carbon capture journal

July / Aug 2012 Issue 28

CCS in Australia

CO2CRC research highlights including Otway project and new capture pilot plant

CarbonNet project: investigating CCS in Victoria

C-Capture: developing safe non-amine solvents

UK and Norway: working together to achieve the promise of CCS

Induced seismic activity from CO2 storage - the debate

CCS with biomass - the way forward for Europe

CCS - realising the potential?

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Getting carbon capture & storage moving faster

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Does the UK's carbon capture and storage industry need to be developing faster? And how do we do it?

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Featuring

Chaired by Stuart Haszeldine, professor of carbon capture and storage, School of GeoSciences, University of Edinburgh

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- Revenue streams from carbon re-use

- Funding gaps + ways to kick-start the initial CCS projects

- Developments with the UK's carbon capture competition

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Front cover: The Otway Project Stage 2B residual gas saturation test was successfully completed. After eleven weeks of continuous operations, the remaining formation water was pumped back into the Paaratte, concluding a sequence of five carefully prepared tests; a hydraulic pressure test, tracer tests, thermal test, RST and dissolution test.

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CO2CRC reaches research milestones

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) has been active in carbon capture and storage research since 2003. The last year has seen a range of research highlights across the CO2CRC portfolio. By Tony Steeper, Communications and Media Advisor, CO2CRC

A highly successful example of the Australian Government's Cooperative Research Centre program, CO2CRC is a joint venture comprising participants from Australian and global industry, universities and other research bodies from Australia and New Zealand, and Australian Commonwealth, State and international government agencies.

CO2CRC collaborates with leading international and national CCS experts to conduct research across the full chain of CCS, including capture, storage and transport, as well as undertaking supporting work in economics, risk assessment and communications.

Capture research

The CO2CRC Capture Research Program covers laboratory research, pilot scale demonstration projects and future large scale designs for a variety of technologies. The aim is to significantly reduce energy requirements and overall capture costs.

The focus is on four separation technologies:

Solvent absorption – the most mature technology and currently the method of choice for CO2 separation. CO2CRC research covers a range of solvents and promoters to enhance the rate and efficiency of the process. Currently there is a particular focus on laboratory and demonstration plant scale work for the precipitating potassium carbonate system that CO2CRC has developed over the last seven years (the UNO MK3 process - see box below).

In **membrane separation research** CO2CRC is developing new materials specifically for CO2, including membrane systems that can be integrated with solvent systems. Currently piperazine-based membranes and ultra-thin membranes using CAP (continuous assembly of polymers) synthesis are showing promise. CO2CRC is also developing high flux homopolymer hollow fibre membranes for post-combustion capture.

In **pressure or vacuum swing adsorption systems**, fixed beds of solid material capture CO2 and release it through pressure changes. CO2CRC has developed a screening model to assess the suitability of potential new materials and has developed patents for some highly promising candidates for CO2 separation from natural gas.

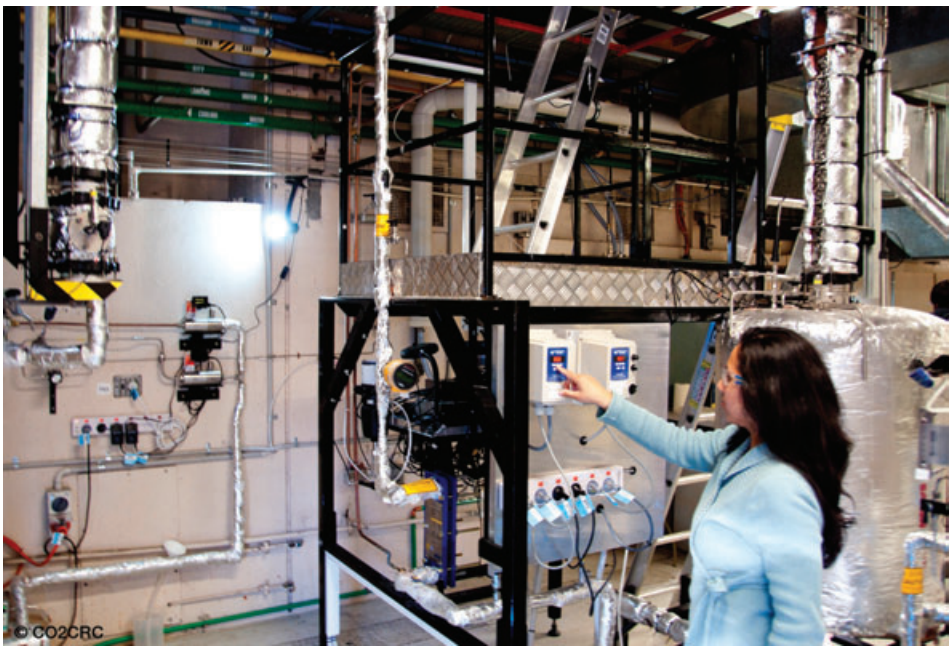

Figure 1 - The UNO MK3 mini-plant will allow researchers to optimise all aspects of the new system (©CO2CRC)

A further area of research, **cryogenic and hydrate separation**, has particular application for pre-combustion and oxyfuel capture, promising greatly reduced energy requirements. Hybrid adsorbent/cryogenic systems look promising for post-combustion capture and are also under investigation.

Technology trials in industry settings have provided very valuable data for capture researchers.

"Our demonstration projects, trialling solvent, membrane and adsorption technologies, have provided real world experience into how these systems work with real flue gas in a power station environment," said Professor Dianne Wiley, CO2CRC Capture Program Manager.

"We have insights into implementing, operating and optimising capture systems and have been able to identify the key technical and economic scale-up pathways for the three main technologies."

Professor Wiley also heads up the CO2CRC economics team, based at the University of New South Wales.

"CO2CRC has developed ICCSEM, a framework for economic evaluation used to assess and validate research directions and integrate CCS systems with energy-production systems, transport networks and storage infrastructure."

"CCS is not a standalone technology. Its commercial viability depends very much on finding the best way of matching available technologies with emission sources and designing the CCS chain to maximize reduction of CO2 emissions at the lowest cost while using the least amount of energy."

Storage research

The **CO2CRC Otway Project**, Australia's first demonstration of the geological storage of carbon dioxide, is the focus of much of CO2CRC's storage research and an ongoing 'field laboratory' for developing many of the technologies and processes required for geological carbon dioxide storage.

In Stage 1 of the project over 65,000 tonnes of carbon dioxide-rich gas were

stored in a depleted gas reservoir and rigorously monitored. Monitoring the stored CO2 has always been a key objective of the project, along with the development of novel cost-effective storage monitoring technologies, to assure that the long-term confinement of CO2 is safe and sustainable.

The recent publication of the Otway Project Stage 1 overview paper Safe storage and effective monitoring of CO2 in depleted gas fields (Jenkins et al., Proceedings of the National Academy of Sciences, December 2011) covers the multidisciplinary nature and wide scope of the research, bringing together research from a large team of world-leading scientists and many years of planning and hard work.

In 2010, a second research stage began, focussing on CO2 storage in deep saline formations - porous rocks containing formation water. Deep saline formations are very common worldwide and have the potential to store many years' worth of CO2 emissions. They represent the vast majority of potential CO2 storage sites.

The aim was to develop a way to measure the proportion of stored CO2 that is permanently trapped in the water-filled reservoir rock after injection. To do this, scientists developed experiments to measure permanently stored CO2 using hydraulic pressure, organic and noble gas tracers, thermal properties, the residual saturation tool and CO2 dissolution.

Figure - aerial view of the Otway project (©CO2CRC)

The five carefully prepared tests were successfully concluded in late 2011, after eleven weeks of continuous operations, by an international research team led by CO2CRC. Data is now being analysed that will lead to tools and techniques to cost-effectively assess the capacity and security of geological carbon storage worldwide, including the world's first 'single well test' which eliminates the need for separate monitoring wells and potentially saves CCS project developers US$5m or more.

Storage research plans (Stage 2C)

Geophysical seismic monitoring has been a major part of the Otway Project monitoring effort since the project began, and over the years a number of different types of geophysical data sets have being collected. The next part of Stage 2, now underway, is to test the effectiveness of time-lapse seismic techniques as a monitoring method, in particular its ability to detect an injected CO2-rich gas mixture in a saline formation.

This will be the first time such an injection will be conducted in Australia and the project will provide useful experience for large scale storage throughout Australia. The approvals process alone will break new ground and CO2CRC is working closely with regulators to define the parameters and the nature of the monitoring system and ultimate approvals protocols.

The Otway Project is a unique research facility because it has a supply of naturally

UNO MK 3 reduces capture costs

A CO2CRC research development with a lot of potential is the new precipitating solvent system, UNO MK 3, based on potassium carbonate.

Developed over seven years, UNO MK3 is showing cost reductions of at least $20 per tonne compared to current technology. The ability to apply UNO MK3 to both pre- and post-combustion sources, particularly Natural Gas Combined Cycle plants, means there is real promise for the technology.

The system integrates several research streams, including equipment choices, powerplant integration and solvent research, to substantially reduce costs and improve its environmental footprint. The first aspect of UNO MK3 is a separation system using potassium carbonate, a solvent similar to baking soda, which reduces energy requirements by up to 20 per cent. The precipitating process also eliminates the need for SOx and NOx removal and the associated capital cost, while producing a by-product that can potentially be used in fertiliser manufacture. One of the benefits of potassium carbonate is that it is an environmentally benign substance with low environmental impact, especially in comparison to current amine solvents.

Fit for purpose equipment designed by CO2CRC can also reduce costs, including CO2CRC's patented concentric concrete columns, which are smaller and cheaper to build than stainless steel columns.

Heat and process integration has been a successful stream of CO2CRC capture research for several years, including pinch analysis of capture plant and power station operations. By integrating the capture process with the power station, CO2CRC has been able to reduce the UNO MK 3 system's energy use by at least 25 per cent.

In May 2012 CO2CRC commissioned a lab scale UNO MK 3 mini-plant at the University of Melbourne. The plant is a highly flexible system capable of capturing 200 kilograms of carbon dioxide per day. It will allow researchers to optimise all aspects of the UNO MK3 system, and then apply the results of trials to a one tonne per day capacity pilot plant at the Hazelwood power station in Victoria's Latrobe Valley now under construction. A UNO MK 3 work program is planned out to full scale demonstration.

The UNO Mk3 system is a CO2CRC project supported by ANLEC R&D and Brown Coal Innovation Australia.

occurring CO2 (mixed with 19 per cent methane), from the nearby Buttress well. For the purposes of Stage 2, an injection of 10,000 – 30,000 tonnes of this gas mixture into the Paaratte formation will take place at a depth of about 1440 metres and a number of geophysical methods will be used to monitor the gas in the saline formation. The aims are demonstrating plume immobilisation after cessation of CO2 injection and also quantifying the smallest detectable amount of CO2 with surface and downhole 4D seismic.

"Demonstrating plume stabilisation after injection will be a significant research outcome," said CO2CRC Storage Program Manager Dr Matthias Raab.

"This hasn't been done before - all current projects are still injecting and their plumes are still moving. Demonstrating stabilisation will be a major step in showing that storage in saline formations can be safe and permanent."

The small volumes of gas to be used represent an interesting analogue to leakage of the CO2 from primary containment and will enable the determination of the sensitivity of the measurement to detect small leaks in the vicinity of such formations. The existing CRC-1 well is very well positioned for time-lapse Vertical Seismic Profile (VSP) surveys and early detection of the CO2 plume.

The proposed injection zone is a seven metre thick reservoir with a permeability of several Darcies surrounded by impermeable layers. The gas plume is thus expected to be relatively thin and large in lateral extent. Therefore, the main challenge for the seismic method is to detect a thin plume on a background of noise.

Otway Stage 1 time-lapse experiments at the project have demonstrated that near-surface soil conditions and intrinsic noise sources degrade the signal-to-noise ratio for the measurement. To improve the likelihood of observing the subtle time-lapse seismic signals, the signal-to-noise ratio conditions under which the measurements are made has to be improved.

