses were put at 30% when it opened in 2014. 'They worked out they could make significant savings just from what they learnt about engineering. The more you build, the more you learn. Boundary Dam was a first of its kind, they now recognise they over-engineered,' said Scowcroft.

Clusters of polluting industries

In Europe, efficiencies can more easily be made by taking advantage of the clusters of polluting industries. Scowcroft noted areas such as Teesside, Merseyside, Antwerp and Rotterdam – ports where all industries that are emitting are close together, where a transmission system for carbon dioxide could be designed that all these emitters can lock into: 'From an economic view it makes much more sense if you share the costs of the pipeline, though there are issues about who is going to operate it.'

Such diversification will boost CCS projects more widely, argued Ong, who believes CCS plants will be able to facilitate more than one conversion technology. He predicts CCS will offer integration. Most carbon capture is used for EOR projects, but they could also offer power generation and gain tax credits in addition. One of those values on its own will not move the project forward: 'but if you combine them in some way it changes the picture'.

A similar pooling approach may evolve to help cut costs when it comes to storing the captured carbon, said Warren. The technology for storing carbon is pretty well established, he noted, given the oil and gas sector in the US has been injecting it into the ground for 40 years. Warren forecasts carbon being piped – or freighted by ship – to storage points: 'Sustainable geology [for storage] isn't distributed equally around the world. We're only starting to look at how we move carbon dioxide between countries.'

Predictability and long-term risks

Scowcroft concluded that the case for business funding of CCS is now strong, with a lack of money now not a problem: 'It is more a question of policy predictability and power risks allocation and how you make risks across the chain manageable. When you have people doing the capturing and others the storage and operating the infrastructure, the question is of apportioning the risks.'

These are very small but come with great consequences if something goes wrong – as with the nuclear industry, who is going to bear the risks?

According to Warren, this goes to the heart of the lessons learnt from the UK's abandoned CCS pilot projects, such as the Shell-SSE scheme in Aberdeenshire, Scotland, which was projected to capture 10–15mn tonnes of carbon dioxide over 15 years. 'You need to develop a deep partnership between government and industry and it needs to be sustained over a deep period of time,' he explained.

Projects take eight years or so to come into operation and that cuts across electoral cycles: 'Industry needs to know government won't change its mind.'

One problem, said Scowcroft, is the long-term nature of storage. 'You may pay a certain amount per tonne of carbon under the EU's Emissions Trading scheme – but will there even be a trading scheme in 50 years' time? Up to a certain point it may be the insurer but after that will governments step in as the insurer of last resort? That may have to be the case.' ●