A key part of the experiment will investigate the signal-to-noise improvements that can be realized with a permanent installation of seismic sensors. The project also aims to quantify the signal-to-noise improvements that can be made depending on the depth of installation of permanent receivers, in comparison to conventional surface deployment.

A small field trial was recently completed to optimise the geophysical equipment, quantify signal-to-noise improvements and evaluate the feasibility of time-lapse borehole seismic using hydrophone strings. The full experiment including the injection of CO2 is planned for 2014.

Figure 2 - The Otway Project is an ideal facility for further carbon storage research (©CO2CRC)

The Otway Project has continued to prove itself to be an ideal facility for ongoing research and an excellent example of multidisciplinary collaboration across many organisations.

The CO2CRC Otway Project involves researchers from Australian universities and research organisations as well as researchers from the United States, Korea, Canada and New Zealand. The Project has been financially supported by the Australian Federal Government, through the Cooperative Research Centre Program, the Victorian State Government and the US Department of Energy, as well as CO2CRC members.

More information

www.co2crc.com.au
www.unimelb.edu.au
www.pnas.org

Sharing research from the Otway Project

Recently an international team from the MUSTANG project visited the project to see the surface facilities and discuss the experiment with the researchers and operators involved.

The MUSTANG project is a collaboration of 19 research and industry organisations funded by the EU's Seventh Framework Programme for Research (FP7). Uppsala University is coordinating the project.

MUSTANG is developing site quantification methodologies for CO2 storage in saline aquifers. Part of the project is a dedicated field-scale injection test at a site in Israel to explore residual gas trapping, a similar test to Stage 2B of the Otway Project.

Over several days the two groups conducted a complete design review of both projects, including the logic behind each decision, what worked and what didn't, and even what gauges to use. The CO2CRC team was asked what they would change if they were to run the experiment again, and why.

Every aspect of the Otway Project trial was challenged, from the surface equipment and the use of tracers, to the underlying reservoir engineering and the way the results were interpreted. The EU group came away with a great deal of practical advice and information, as well as the conclusion that Stage 2B had been a well designed and well executed experiment.

As the EU project continues to develop, the CO2CRC storage group will continue to contribute, as a member of the MUSTANG science advisory board, and will watch the injection in Israel with interest.

Australia's CarbonNet Project receives CCS Flagship status

Australia's CarbonNet Project is investigating the potential for large scale CCS in east Victoria, where it is anticipated 1-5 mega tonnes per annum could be stored in the Gippsland Basin's world-class storage resources by 2020, with potential for significant scaling up. The project has just received AUS$100M for feasibility studies.

In February 2012 the CarbonNet Project was selected by the Australian Government as a carbon capture and storage (CCS) Flagship project and awarded AU$100 million in joint Commonwealth and Victorian government funding.

The funding allows for the progression of the project's feasibility stage to 2014, building on initial research and investigating the potential for large-scale, commercial CCS in Victoria's Gippsland region.

The Gippsland region is widely recognised as a world-class location offering significant potential for CCS technology. The nearby Latrobe Valley is home to power stations responsible for generating more than 90 percent of the state's electricity, while the offshore Gippsland Basin has been found to contain both the best quality and largest volume of CO2 reservoirs from 25 major basins across Australia (2009 National Carbon Task Force).

The potential of the region was acknowledged by the Australian Government and its Independent Assessment Panel, which selected the CarbonNet Project as a CCS Flagship project.

Managed by the Victorian Department of Primary Industries, the CarbonNet Project is an exciting prospect for the region, offering the potential for an innovative new industry that will secure jobs, boost skills and attract investment while strengthening Victoria's energy security in a low carbon future.

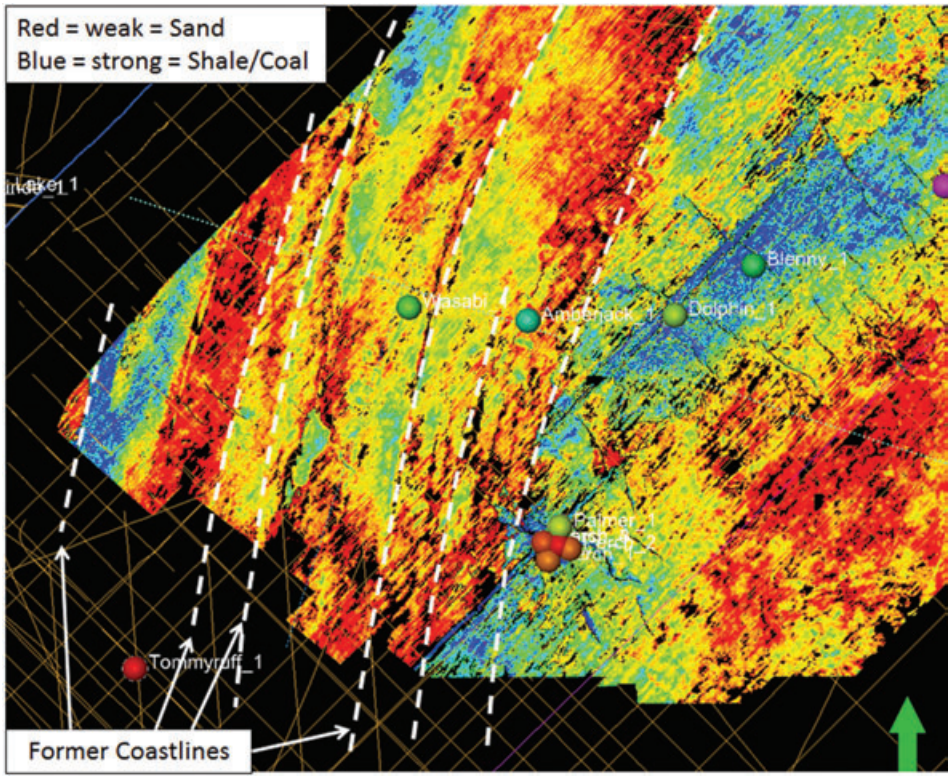

Figure 1 - Former shoreline positions: The migration of the coastline over millions of years has led to the formation of layers of both sandstone and hard shale rock below the offshore region in the Gippsland Basin. This creates great potential for offshore CO2 storage in the porous sandstone hundreds or thousands of metres below the surface, with overlying layers of shale offering thick layers of impermeable cap rock.

The project – background

The CarbonNet Project aims to capture and store 1-5 million tonnes per annum by 2020, with the potential to rapidly scale up.

The geology of the Gippsland Basin offers excellent potential for long term offshore storage of significant quantities of CO2. The CarbonNet Project is investigating the potential to store CO2 in the Latrobe Group (a set of geological layers of reservoir sands and sealing shales and coals). CO2 would be stored below a primary seal, which comprises thick shale rock and tight formations correlated across the project area. A high-quality regional top seal (the Lakes Entrance Formation), which covers the entire Latrobe Group reservoir package, will act as a secondary seal for stored CO2.

This top seal has secured large columns of hydrocarbon gas in high-quality sandstone reservoirs for millions of years, providing a strong indication of its added ability to contain CO2 safely at depth for equally-long periods. Over time, dissolution of CO2 into the deep formation waters and chemical reactions with rock minerals will help permanently stabilise and trap the CO2.

Evaluating potential storage resources

The CarbonNet Project benefits from geological data acquired and made public by the oil and gas industry, which has operated in the region for decades. CarbonNet researchers have analysed high resolution details of the subsurface geological strata from 2D and 3D acoustic imaging data (seismic data), together with rock core material and information from over 50 existing wells.

The construction of 3D models for the onshore, coastal and near-shore areas of the Gippsland Basin have allowed researchers to analyse potential storage sites and predict the behaviour of CO2 throughout the storage process including injection, migration and stabilisation.

Prospective storage sites have been evaluated and short-listed in a process similar to that employed by the oil and gas industry, with a focus on safe and secure storage. In May 2012, an independent peer review commenced to evaluate and verify data

with the aim of selecting the optimum one or two potential sites for further detailed mapping and appraisal drilling.

CarbonNet is looking at several potential sites in the near shore area (within 3 to 20 km off the coast). These are medium to large structural traps that do not contain significant oil or gas resources. Each appears large enough to contain 50 to 350 million tonnes of CO2 in simple structural traps with their own primary seals below the proven regional secondary seal.

CarbonNet researchers are developing detailed 3D models of these structures and modelling the potential minor affects of CO2 injection on aquifer pressure and water quality at the offshore locations. Detailed mapping to determine the exact shape of the CO2 gas cap allows researchers to assess any potential for the injected CO2 to migrate sideways or downwards out of the geological trap if it were to be 'overfilled'.

Following selection of the optimum site in terms of storage potential and safety, an appraisal well will be drilled to retrieve rock samples to accurately assess the properties of the primary seal or cap rock, as well as other secondary regional seal rocks that lie above. Drilling may take place from an onshore location and extend to the offshore potential storage site, or it may involve setting up a jack-up drilling rig similar to those used in the oil industry.

In addition to laboratory testing of rock core material, threshold pressure tests involving water and possibly nitrogen gas will be conducted on the reservoir rock and seals to confirm sealing capacity and help determine that the site will be safe for CO2 storage.

Additional seabed and subsurface surveys will be commissioned to measure in further detail the geology and environment of the potential storage site and to establish a baseline for ecological studies.

Under Australian greenhouse gas legislation existing oil and gas operations are given precedence over CO2 storage, however in 20-30 years depleted oil and gas fields could provide additional storage capacity. CarbonNet researchers are also investigating other offshore long-term options, with studies focused on planning for multiple use of the Gippsland Basin pore space without impacting on other users.

CarbonNet researchers have simulated CO2 injection at depths significantly below the oil and gas pools that sit at the top of the reservoir. Analysis has examined how effective additional shale and coal layers lying below the main top seal/cap rock are at trapping CO2. Several oil and gas pools trapped at similar depths in nearby parts of the basin

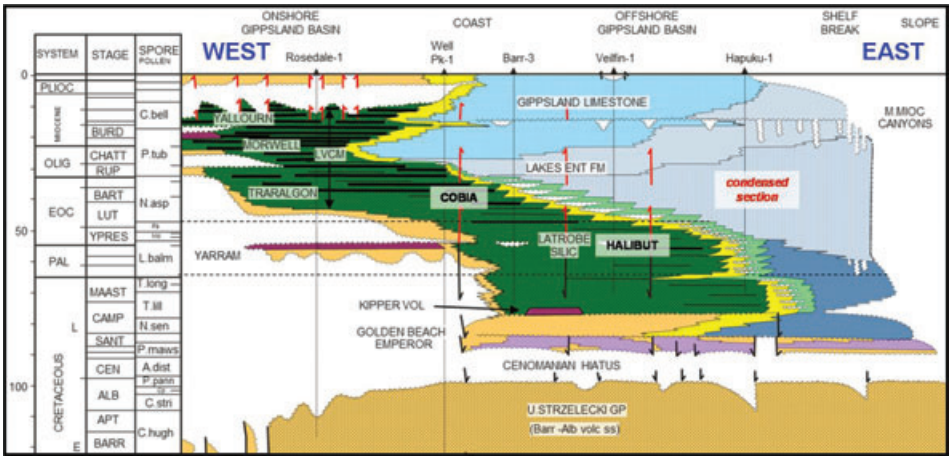

Figure 2 - Chronostratigraphy of the Gippsland Basin

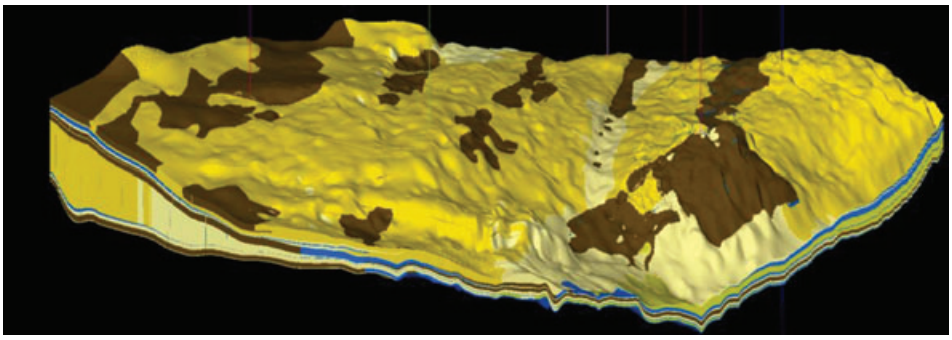

Figure 3 - Geological model of the Gippsland Basin

demonstrate the ability of these layers of shale and coal to act as effective seals – despite being only a few metres thick in places.

CarbonNet and independent analysis indicates that with injection of over 50Mt of CO2, trapping is 90-95 percent efficient at these deeper levels over 100-250 years. The time taken for even small amounts of CO2 to rise through the additional layers to the top of the storage reservoir is approximately 20-60 years.

What's next?

The CarbonNet Project will move towards the demonstration of large-scale carbon capture and storage.

Evaluation of short-listed potential storage sites will continue with the aim of selecting one or two sites for high grade detailed mapping to determine the optimum location for the safe, long term storage of CO2. This will be followed by the drilling of data appraisal wells.

Investigation into suitable potential carbon capture plants and technology will continue, along with assessment of transport pipeline routes to the selected injection site.

Defining the commercial structure and underlying principles to attract private sector investment is also a focus during this stage of the project.

Community and stakeholder engagement is a strong focus. The project's broad range of stakeholders include landholders and the local community, federal, state and local government, industry and industry groups, community groups, environmental organisations and the global CCS community.

Knowledge sharing is an important aspect of the CarbonNet Project and findings and experience gained from the large amount of research being undertaken will be shared with stakeholders in the interest of accelerating the development and demonstration of CCS technologies.

While there are many challenges ahead, the CarbonNet Project, with its prime location, ability to rapidly escalate to commercial deployment and support of its partners – which include the Australian Government, the Global CCS Institute, CO2CRC and industry - has the potential to be a world-class contender in the CCS space.

More information

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How 'learning by doing' can make the UK a leader in the global Carbon Capture market

Why it's vital for the UK and Norway to work together to deliver on the promise of CCS.

By Anne Strømmen Lycke, chairperson, the Technology Centre Mongstad

Six years ago, Statoil's oil refinery in Mongstad, Norway may have looked an unlikely birthplace for one of the world's key climate change solutions. Covering four square kilometres of coast, the facility was Europe's second largest crude oil processor, after Rotterdam.

Now, alongside the refinery, Mongstad houses the world's most advanced test facility for capturing greenhouse gas emissions from fossil fuels. Anne Strømmen Lycke, chairperson, the Technology Centre Mongstad, discusses why the opening of the Centre is vital to the UK's transition to the low carbon economy.

The recent launch of the UK Carbon Capture & Storage (CCS) Competition and CCS Roadmap provides a much-needed shot in the arm to this exciting industry, both by financially and in displaying the UK Government's commitment to this vital technology. The offer of £1bn together with the development of a suitable financing package under the UK's Electricity Market Reform will enable companies to make the necessary investment decisions that will bring forward the first CCS projects in the UK.

Despite a half-decade delay and numerous setbacks, the industry remains positive about CCS, and the UK is in one of the strongest positions to commercialise the technology; generating around 100,000 jobs and 6.5bn in the 2020s. Industry is already responding, in April plans for a new commercial-scale CCS project were announced and another proposal also announced major inward investment from Samsung bringing to seven the number of proposed large scale projects in the UK.

With the policy framework in place, now, it's critical for CCS technologies to deliver on the Government's support, by bringing forward innovative demonstration projects. The UK Energy Research Council (UKERC) spent two years researching CCS and has found that a regulatory approach making CCS compulsory in all fossil plants will only work if the technology is more advanced. The report's lead author Dr Jim Watson, director of the energy research group at Sussex University, said:

"…unlike other low-carbon technologies, CCS doesn't exist at the commercial scale. We don't know when they will be technically proven at full scale, and whether costs will be competitive with other low-carbon options. So it is vital that the government's commitment leads to several full-scale CCS projects as soon as possible; only through such learning by doing will we know whether it is a serious option for the future."

The official opening of Technology Centre Mongstad in May 2012

In order to get the technology to this stage and encourage further support through the Electricity Market Reform, it's up to industry to ensure that it maximises efficiency and minimises the cost of new CCS plants. To secure investor confidence, the industry needs to demonstrate the commercial reality of CCS and dispel the view that CCS is an expensive, risky distraction - purely in pursuit of carbon reduction.

A key element of the scaling up of technology development is CCS testing. That's why at Mongstad, we have issued a call to action for technologists to make use of the test facilities we have been developing since 2007. The amine CO2 capture plant is the largest, most comprehensive and flexible test facility in the world. The UK's significant existing investment in pilot CCS plant, as well as its proximity to the UK, makes it an ideal test partner. In addition to offering testing new technologies, we're inviting technology firms to demonstrate their equipment at scale at Mongstad, which is key for driving ongoing investment.

Given the Government's clear policy signal, the proposals are being developed for the £1bn competition. However, in the run up to the competition winners being announced, it's vital that CCS developments continue to be tested and proven, both in order to win ongoing investment, as well as to build a demand for the technology, so that when CCS is commercialised, there are qualified buyers. Industry has to believe there is a market for CCS. By demonstrating technologies at scale and showing the knowledge and experience in constructing cost effective CCS, TCM will prove the potential of CCS in the transition period between now and the opening of the first demonstration plants in 2016.

2012 is critical to force CCS into mainstream thinking as a lucrative investment; if we work in silos we may miss our window to make that happen. Instead, by collaborating, we can create the momentum for a standardised group of CCS technologies, which will provide investors with the security they

need. Also, by working together, the industry can address other important areas including developing skills and the supply chain, storage and CCS infrastructure.

In order to commercialise CCS, it is essential that lessons learnt and improvements made can be shared. The Government's CCS Commercialisation Programme is focused on learning by doing; and the best way to achieve that is by sharing the knowledge already in existence of developing CCS.

The Confederation of British Industry (CBI) supports the Government's CCS roadmap, but with the caveat that collaboration and sharing of best practice is crucial. According to Rhian Kelly, the CBI's director for business environment policy:

"The Government must learn lessons from its previous (CCS) competition, which took too long and was eventually abandoned. This time around the competition must be simpler and completed as quickly as possible."

Included in the UK Government's programme of interventions is a commitment to develop an international engagement strategy focused on learning from other projects around the world to help accelerate cost reduction in the UK, and sharing knowledge. By focusing on international collaboration and learning from other tested projects, the UK can develop cost effective CCS plants.

The Mongstad test centre was first conceived by the Norwegian state and Statoil in 2006, since then, a myriad of organisations have come together to form a partnership to develop CCS, including Shell, Sasol, Aker Clean Carbon and Alstom.

Aerial view of the completed site

More information

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www.cbi.org.uk/media-centre/press-releases/2012/04/cbi-responds-to-re-launch-of-ccs-competition/

Influencing public opinion on CCS

Head of Energy at communications agency PPS Group, Leander Clarke, outlines what the carbon capture and storage industry needs to do in order to tackle the public engagement challenges facing the establishment of CCS facilities in the UK.

In April 2012, the UK Energy Research Centre, led by Professor Jim Watson, released a report which analysed the barriers to developing the CCS industry in the UK. Among the seven key challenges identified during the exhaustive two-year study, was the question of public acceptance. The report was issued as the UK Government confirmed its £60m contribution to a larger international fund which will support the development of CCS in emerging markets.

With any significant development project, taking local stakeholders along with you during the planning phase is vital to the long-term stability of the project.

CCS technology faces two considerable challenges on this front: firstly the potential distance between the capture and final storage points of the carbon makes consulting those affected a challenge.

The second point is connected to the public's unfamiliarity with the technology: any future full-scale development would be the first of its kind, apart from existing demonstration scale facilities.

The failure of the previous competition by the UK Government to design, build and operate a CCS plant has not helped the public perception of the technology. Environmental campaigners question whether the technology can actually work, where as economist analysts argue that the cost of developing a viable project outweigh the rewards.

Local communities are also likely to have concerns about the viability of the technology but more so about the location of new infrastructure.

So, how should the sector approach these communications challenges in order to secure public acceptance?

Start talking early

It's vital that the discussion relating to the need for CCS is started prior to proposals being made public for new power stations, pipelines and storage facilities.

In this sense, the sector has a great opportunity to pick up the subject and start building the foundations in a strategic way. After all, it's unlikely that anybody else is going to do it for you. The work undertaken by the Carbon Capture & Storage Association shows the way forward here: clear, concise messaging designed to prepare the ground for future development.

It is important to establish the risk-reward equation. What are the potential issues with CCS which need to be addressed? What benefit will CCS have to the UK at a national level, but also locally?

At a national level the role CCS can play in keeping the lights and tackling climate change need to be fully extolled. At a local level, demonstrating what a local community stands to gain is an important message to help achieve public acceptance. What are the employment opportunities? How will local companies benefit from supply chain opportunities? How will the local authority stand to benefit from business rates retention?

When it comes to consulting local communities on proposed new infrastructure, the Localism Act has placed early public engagement at the top of the agenda. The Act, which came into law in November 2011, requires developers of significant projects to consult with communities before submitting an application. There is an expectation that local people will be involved earlier and engaged with more deeply. This, it is hoped, will lead to greater community acceptance and buy-in towards development.

This is a brave new world for some developers while others have been operating within the spirit of the rules since before they were on the statute book. Of course, the proof of the pudding will be in the eating and the impact of localism remains to be seen.

Leander Clarke, Head of Energy at PPS Group

A consistent message

What is clear, is that achieving public acceptance and understanding of unfamiliar, and potentially controversial CCS projects, will require not only dedication on the part of individual developers to explain their proposals, but also the industry as a whole.

Presenting a unified voice on the role of CCS in the wider energy mix, its benefits and the role it can play in curbing climate change will be vital in building and maintaining public acceptance.

More information
www.ppsgroup.co.uk

Aquistore Open House updates community

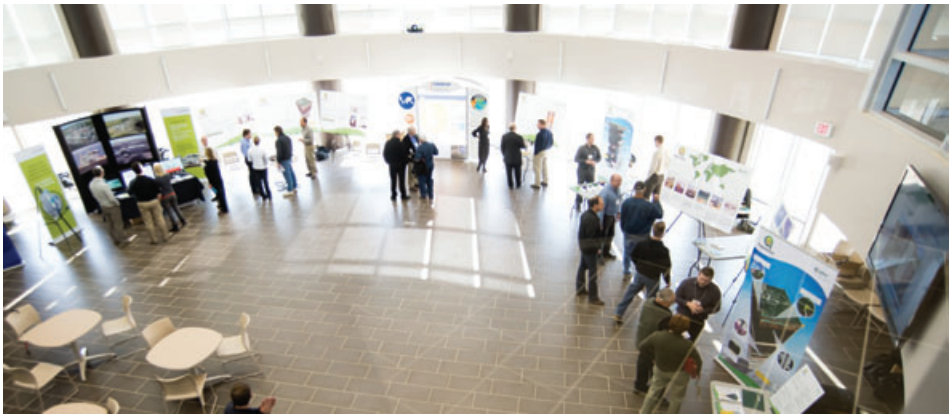
The community of Estevan in south-eastern Saskatchewan, Canada was abuzz about all things CCS recently.

The Petroleum Technology Research Centre (PTRC) hosted an Open House on April 11th to inform the public about its Aquistore project, an independent CO2 research, storage and monitoring project now underway near the community in Saskatchewan. PTRC was providing information about the project, seeking feedback and responding to questions.

Over 60 residents came out to the event, many of them local business owners, community leaders and farmers located in and around the project area. "We had concerns living so close to Boundary Dam and found this presentation day answered a lot of our questions and concerns." (attendee survey response, April 11, 2012).

Aquistore seeks to demonstrate that storing carbon dioxide deep underground (in a brine and sandstone formation), is a safe, workable solution to reduce greenhouse gases. The source of the industrial CO2 will be SaskPower's Boundary Dam Power Plant (a lignite fired electrical generating station).

To kick off the Open House PTRC CEO Dr. Malcolm Wilson along with Doug Nixon of SaskPower presented their CCS initiatives at the Estevan Chamber of Commerce Luncheon. Dr. Wilson noted that the carbon capture and sequestration project has now captured both local and international attention, "Weyburn has been the household word for CO2 storage, and now it will be Estevan that will be popping up on the world maps with the commercial sized capture, storage and test facilities. The experts working on the Aquistore project are looking at this as a fully integrated project."



The Aquistore Open House event was attended by over 60 residents

Working together

The PTRC has joined forces in a unique partnership with SaskPower, a Saskatchewan Crown corporation, to demonstrate that advanced CCS technologies can be deployed to mitigate CO2 emissions for a wide cross-section of industrial sources.

The joint CCS project is divided into its primary components, with SaskPower managing the capture of CO2 from its Boundary Dam Power Station (a lignite fired electrical generating station), and PTRC managing the storage of CO2 through its Aquistore Project.

SaskPower is rebuilding one of its coal-fired generation units and equipping it with a carbon capture system. The CO2 stripper and sulphuric acid storage tank were installed last month at the Boundary Dam facility, which is located in Estevan, Saskatchewan.

On the storage side, PTRC's Aquistore Project plans to demonstrate the safe long-term storage of CO2, three kilometers deep underground in a saline reservoir, with its entry point conveniently located two kilometers west of Boundary Dam. The research starts with an unprecedented intensive seismic acquisition. "Right now we have field crews installing 630 geophones in a permanent seismic array," explains Dr. Wilson. "This allows us to gather reliable, high quality geological data throughout the project and compare it to baseline."

The Aquistore Project will build on the knowledge developed through PTRC's 10 year management of the IEA GHG Weyburn-Midale CO2 Monitoring and Storage Project, which is the world's largest CO2 measurement, monitoring and verification initiative, in collaboration with a CO2 enhanced oil recovery project. As an international project, it has created research opportunities and results that are the envy of the world.

"The captured CO2 from Boundary Dam will be used partially for demonstrating deep geological storage of CO2 through the Aquistore Project," explains Mr. Monea. "We also hope to make it available to market for enhanced oil production."

Once operational (anticipated in the first quarter of 2014), the joint CCS project will lead to the reduction in greenhouse gas emissions of one-million tonnes/year. "It is our plan that the learning be transferable to industry globally," explains Dr. Wilson.

More information

www.ptrc.ca

CCS - realising the potential?

Carbon capture and storage: realising the potential? is the culmination of a two-year project funded by UKERC and led by Professor Jim Watson, Director of the Sussex Energy Group.

The project is an independent, inter-disciplinary assessment of the viability of CCS technologies from now to 2030. Although these technologies could be a crucial component of global climate change mitigation strategies, there are significant uncertainties about their technical, economic and financial viability.

The report's lead author, Professor Jim Watson, Director of the Sussex Energy Group at the University of Sussex says:

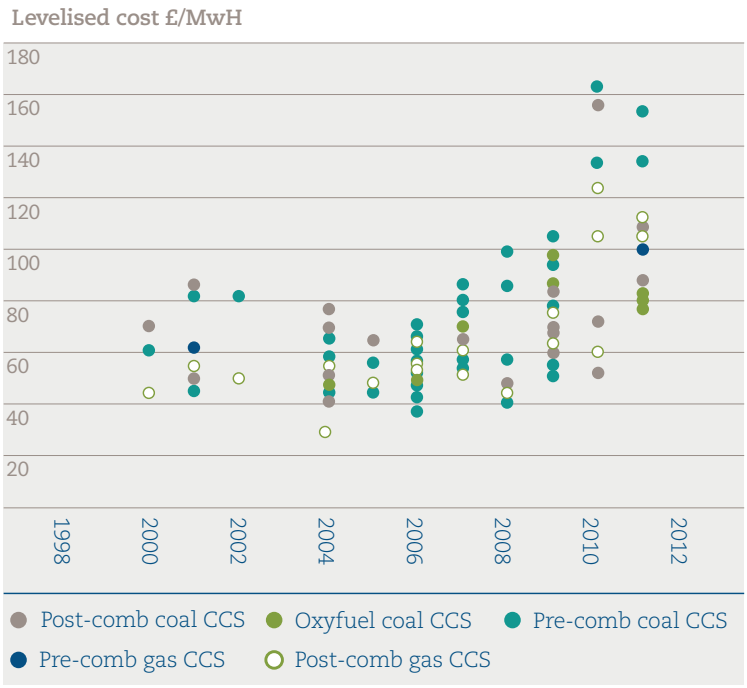
'We still don't know when CCS technologies will be technically proven at full scale, and whether their costs will be competitive with other low-carbon options. So it is vital that the Government's commitment to these technologies leads to several full scale CCS projects as soon as possible. Only through such learning by doing will we know whether CCS is a serious option for the future, and how the technical, economic and legal uncertainties currently facing investors can be overcome'

The report draws lessons from history, and concludes that previous technologies have faced similar challenges to those affecting CCS technologies today. In the past, such uncertainties have been resolved sufficiently for these technologies to succeed. While care is needed when learning from history, the findings offer some optimism that, given the right actions by government and industry, the uncertainties surrounding CCS can also be dealt with.

But even if rapid progress is made with the UK's re-launched demonstration programme, which aims to have CCS plants operational later this decade, difficult choices will remain for government and other decision makers, say the authors. The report identifies four key areas where such choices need to be made:

- Deciding whether to keep options open, or close them down. The French government focused on one technological variety early on for its nuclear programme. Doing this for CCS may help speed up development, but there is a risk of picking inferior technology. The authors caution that it is too early for government and industry to close down on a particular variant of CCS technology. They welcome the plans for several substantial demonstration projects which will help to identify which variants of CCS technology can be scaled up successfully.

- Designing financial support for effective CCS demonstration and deployment. A regulatory approach that makes CCS compulsory for all fossil plants will only work if the technology is more advanced, and the additional costs can be passed onto consumers. CCS technologies are not yet at this stage. In the mean time, the government should ensure that industry maximises efficiency and minimises costs of new CCS plants. History shows that not all demonstrations will perform as expected, and government should ensure that lessons are learned from successes and failures.



CCS costs (Source: Jones 2012)

- CCS deployment is a marathon, not a sprint. Developing new energy technologies can take a long time, and the process is often far from smooth. The report shows that costs do not necessarily fall in the way supporters hope – and can rise for several years before they come down, as technologies are scaled up. This requires patience. Government also needs to ensure it has an independent capability to assess costs to inform future decisions about whether to continue with public funding for CCS or to divert resources to other low carbon options.

- Dealing with storage liabilities. The report shows highlights lessons from UK nuclear waste management policy to show how complex liability arrangements for CO2 storage could be. For CCS, a balance needs to be struck between limiting liabilities for investors and protecting the interests of future taxpayers. Agreements will be needed on where this balance should lie, and what arrangements are needed to fund and insure against potential liabilities.

The project is a collaboration of four universities: Sussex, Edinburgh, Cardiff and Imperial College. It was conducted in close co-operation with a stakeholder steering group, chaired by Dr Tony White.

The project team includes the following people:

University of Sussex: Jim Watson and Florian Kern

University of Edinburgh: Stuart Haszeldine, Jon Gibbins, Nils Markusson, Hannah Chalmers, Navraj Ghaleigh, Francisco Ascui and Stathis Arapostathis and Mark Winskel

Imperial College: Rob Gross and Phil Heptonstall

Cardiff University: Peter Pearson

More information

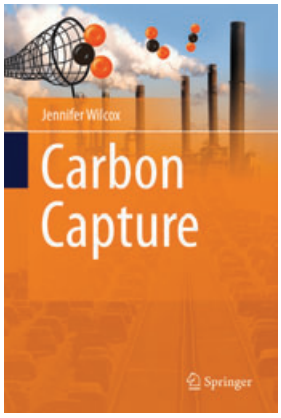
www.ukerc.ac.uk
www.sussex.ac.uk/sussexenergygroup

Review - three new books on CCS

Three complementary new books on CCS have been published - the first academic textbook, an overview for the non-specialist reader and a guide to social and policy issues.

Carbon Capture by Jennifer Wilcox

The first carbon capture textbook, this is the most comprehensive of the three on carbon capture methods, also including a section on compression and transport.



As carbon capture is a multidisciplinary effort, it is suitable for those from a variety of backgrounds wishing to study the subject, chemisry, physics, engineering, materials science etc.

It introduces the basic concept of mitigating CO2 emissions to combat climate change and goes through the major sources of anthropogenic CO2.

The basic principle of capturing a gas is described, "At the heart of any CO2 capture technology is the material and its required properties for optimizing mass transfer from a gas mixture to a captured phase. The material may be a solvent, sorbent, membrane or catalyst. Mass transfer acts as the bridge and links the optimal material properties with the overall separation process, whether it is a combined absorber-stripper system, sorption apparatus, membrane module, or catalytic reactor. The material properties, mass transfer, and capture process must be considered as coupled and inherent to the system in total."

Chapters cover each of the 'traditional' capture methods: Absorption, Adsorption, Membrane Technology, and Air Separation, with a focus on the operating, maintenance and capital costs of each process.

Other methods including algae, CO2 conversion to chemicals and mineral carbonations are also given a chapter each.

Compression is covered near the beginning as it provides an introduction to the phase behaviour of CO2 which is relevant to the discussions on capture methods.

Worked examples and problems for students are given in each chapter (with teacher's answer book).

Capturing Carbon by Robin Mills

A more general and gentle introduction to the subject, 'Capturing Carbon' is aimed at the interested but non-technical reader. It covers the full range of the subject including climate change and fossil fuel use, legal and policy issues and the full chain of carbon capture, transport and storage.

Which is not to say that it lacks detail - it is packed full of information and additional appendices, notes and a lengthy bibliography provide all the further reading the most fact hungry reader could wish for.

The book takes you through each aspect, whether technological, political or social, in a clear and concise way that will appeal to those wanting to get a quick grasp of the issues.

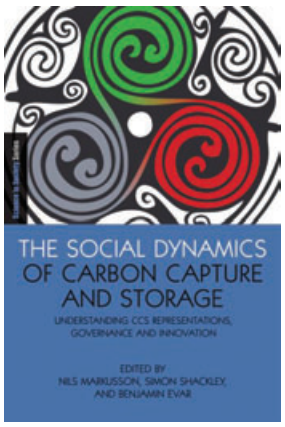
It clearly outlines the potential costs involved and the value of various methods as climate change mitigation tools. It looks at the impact of CCS on society and public understanding and reaction. It also evaluates the opportunities and risks for business and the potential for investors.

The conclusion strongly advocates CCS as a potential solution to a dangerous problem and criticises those who stand in its way on ideological grounds. "If you are an environmentalist, then stand up for solutions rather than negativity and doom-saying. Challenge energy companies hard when they propose carbon capture, but be prepared to give it a fair chance."

Overall an excellent introduction to the subject that would quickly get the interested reader up to speed and enable them to have all the facts at their disposal.

The Social Dynamics of Carbon Capture and Storage

A series of discussions by various authors, including several by the editors, this book focusses on the contribution social sciences can make to our understanding of CCS and its role in combating climate change.



As the editors comment in the introductions, "One consequence of CCS sitting on the fault line between the fossil regime and the climate change imperative is that CCS presents a great opportunity to study conteroversy, conflict and the politicisation of technology, especially as CCS migrates from the imaginaries of R&D to fully realised investments."

It is divided into three broad sections, 'Perceptions and representations', 'Governance' and 'Innovation' each containing an introduction and two or three essays.

It covers the roles and positions that different publics, NGOs, industry, political parties and media are taking up; the way CCS is organised, supported and regulated; and how CCS is being debated and judged.

The authors argue that, "the technology is undergoing a crisis and will need to find new applications and support among new social groups. If successful, this means that the technology itself will be transformed."

More information

Carbon Capture by Jennifer Wilcox is published by Springer and is available in Hardcover and eBook editions (335p) www.springer.com

Capturing Carbon: The New Weapon in the War Against Climate Change by Robin Mills is published by C Hurst & Co and is available in hardcover and Kindle editions from Amazon (288p)

The Social Dynamics of Carbon Capture and Storage: Understanding CCS Representations, Governance and Innovation, edited by Nils Markusson, Simon Shackley and Benjamin Evar is published by Routledge and is available in Hardcover, Paperback and Kindle editions from Amazon (352p)

ZEP releases CCS costs study

The EU Zero Emissions Platform (ZEP) report concluded that CCS would be cost-competitive with other low-carbon energy technologies, including on-/offshore wind, solar power and nuclear, post 2020.

The report was compiled by the companies, scientists, academics and environmental NGOs that together make up the ZEP. It was based on new data provided exclusively by ZEP member organisations on existing pilot and planned demonstration projects.

Key conclusions of the report are:

CCS is on track to become one of the key technologies for combating climate change

In order to keep global warming below 2ºC – cost-effectively – CCS must provide 20% of the global cuts required by 2050, according to the International Energy Agency (IEA); the costs of doing so without CCS will be over 70% higher. In turn, CCS will enable Europe to enjoy a surge in economic growth – creating new jobs, boosting industry and promoting technology leadership.

ZEP's study indicates that the EU CCS demonstration programme will not only prove the costs of CCS, but provide the basis for future cost reductions, enhanced by the introduction of second-and third-generation technologies. CCS is therefore on track to become one of the key technologies for combating climate change – within a portfolio of technologies, including greater energy efficiency and renewable energy.

CCS is applicable to both coal- and gas-fired power plants

CCS can technically be applied to both coal- and gas-fired power plants. Their relative economics depend on power plant cost levels, fuel prices and market positioning, whereas applicability is mainly determined by load regime. While co-firing with biomass is not covered in the study, it will be in future updates as it provides significant abatement potential when combining CCS with sustainably-produced biomass feedstock.

All three CO2 capture technologies could be competitive once successfully demonstrated

The study covers first-generation capture technologies only (post-combustion, pre-combustion and oxy-fuel). Using agreed assumptions and the Levelised Cost of Electricity as the main quantitative value, there is currently no clear difference between any of these and all could be competitive in the future once successfully demonstrated. The main factors influencing total costs are fuel and investment costs.

Early strategic planning of large-scale CO2 transport infrastructure is vital to reduce costs

Clustering plants to a transport network can achieve significant economies of scale – in both CO2 transport and CO2 storage in larger reservoirs, on-and offshore. Large-scale CCS therefore requires the development of a transport infrastructure on a scale matched only by that of the current hydrocarbon infrastructure. As this will lead to greatly reduced long-term costs, early strategic planning is vital – including the development of clusters and over-sized pipelines – with any cross-border restrictions removed.

While the study focuses on power generation, the application of CCS to heavy industry and fuel transformation could abate ~15% of all global man-made CO2 emissions by 2050 (IEA). Indeed, in steel and cement production, for example, it is the only means of achieving deep emission cuts. If different CO2 sources – power, industry and fuel transformation – are located in close proximity, they can therefore share CO2 transport and storage infrastructure, and should be included in all National CCS Master Plans.

A risk-reward mechanism is needed to realise the significant aquifer potential for CO2 storage

Location and type of storage site, reservoir capacity and quality are the main determinants for the costs of CO2 storage: onshore is cheaper than offshore; depleted oil and gas fields are cheaper than deep saline aquifers; larger reservoirs are cheaper than smaller ones; high injectivity is cheaper than poor injectivity.

Given the large variation in storage costs (up to a factor of 10) and the risk of investing in the exploration of deep saline aquifers that are ultimately found to be unsuitable, a risk-reward mechanism is needed to realise their significant potential and ensure sufficient storage capacity is available – in the time frame needed.

Creating a secure environment for long-term investment in Europe

The current main incentive for the EU-wide deployment of CCS is the price of Emission Unit Allowances (EUAs) under the EU Emissions Trading System (ETS). However, based on current trajectories, this will not be a sufficient driver for investment after the first generation of demonstration projects is built (2015 - 2020).

Enabling policies are therefore required in the intermediate period – after the technology is commercially proven, but before the EUA price has increased sufficiently to allow full commercial operation. The goal: to make new-build power generation with CCS more attractive to investors than without it.

Until a support system for biomass is in place, co-firing with CCS will not be commercially viable. A negative emission factor for such use of biomass under the ETS Directive is therefore necessary in order to create a level playing field between renewable energy and fossil fuel-based CCS. This can be achieved through project-specific applications to the European Commission, which has signalled that it would welcome such requests from Member States.

Incentives for CCS in heavy industry and fuel transformation are also urgently required: to date, only the "NER 300" mechanism provides any significant amount of funding for such applications.

Finally, there is an urgent need to drive down costs via new well-targeted R&D into next-generation technologies, as defined by ZEP in its 2010 report: "Recommendations for Research to Support the Deployment of CCS in Europe beyond 2020." This identifies key areas for improvement, together with the main strands for R&D to 2030 and beyond.

More information

www.zeroemissionsplatform.eu

Biomass with CCS - the way forward for Europe

A report into the use of biomass with CCS as a climate change mitigation technology has been released by the EU Zero Emission Platform (ZEP) and the European Biofuels Technology Platform (EBTP).

The key conclusions of the report were:

• Recent research indicates that more powerful technologies are now needed to keep global warming below 2°C – and avoid irreversible climate change. This is echoed by warnings from both the United Nations Framework Convention on Climate Change (UNFCCC) and the International Energy Agency (IEA).

• There is therefore an urgent need for carbon-negative solutions such as Bio-CCS – the only large-scale technology that can remove CO2 from the atmosphere. Bio-CCS combines sustainable biomass conversion with CO2 Capture and Storage (CCS) – e.g. in biofuels and bioenergy production – and is already being deployed at industrial scale in the U.S.

• Use of biofuels and bioenergy is steadily increasing in the European Union (EU) due to targets for renewable energy sources and certain biofuels production routes could provide "low-hanging fruits" for early, low-cost CCS deployment.

• A recent study indicated that, globally, Bio-CCS could remove 10 billion tonnes of CO2 from the atmosphere every year by 2050 using available sustainable biomass – equivalent to a third of all current global energy-related emissions. In Europe, Bio-CCS could remove 800 million tonnes of CO2 from the atmosphere every year by 2050 using available sustainable biomass – equivalent to over 50% of current emissions from the EU power sector. This is in addition to any emissions reductions achieved by replacing fossil fuels with that biomass.

• Bio-CCS could ultimately result in industry sectors whose overall emissions are below zero, which could then offset emissions in other sectors where reductions are more difficult to attain.

The following actions are therefore urgently required at EU level:

• As for other low-carbon technologies, establish economic incentives to enable the large-scale deployment of Bio-CCS – in particular, reward negative emissions via the capture and storage of biogenic CO2 under the EU Emissions Trading Scheme, in the same way as for fossil CCS.

• Identify and incentivise the clustering of small-scale biogenic emission sources with other emission sources in order to achieve economies of scale for CO2 transport and storage.

• Undertake R&D to determine the costs of the various Bio-CCS routes, including additional costs induced by corrosion and other technology challenges when co-firing with high biomass percentages in existing boilers.

• Establish dedicated funding for R&D and pilot projects to further develop and prove advanced technologies.

• Address issues specific to Bio-CCS deployment (e.g. accelerate deployment of advanced biomass conversion processes) and establish an EU roadmap towards 2050.

• In addition, establish additional non-ETS measures to enable EU CCS demonstration projects to take Final Investment Decision (FID) and provide security for long-term investment.

Bio-CCS: a definition

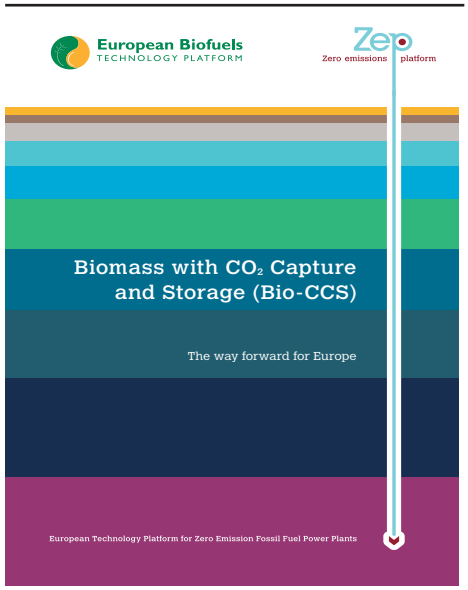
Bio-CCS may be defined as processes in which CO2 originating from biomass is captured and stored. These can be energy production processes or any other industrial processes with CO2-rich process streams originating from biomass feedstocks. The CO2 is separated from these processes with technologies generally associated with CCS for fossil fuels.

Biomass binds carbon from the atmosphere as it grows; but with the conversion of the biomass, this carbon is again released as CO2. If, instead, it is captured, transported to a storage site and permanently stored deep underground, this would result in a net removal of CO2 from the atmosphere.

Bio-CCS: the only large-scale technology that can remove CO2 from the atmosphere

Bio-CCS has already entered the European policy debate: the EU Energy Roadmap 2050 not only confirms that "For all fossil fuels, Carbon Capture and Storage will have to be applied from around 2030 onwards in the power sector in order to reach decarbonisation targets, it also recognises that CCS "combined with biomass could deliver 'carbon negative' values".

Yet Bio-CCS is, to a large extent, an unexplored avenue of action, with a number of complex questions to be analysed and answered. In 2011, the European Biofuels Technology Platform (EBTP) and the European Technology Platform for Zero Emission Fossil Fuel Power Plants – known as the Zero Emissions Platform (ZEP) – therefore set up a Joint Taskforce (JTF) Bio-CCS12 in order to guide and accelerate this vital work and ensure its place within EU policy and R&D priorities; Bellona Europa – a member of both ZEP and EBTP – runs the JTF Bio-CCS Secretariat.



The JTF Bio-CCS works in a similar way to its mother platforms in bringing together high-level stakeholders and experts from relevant industries, research and civil society in order to identify the most effective and appropriate means of developing and deploying Bio-CCS technologies.

More information

www.zeroemissionsplatform.eu
www.biofuelstp.eu

IEA report on CCS progress

The IEA and Global CCS Institute presented the report, 'Tracking Progress in Carbon Capture and Storage', at the 3rd Clean Energy Ministerial (CEM) meeting in London.

At the 2011 CEM meeting in Abu Dhabi, the CEM Carbon Capture, Use and Storage Action Group (CCUS AG) presented seven recommendations on concrete, near-term actions to accelerate global carbon capture and storage deployment.

The new report tracks progress made against the 2011 recommendations and focuses on key questions such as how Energy Ministers can continue to drive progress to enable CCS to fully contribute to climate change mitigation.

It concludes that, despite developments in some areas, significant further work is required. CCS financing and industrial applications continue to represent a particularly serious challenge.

To produce the report, the IEA and Global CCS Institute conducted formal interviews with committed governments in January and February 2012, building on informal consultation and progress tracking throughout 2011.

The seven substantive recommendations endorsed by Energy Ministers at CEM 2 include the following objectives to be achieved by CEM 3.

Recommendation 1: Reduce the financial gap. Advance policies that address the financial gap and risk associated with early mover CCS demonstration and deployment.

Recommendation 2: Funding support in developing economies. Identify and advance appropriate funding mechanisms to support the demonstration of large-scale CCS projects in developing economies.

Recommendation 3: Develop legal and regulatory frameworks. Advance the development of legal and regulatory frameworks for CCS demonstration and deployment.

Recommendation 4: Acknowledge importance of marine treaty amendments. Promote the importance to global CCS deployment of ratifying key international marine treaty amendments.

Recommendation 5: Share knowledge. Support and encourage the development of best practice knowledge sharing from early mover projects, in particular those with public funding.

Recommendation 6: Investigate CO2 storage. Review key gaps in storage data coverage and knowledge, and progress storage exploration and capacity assessment.

Recommendation 7: Support CCS in industry. Recognise the potential of CCS for industrial emission sources and review demonstration opportunities.

More information

www.iea.org
www.globalccsinstitute.com

Policy, company and regulation news

Ayrshire Power CCS project withdrawn

www.ayrshirepower.co.uk

Ayrshire Power, developer of a CCS power project at Hunterston, North Ayrshire in the UK, said it has put its plans on hold due to lack of investment certainty.

It is withdrawing its planning application and withdrawing from the current CCS demonstration project funding competitions.

APL said it had taken the decision, "due to the level of uncertainty surrounding the ability to secure the necessary financial investment to build the power station in the foreseeable economic climate."

The decision means that the Public Local Inquiry for the development will not now proceed this autumn. North Ayrshire Council had already rejected the project plans before in November 2011.

Commenting on the decision, Muir Miller, APL's project director said, "Whilst we believe we have a strong case to succeed in the planning inquiry, we cannot proceed with the significant risk that the current power station design and fuel mix could not be funded and built in the necessary timetable following the grant of consent."

"However, we remain convinced that this project could give Scotland a superb opportunity to lead the development of full-scale carbon capture and storage, which will be vital in reducing global emissions and accords with Scottish Government policy to cut carbon emission and back-up intermittent renewable energy supplies."

"The project would also bring a large number of new jobs and new economic opportunities to a hard-pressed area which has been impacted particularly badly by the recession. The opportunity to develop a CCS cluster on the west coast of the UK that could store over one billion tonnes of carbon dioxide by 2050 remains an exciting prospect."

"We still believe that new coal-fired power stations fitted with carbon capture and storage will play an important part in plugging the energy gap until alternative sources of low carbon energy can replace fossil fuels. Hunterston remains an ideal location for such a power station. However, the timing of the economic slowdown and funding uncertainty have not worked in our favour. We will now take some time to consider our options and determine under what circumstances we will revisit our proposals."

BOC takes stake in 2Co Energy's Don Valley CCS Power Project

www.2coenergy.com

BOC has agreed to take a 15 per cent stake in the development of the 2Co Energy's Don Valley CCS Power Project in South Yorkshire.

Under the agreement with 2Co, BOC and its parent company Linde will be contracted to supply the carbon capture technology and air separation units (ASUs) for the CCS plant, which will be built at Stainforth in the Humber Gateway.

Earlier this year, Samsung C&T agreed to take a 15 per cent equity stake in the power project.

Initially, BOC will work with 2Co Energy's other contractors to

complete the project's revised FEED (Front End Engineering and Design) study. Linde Engineering will construct the twin ASUs which will produce the oxygen needed for the coal gasification process, and the carbon capture process will use Linde's Rectisol technology. The ASUs will have the biggest air separation capacity in Europe, each producing around 3,000 tonnes of oxygen a day. BOC will also provide operations and maintenance services for the ASUs.

The Don Valley Power Project is one of the most advanced and

cost-competitive CCS projects in Europe. The 650MW project will

generate enough reliable low-carbon electricity to power one million UK homes from 2016.

The project aims to anchor a 'cluster' of additional CCS projects in the Humber Gateway region. The Yorkshire-Humber region contributes around 18 per cent (90mt CO2/yr) of the UK's annual CO2 emissions.

Global CCS Institute to facilitate CCS knowledge sharing in Europe

www.ccsnetwork.eu

The Global CCS Institute has won a tender to provide secretariat and knowledge dissemination services for the European Commission's Carbon Capture and Storage (CCS) Demonstration Project Network.

The Institute, together with consortium partners TNO, IFP and SINTEF, will provide these services for four years. Delivery of the service started in March 2012.

Currently comprising six leading CCS projects, the Network fosters knowledge sharing amongst European CCS proponents and stakeholders, and strives to improve public understanding of the contribution this technology can make to reducing greenhouse gas emissions.

Services under the €3 million agreement comprise coordination of network secretariat, communications activities, aggregation and dissemination of data, and meeting facilitation.

DECC announces potential UK CCS competition entrants

www.decc.gov.uk

The UK Government has published a list of companies that have signalled their intention to apply to the new UK CCS competition.

Publication of the list is aimed at encouraging further discussion within the CCS industry to support collaboration between companies and any interested suppliers.

The list covers companies that have indicated that they will lead a bid and not all companies that may be involved in that bid. It is not a list of applicants – the closing date for bids remains 3 July.

Over the coming weeks DECC will continue to hold meetings with potential bidders to ensure that Government and Industry continue to work together and bidders can submit their best bids possible.

DECC will also be making bidder documentation available in the coming weeks.

U.S. DOE sponsored project aims to reduce CCS costs

www.nationalcarboncapturecenter.com

Results from the project at the Department of Energy's National Carbon Capture Center (NCCC) may ultimately lead to lower-cost carbon-capture technologies.

Changes in operating conditions coupled with changes in commercially manufactured catalysts can produce both power generation increases and significant cost savings at Integrated Gasification Combined Cycle (IGCC) power plants, according to new research from a U.S. DOE-sponsored project.

Advanced power plants using IGCC technology convert coal into a synthesis gas, or "syngas," which can then be combusted to produce electricity. The syngas contains combustible hydrogen and carbon monoxide (CO), along with water, nitrogen, and CO2, a greenhouse gas.

To capture CO2 and prevent its release into the atmosphere, the syngas is "shifted" in a chemical process called the water-gas shift (WGS) reaction. The reaction converts CO into CO2 in the presence of a catalyst and steam and produces additional hydrogen for combustion. A large amount of steam ensures maximum conversion of CO and inhibits side reactions, but it also reduces the overall efficiency of the IGCC plant. The amount of steam is quantified by the steam-to-CO ratio of the gas fed to the WGS reactor.

Testing a variety of commercially available WGS catalysts, NCCC researchers were able to significantly reduce the steam-to-CO ratio while still achieving high CO conversion without side reactions. A reduction in the ratio translates into increased net power output and a smaller increase in the cost of electricity associated with carbon capture. Specifically, the 1.0 reduction in steam-to-CO ratio that was achieved corresponds to a 40-megawatt increase in power generation in a 500-megawatt IGCC plant. This could result in cost savings of more than $275 million over a plant's estimated 30-year lifespan at current IGCC power costs of about $33 per megawatt-hour.

NCCC researchers are providing the test results to manufacturers to assist them in specifying future WGS systems for IGCC plants that incorporate carbon capture. The researchers are also planning further tests with other commercially available, newly formulated WGS catalysts. In addition, the findings are being implemented at a commercial IGCC plant now under construction in Kemper County, Miss. The plant will showcase a transport gasifier technology developed at the NCCC.

Located in Wilsonville, Ala., the NCCC is a state-of-the-art test facility dedicated to the advancement of clean coal technology. The Office of Fossil Energy's National Energy Technology Laboratory, in cooperation with Southern Company Services, established the NCCC to bolster national efforts to develop cost-effective technologies to capture the CO2 produced by fossil-fueled power plants and help secure the nation's energy future.

CCUS to feature in demonstration sessions at Pittsburgh Coal Conference

www.netl.doe.gov

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) has organized a series of information sessions, titled 'Clean Coal Demonstration and Commercial Projects', to be presented at the 29th Annual International Pittsburgh Coal Conference (PCC), October 15-18, 2012.

The sessions will address two sides of large-scale clean coal technology (CCT) projects.

In six technical sessions, speakers will review the status of current U.S. and international demonstration and commercial projects for coal-based power, fuels, and chemicals production, including carbon capture, utilization, and storage (CCUS), advanced gasification and combustion systems, syngas clean-up and utilization, and regulatory impacts on demonstration and commercial

projects.

In three business sessions, presenters will address the financing of CCUS and other CCT projects, as well as investment and risk management strategies for advanced coal technologies demonstration and commercialization projects.

PCC will be held at the David L. Lawrence Convention Center in Pittsburgh, PA and is co-hosted by the University of Pittsburgh's Swanson School of Engineering and NETL.

California's Hydrogen Energy project moves forward

hydrogenenergycalifornia.com

SCS Energy California (SCS), the owner of the Hydrogen Energy California (HECA) project, has filed with the California Energy Commission an amended application for certification of the plant, underscoring its commitment to building the 300-megawatt power plant.

The HECA project is co-funded by the U.S. Department of Energy and administered by the National Energy Technology Laboratory (NETL) under its Clean Coal Power Initiative (CCPI-Round 3).

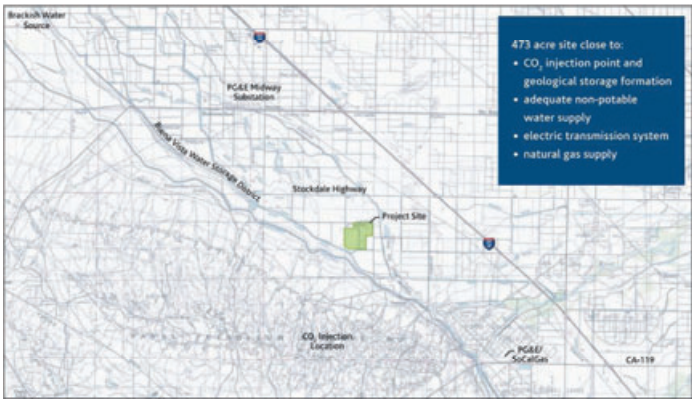
SCS said the action will create thousands of construction and permanent jobs, is a major step to promote clean energy and will advance California's long term climate strategy.

The filing resumes a comprehensive regulatory review process which, upon approval, would grant permission for construction and operation of one of the world's first hydrogen powered plants with carbon capture, utilization and storage (CCUS).

HECA is an Integrated Gasification Combined Cycle project that will manufacture hydrogen to be used to generate nearly 300 megawatts of low-carbon electricity and to produce low-carbon nitrogen based products, such as fertilizers. The products and power produced by the project have a lower carbon footprint than similar products produced from the combustion of fossil fuels, including natural gas. This low-carbon footprint is accomplished by capturing more than 90 percent of the carbon dioxide (CO2). CO2 will be transported for use in enhanced oil recovery (EOR) in the adjacent Elk Hills Oil Field (EHOF) owned and operated by Occidental of Elk Hills, Inc. (OEHI).

HECA has been an important public-private partnership with the U.S. Department of Energy. Project development is supported in part by a $408 million grant that was competitively awarded to HECA in recognition of the project's importance in demonstrating critical carbon capture and enhanced oil recovery technology at a commercial scale.

Since acquiring the project, SCS has modified the former HECA design to improve its economic viability and better serve market needs, while continuing to adhere to the strictest environmental standards. In addition, HECA has selected Mitsubishi Heavy Industries' oxygen-blown dry feed gasification technology as a key component of the project. The Project will gasify a blend of coal and petroleum coke to produce hydrogen-rich gas. Because the project has new and improved features from the original HECA design, the project team developed and submitted an amended permit application for regulatory review.



Site of the Hydrogen Energy California IGCC project

Powertech Labs to help design carbon capture and recycling plant

www.powertechlabs.com

Powertech has signed a technology development agreement with Mantra Energy Alternatives, a subsidiary of Mantra Venture Group.

As part of the agreement, Powertech will provide testing facilities and expertise to advance the technology behind Mantra's Electro-reduction of Carbon Dioxide (ERC) process.

Additionally, Powertech will help design the ERC demonstration unit for the pending carbon capture and recycling (CCR) pilot project with Lafarge Canada.

Mantra's ERC process is a form of CCR that aims to capture CO2 from industrial activities, such as cement production, and convert it to marketable chemicals like formate salts or formic acid. The ERC pilot facility will be operated at the Lafarge cement plant in Richmond, British Columbia.

In preparation for the project, Powertech will be working with Mantra to:

- Identify opportunities to increase performance and scalability of Mantra's existing ERC reactor.

- Design a proof-of-concept CO2 enrichment process suitable for the specific flue gas at the site to add to the front end of the ERC process.

- Create a conceptual design for the pilot plant that is capable of converting up to 100 kilograms of CO2 per day to formate salts or formic acid, and that can operate 24 hours per day.

Mantra also announced that it is working with Pacific Carbon Trust, a British Columbia Crown corporation, to assess the potential for Mantra's ERC process to generate carbon offsets, which could help the technology move towards full commercialization.

UK's CCS Cost Reduction Task Force appoints chair

www.decc.gov.uk

The position of Chair of the UK's Carbon Capture and Storage Cost Reduction Task Force has been accepted by Dr Jeff Chapman.

The Task Force is being set up to help tackle the challenge of ensuring that CCS is cost competitive with other low carbon technologies by the early 2020s.

Dr Chapman is Chief Executive of the Carbon Capture and Storage Association, the body which represents the UK's CCS industry. He said:

"I am delighted and honoured to accept the position of Chair for the CCS Cost Reduction Task Force. CCS will be an essential and cost-effective technology solution in the mitigation of climate change. Similar to other low-carbon technologies, CCS will incur additional costs in the early years of deployment, but with good planning and optimisation it will be possible to drive down costs in a short timeframe. The sooner we set about this task the sooner we will get on track for cost-efficient decarbonisation of power and industry."

The objective of the Task Force is to advise Government and industry on the steps needed to reduce the cost of CCS for the next wave of projects after the Government's CCS Commercialisation Programme. The Task Force will play an invaluable role setting out a vision for the next phase of development for CCS and securing industry agreement to the shared actions that Government and industry must take. The Task Force will produce a final report in early 2013.

Capture news

Imperial College London opens £2 million carbon capture pilot plant

www.imperial.ac.uk/chemicalengineering

Imperial's carbon capture pilot plant will provide hands-on education in a controlled environment for the College's undergraduate engineers.

The plant demonstrates how CO2 emissions can be captured by a power plant. Through this, students will learn the principles that can be applied in a range of industrial settings including petrochemical plants. It is expected over 8,000 undergraduates will be trained during the plant's predicted 25 year lifespan.

The Plant will also perform several other roles: a summer school for engineering students from around the world; a laboratory for Imperial academics who are improving technology to capture CO2 emissions; and a location for the energy and chemical engineering sector to train staff in the capital.

Dr Daryl Williams, Director of the Pilot Plant Project at Imperial College London, says: "This plant gives Imperial students the opportunity to run one the most sophisticated carbon capture pilot plants in the world – quite a contrast from spending time in seminars and lectures. We can create a range of scenarios for students, so that they can experience and help to solve the problems that engineers in the real world face every day."

The plant separates 1.2 tonnes of CO2 from other harmless emissions in a continuous process that sees the gases remixed and separated again and again to demonstrate how industry in the future would capture CO2 emissions.

The technology behind Imperial's plant works by capturing the CO2 in an "absorber column", where a solution called monoethanolamine (MEA) captures the CO2 in droplets and transports it to a "stripper column" that heats the MEA and strips out the CO2 so that it can be stored. Each day, the process separates 1.2 tonnes of CO2, which is stored and then recycled for use again the next day in the demonstration.

Some of the world's most advanced equipment for monitoring and controlling chemical plants is being trialled in Imperial's facility to enable students to learn about some of the devices that they may be using in industry in a few years' time. The plant includes 250 sensors that monitor a range of things including temperature and pressure, some of which are wireless or powered by excess energy harvested from the plant, and four surveillance cameras, enabling students to zoom in and monitor any aspect of the facility in real-time.

Students will also be able to dial in to the Plant using their iPads to carry out mock repairs to the facility. The idea behind this technology is that undergraduates will learn how engineers in the future will be able to be offsite and still communicate with staff, monitor situations and get remote access to the systems to solve problems.

The control room, the nerve centre of the plant, is sponsored by the power and automation company ABB. The room has been ergonomically designed to minimise fatigue, reduce stress on the body, eliminate eye strain and optimise efficiency in students while training.

During training exercises, students can take part in a range of scenarios including an emergency situation, where the room morphs: desks rise and screens move forward, so that students can practise their emergency response in line with industry recommendations for a crisis, which includes working from a standing position in a calm environment.

New system reduces carbon capture costs by $20 per tonne

www.co2crc.com.au

A solvent similar to baking soda is the centrepiece of a new carbon capture system that can reduce the cost of capturing carbon dioxide from power stations by at least $20 per tonne compared to current technology.

The UNO MK3 system, developed by the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), integrates several research streams to reduce separation costs.

CO2CRC Chief Technologist Barry Hooper said that a focus on the big picture was the key to the technology. "CO2CRC capture research focuses on three aspects of carbon capture to make improvements to the overall system – the separation medium, the right equipment and integration with power plant operations," he said.

The first aspect of UNO MK3 is a separation system using potassium carbonate, a solvent similar to baking soda, which may reduce energy requirements by up to 20 per cent. The precipitating process also produces a by-product that can potentially be used in fertiliser manufacture.

Secondly, fit for purpose equipment designed by CO2CRC has reduced costs. For example the patented concentric concrete columns are smaller and cheaper to build than stainless steel columns.

The third thread is that of heat and process integration. By integrating the capture process into the power station, CO2CRC has been able to reduce the system's energy use by at least 25 per cent.

Masdar Institute to hold summer research project on amine-based solvents

www.masdar.ae

The Masdar Institute of Science and Technology will offer a research project on amine-based solvents for post-combustion carbon capture as part of its six-week summer internship programme for UAE nationals.

Named "Development of Advanced Amine-Based Solvents for CO2 Post-Combustion Capture," the program is open to UAE national students from Chemical Engineering or Chemistry with some experience or interest in handling chemicals and laboratory equipment.

The summer internship programme is scheduled to commence on 1st July, with applications due by 3rd May.

The research project is focused on the development of advanced chemical sorbents for carbon capture and the major tasks including synthesizing, screening, and evaluating new chemical solvents for CO2 separation from flue gas.

Siemens and Masdar Institute CCS research project completed

www.energy.siemens.com

Siemens and the Masdar Institute of Science and Technology have successfully conmpleted their first CCS research collaboration project.

The collaborative R&D projects are focused on the improvement and adaptation of the proprietary Siemens Post-Combustion technology to the requirements of the local markets, i.e. CO2 capture at gas fired power stations and utilization of CO2 for enhanced oil recovery (EOR).

The first project, "Evaluation of CO2 Purification Requirements and Evaluation of Processes for Impurities Removal from the CO2 Product Stream", began in May 2011. The project evaluated the CO2 purification requirements for the CO2 pipeline transportation, enhanced oil recovery (EOR) and CO2 geological storage. Furthermore it assessed the CO2 streams specifications and impurities combined with the selection and evaluation of the processes for CO2 stream purification.

C-Capture developing safe non-amine solvents

C-Capture, a company commercialising technology developed at Leeds University in the UK, is developing novel non-amine solvents for the capture of carbon dioxide from flue gas streams.

By Danny Lynham, C-Capture

Our philosophy is to develop novel solvents that have a benign toxicological profile, can be produced from renewable sources and can capture and release CO2 more efficiently than incumbent technology. The most well developed and benchmark technology is that of amine systems.

C-Capture has taken the approach of utilizing, as close as possible, the same temperature swing capture/release cycle as has been used most in post-combustion carbon capture engineering systems.

By keeping the engineering systems as close as possible to the tried and tested amine type systems, C-Capture is minimizing the engineering (technology) risk and investment required for implementation – it is precisely this reason why C-Capture has been building a bespoke development facility at the Innovation Accelerator on the Wilton Centre site.

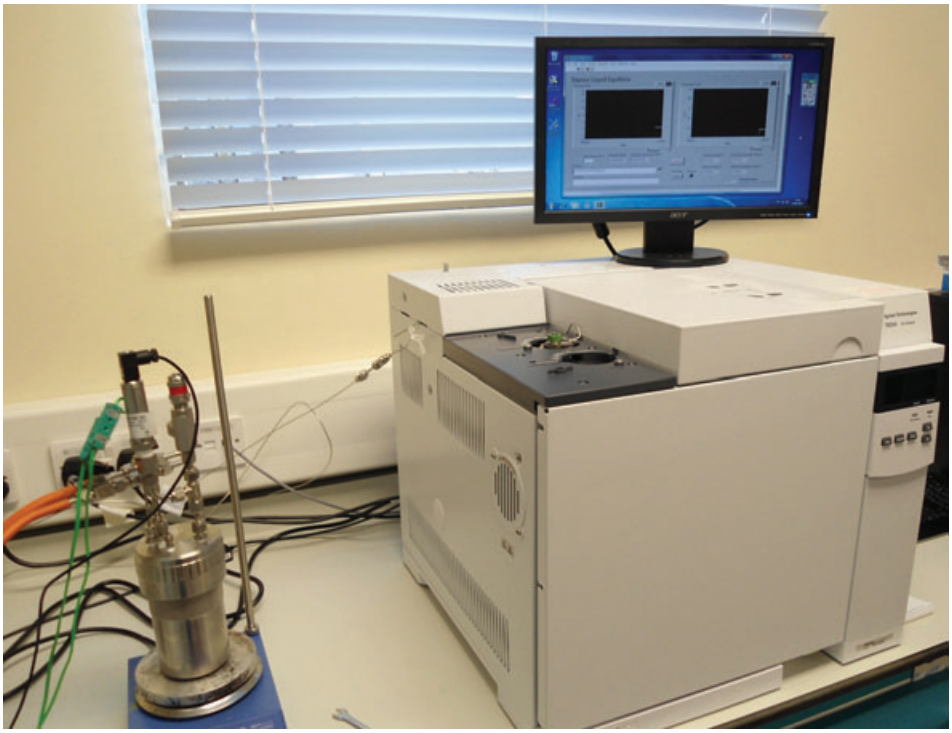
This development centre consist of a 'pre-pilot scale' test rig and has been designed to test solvent systems "straight from the lab", as Prof. Chris Rayner, founder and Director of C-Capture explains;

"Our rig has been specifically designed to fill a gap that exists in the solvent design and testing cycle. It is tremendously difficult to demonstrate the efficiency and continuous operation of genuinely new and novel solvents that have been developed inside of a laboratory environment at the 1g CO2/hour scale, by taking them to a test facility that might require 1,000kg CO2/hour to run.

We have built our solvents from the ground-up on new chemistry researched at the University of Leeds – not just re-engineering or tweaking existing formulations.

The tool box in the existing chemistry has its limitations and there are a lot of unknowns in the long-term stability and toxicity of some of the species. More research is required into what these might be.

We have designed our solvents to be a cradle-to-grave renewable where possible using 'environmentally responsible' materials – whilst delivering improved technical performance. Our initial results have been incredibly encouraging and we are awaiting results from our pre-pilot rig that will demonstrate this on an industrially relevant scale."



The C-Capture VLE (vapour-liquid-equilibrium) equipment including a pressurized container and sampling system, with GC analysis.

C-Capture's solvent development work is completed at the University of Leeds where the company has access to cutting edge research laboratories and analytical tools allowing precise measurements of solvents and any byproducts in any part of the chemical process – this includes a VLE (vapour-liquid-equilibrium) measurement system that can actively measure the change in atmospheric composition in the chamber over time, and at varying temperatures and pressures – an important aspect of any solvent/gas system.

By taking the approach of using new, non-amine, chemical solvents whilst utilizing the existing engineering technology C-Capture are evaluating the

Close-up of the VLE (vapour-liquid-equilibrium) measurement system

capture/release cycle as a whole and will be using data generated from the development facility to model the economic process for the system as a whole, and not just the capture + release stages. This should provide invaluable information to compare with existing systems.

C-Capture has been funded by IP Group plc, including funding from the North East Technology Fund. Duncan Lowery, a Director of the fund stated "C-Capture is a fantastic business that is absolutely of its time and which could put the North East on the map in terms of this emerging green technology.

It is a good example of the type of clean technology we are seeking to back, that is, it makes sense in today's economy as well as having significant future potential. We have real confidence in the C-Capture team and believe the specialists there are well placed to make a vital difference at a time when expertise in this field is still limited."

For the next stage of development, C-Capture will look for engineering partners to test the solvent systems in even larger scale testing, with a view to develop the technology jointly and offer a strong differentiator for CCS engineering solutions.

The C-Capture team (L to R): Dr. Doug Barnes, Prof. Chris Rayner, Duncan Lowery, Danny Lynham, Richard Dennis and Caspar Schoolderman (photo taken at the Wilton Innovation Accelerator facility that houses the rig)

More information

C-capture was formed in 2009 as a spin-out from the Department of Chemistry at the University of Leeds, based on IP generated through many years' experience working in the area of CO2 chemistry.

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www.leeds.ac.uk

Transport and Storage news

North American Carbon Storage Atlas published

www.nacsap.org

The United States, Canada and Mexico have collaborated on the first-ever atlas which maps the potential carbon dioxide storage capacity in North America.

According to the North American Carbon Storage Atlas (NACSA), there is at least 500 years of geologic storage for carbon dioxide emissions in North America. These areas could be used for storing carbon from industrial sources or power plants.

In addition to estimating the storage capacity for North American oil and gas fields, coal fields and saline reservoirs, NACSA also notes the location of a total of approximately 2,250 large stationary carbon dioxide sources.

Documenting the location of large stationary carbon dioxide emission sources and the locations and storage potential of various geological storage sites helps quantify the benefits and opportunities for potential carbon capture, utilization and storage (CCUS) projects.

Created through the North American Carbon Atlas Partnership, a joint cross-border mapping initiative by the United States, Canada, and Mexico, NACSA includes both low and high estimates for potential carbon dioxide storage capacity in North America. The low case estimates potential capacity of 136 billion metric tons for oil and gas fields; 65 billion metric tons for coal fields; and 1,738 billion metric tons for saline reservoirs, collectively representing over 500 years of storage.

Also being launched alongside the hard-copy atlas are the NACSA website and online viewer. The website contains information about CO2 stationary sources and storage resources in North America, as well as methodologies for estimating storage resources and links to additional information.

The online viewer is accessible from the NACSA website and houses data from all three countries, along with analytical tools to address CCUS deployment. Intended for a broad range of users, the online viewer gives users interactive access to the map layers and data used in the atlas.

Future geological storage options in North America

CO2 Capture Project launches interactive educational tool

www.co2captureproject.com

The CO2 Capture Project (CCP) has released an interactive version of its popular 'In Depth' brochure.

The interactive version allows online

visitors to go on a journey underground to find out more about CO2 capture and storage and offers a spatial perspective on CO2 storage.

The digital In Depth tool is available to view on the CCP Multimedia page.

U.S. DOE publishes new CCUS best practices manual

www.netl.doe.gov

Best practices for managing wells used to store CO2 in geologic formations are the focus of a publication just released by the U.S. Department of Energy (DOE)'s National Energy Technology Laboratory (NETL).

The newest manual in the Department's series on current best practices associated with carbon capture, utilization, and storage (CCUS), Carbon Storage Systems and Well Management Activities covers the planning, permitting, design, drilling, implementation, and decommissioning of CO2 storage wells.

The manual builds on lessons learned through NETL research, the experiences of the laboratory's regional partnerships in conducting CCUS field tests, and the acquired knowledge of industries that have been actively drilling wells for more than 100 years.

The manual as well as other publications concerning carbon storage, are available on NETL's CCUS reference shelf.

Could CCS cause induced seismic activity?

Two recent publications have raised the question of CO2 storage activities causing induced seismic events. Scientists from the U.S. Clean Air Task Force (CATF) and the Petroleum Technology Research Council (PTRC) have responded.

A report from the U.S. National Research Council suggested that CCS may have the potential for inducing seismic events.

The report examined the potential for energy technologies , including shale gas recovery, CCS, geothermal energy production, and conventional oil and gas development, to cause earthquakes.

The report suggested that CCS may potentially induce seismic events because significant volumes of fluids are injected underground over long periods of time.

However, insufficient information exists to understand the potential of carbon capture and storage to cause earthquakes, because no large-scale projects are as yet in operation. The committee that wrote the report said continued research will be needed to examine the potential for induced seismicity in large-scale carbon capture and storage projects.

At the same time, Mark Zoback and Steven Gorelick in the Proceedings of the National Academy of Sciences argued that, "there is a high probability that earthquakes will be triggered by injection of large volumes of CO2 into the brittle rocks commonly found in continental interiors. Because even small- to moderate-sized earthquakes threaten the seal integrity of CO2 repositories, in this context, large-scale CCS is a risky, and likely unsuccessful, strategy for significantly reducing greenhouse gas emissions."

Petroleum Technology Research Council

Dr. Malcolm Wilson, Chief Executive Officer of the PTRC, said they welcome such opinions being expressed and agree that this issue warrants continued debate. "The issue is not new and has not been ignored in research; indeed, there is already much science- based debate on the impacts of induced seismicity," he said.

The PTRC is currently in the final stages of writing and editing a Best Practice Manual for validating CO2 geological storage, arising from the completion of research in the Weyburn-Midale Project, and its conlusions included:

• Seismic activity in context

As noted in some media coverage of Drs. Zoback's and Gorelick's piece, any oilfield work (whether drilling a well or deploying enhanced oil recovery techniques such as water flooding) has the potential to produce microseismic activity, and in some cases small magnitude earthquakes. The Weyburn-Midale Project has used various measurement methods, including underground seismic monitoring and 3 and 4-dimensional seismic imaging, during the characterization of the Weyburn oilfield and the subsequent monitoring of CO2 in the subsurface. Microseismic events having moment magnitudes of less than -1 have been recorded. This sort of activity is so minute that it is measurable only with the most sensitive equipment deployed deep underground.

• Trapping mechanisms and seismic activity

The theoretical implications of Drs. Zoback's and Gorelick's work suggest seismic activity (earth quakes) associated with large-scale injection of CO2 may potentially compromise the trapping mechanisms of these reservoirs (caprock). In the case of Weyburn and Midale, this would suggest that the mechanisms which have kept the oil and gas in place in the reservoir (and into which the CO2 is being injected) may be compromised by either the reactivation of faults or the creation of new ones by such seismic events. In 11 years of research, no such fault reactivation or creation has occurred at Weyburn and the Caprock remains intact – this, despite the industrial scale injection of close to 2.8 million tonnes of new CO2 per year (more than 5 million tonnes annually if recycled CO2 is included). Faults are, in many cases in relation to the trapping of oil and gas, actually a desirable geologic structure, and offer increased retention of fluids and gases in the subsurface.

Clean Air Task Force

Dr Bruce Hill, senior staff geologist at CATF, rebutted the claims.

"Taken together, the weight of evidence suggests that CCS technology is viable and that a combination of storage options will provide capacity for large volumes of captured CO2," he said. "Whether all the carbon dioxide emitted by industrial activities in the U.S. and around the world can be captured and stored remains to be seen, but CCS is viable and has an essential important role to play in reducing greenhouse gases. With numerous small-scale CO2 injections and four decades of EOR under our belt, now is the time to invest in the understanding of large-scale geologic storage, rather than abandon it.

More information

www.nationalacademies.org
www.nap.edu
www.pnas.org
www.catf.us
www.ptrc.ca

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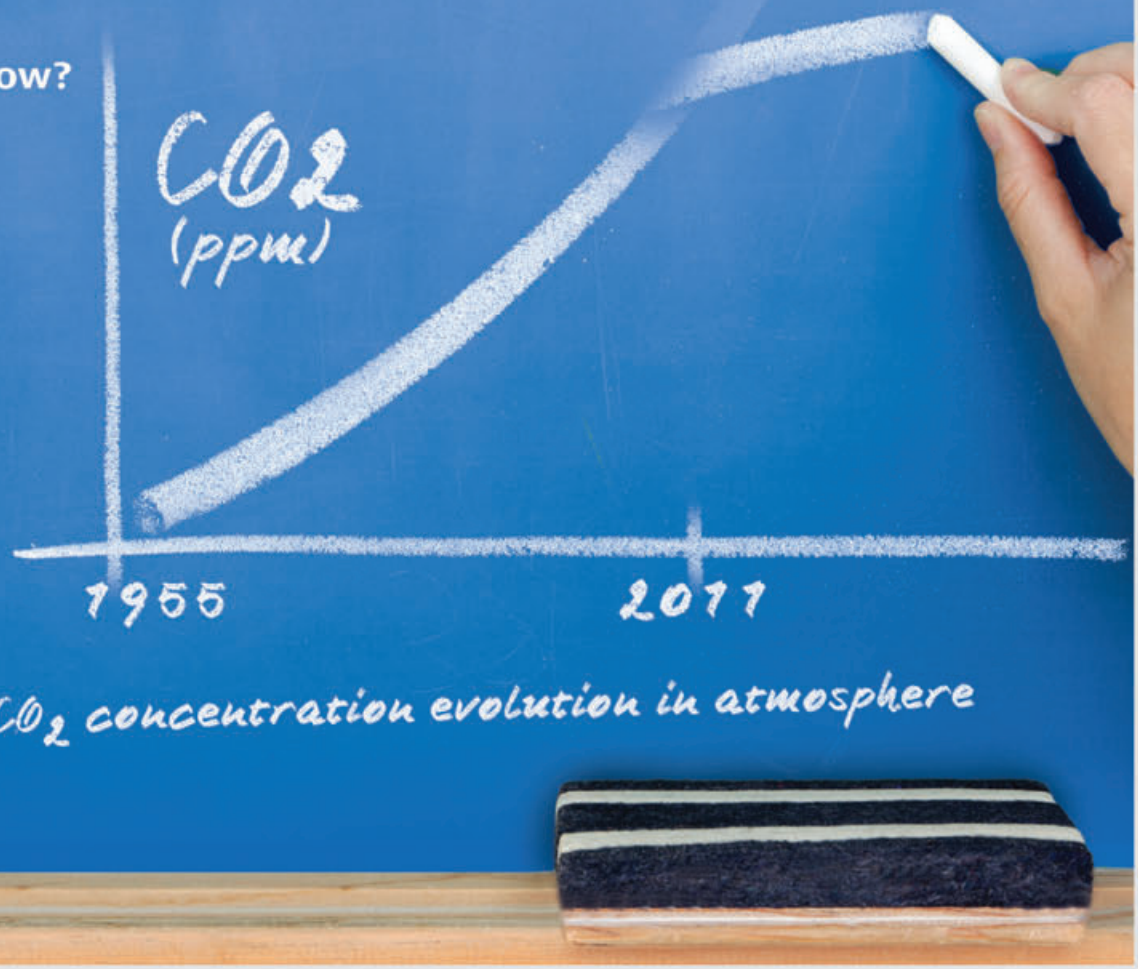

CO_2 concentration evolution in atmosphere

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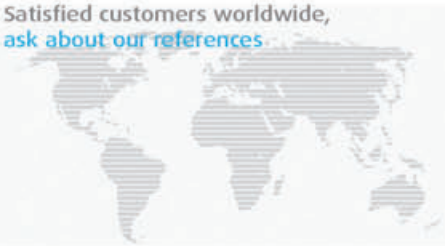

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