Carbon Capture Journal

CCS in Australia

Loy Yang post combustion carbon capture PICA pilot plant

Otway project moves to Phase 3

CarbonNet progresses to commercial phase

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Australian Carbon Capture Utilisation and Storage: are we there yet?

New test campaign at Technology Centre Mongstad

Setbacks for CCS as Kemper and ROAD projects cancelled

Statoil evaluating new CO2 storage project in Norwegian waters

ETI report says enough CO2 storage capacity for UK until at least 2050

CCS IS viable and we can use it to create jobs and hit climate targets

A new report casting doubt on the viability of the climate change technology, carbon capture and storage, was covered by The National.

By Indira Mann, Scottish Carbon Capture & Storage (First published in The National)

The report by energy economist, Prof Gordon Hughes, for the Global Warming Policy Foundation (GWPF), claims that CCS will never be realised due to its high cost.

It points to millions already spent in "trying to get carbon capture to work for coal-fired power stations" and suggests that, in a future where coal will still be relied upon, in developing countries at least, CCS will be too expensive to deploy.

The GWPF is a think tank set up to challenge what it claims are "extremely damaging and harmful" policies aimed at mitigating climate change, and it calls into question the scientific basis for taking action.

Climate change is no myth. It is already affecting millions of people, and adversely impacting on ecosystems, around the globe. More than nine out of 10 climate scientists agree that its cause is carbon emissions. In 2013, a review of more than 4000 research papers showed that 97 per cent of them pointed to humans as the cause of global warming.

That brings us to the potential for CCS technology, alongside using energy more efficiently and weaning ourselves off fossil fuels for good.

Full-chain CCS is already operating worldwide – on natural gas production, on refining and, yes, on coal-fired power. Last year, Norway celebrated 20 years of safe operations at its Sleipner natural gas field. Sleipner and a subsequent project, Snohvit, have collectively stored over 20 million tonnes of CO2 and shown that North Sea CCS is both technically viable and geologically secure.

We have a huge and as yet untapped opportunity to deliver CCS in the UK. It has failed to get off the ground here, not because it is a "Utopian dream" or "too expensive" but because of last-minute Treasury U-turns and a lack of clear policy for investors to rely on.

In Scotland, the government recognises the value of CCS as a means of achieving climate targets (domestic and Paris Agreement obligations), building a new economic opportunity, transitioning the skills and workforce of the oil and gas industry and exporting Scottish expertise.

The Teesside Collective, a grouping of industrial emitters, is developing plans for an industry "cluster" sharing access to offshore CO2 storage

A new industry making use of our vast and well-understood CO2 storage resource beneath the North Sea could serve the rest of Europe, which has a lot of carbon to shift. Hughes focuses on coal, but CCS has wider applications. Currently, it is the only technology that can help industry tackle emissions while remaining competitive.

The Teesside Collective, a grouping of industrial emitters, has recognised this opportunity and is developing plans for an industry "cluster" sharing access to offshore CO2 storage. In Scotland, we have similar opportunities, for example, at Grangemouth, where Summit Power is designing a CCS project featuring a natural gas power station.

There is now much talk about the potential for hydrogen production with CCS to deliver zero-carbon heat and transport, which create a sizeable slice of our domestic emissions. Leeds City Gate H21 is one project worth checking out. Hydrogen is also being actively considered in Scotland: our draft Energy Strategy mentions hydrogen explicitly.

The cancellation of the UK Government's CCS Competition wounded but did not kill hopes for delivering CCS here. We have learned from the experience and reshaped our approach. At SCCS, hundreds of researchers are working on delivering a cost-competitive, safe and effective CCS industry worldwide at a scale that can give us a fighting chance of reining in climate change.

In 2015, a study by the Energy Technologies Institute said a failure to deploy CCS would double the annual cost of reducing carbon emissions to the UK economy "from circa one per cent to two per cent of GDP by 2050". And if we don't get to grips with climate change, dealing with the consequences will knock any other costs right out of the ballpark.

More information

www.sccs.org.uk

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Front cover:
Examining core samples from South West Hub CCS Project near Perth
Back cover:
PICA post-combustion capture project against AGL Loy Yang brown coal-fired power station

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Leaders - CCS in Australia

Projects and policy

Capture and utilisation

Transport and storage

Australian Carbon Capture Utilisation and Storage: are we there yet?

How often has it been said that carbon capture and storage (CCS) has "missed the boat", is "too expensive", or other comments in a similar vein? Are these statements factual? By looking back over the last 10 years at the Australian and global CCS scene, a large number of changes and leaps forward have been achieved to advance the research and the commercial deployment of not only carbon capture, but CO2 utilisation as well as storage.

By Linda Stalker, Science Director of the National Geosequestration Laboratory

In Australia, capture activities have been demonstrated at small scale, and several examples come to mind, from the Callide Oxyfuel Project in Central Queensland which aims to demonstrate technology that can reduce emissions by up to 90% from coal combustion, to the post-combustion and capture technology that has been demonstrated at the Hazelwood Power plant in Victoria.

While this article generally reviews storage activities, researchers and industry are increasing focusing on carbon utilisation, to demonstrate potential development of new products that are based on the abundant supply of CO2 at the end of other processes such as fertiliser production.

At the most recent Greenhouse Gas Technologies conference, it was acknowledged that while interest and focus grows in utilisation, the amount of carbon-based feedstock is far in excess of the volumes that can be used to generate new products. Rather, utilisation could be seen as a value add, providing additional jobs as a small related plant is developed alongside major CO2 emitters.

A recent announcement in India has seen the development of a capture plant providing clean CO2 as feedstock for a soda ash plant. An Australian company has developed technology that works with the cement and lime industries to capture and use the CO2 in the process. The Norwegian Government's facility at Mongstad continues to test new technologies in all aspects of capture, transport, and utilisation going forward.

Storage assessments have progressed through the support of the Australian Government's Clean Energy Initiative, enabling progress at the South West CCS Hub in Western Australia and CarbonNet in Victoria. The CTSCo Project in the Surat Basin, Queensland has also grown in prominence, through a range of funding efforts to characterise a site in the Surat Basin.

Demonstration projects such as the CO2CRC Otway Project in Victoria, have developed multi-stage approaches to investigating the fate of CO2 and how best to measure, monitor and verify the containment of CO2 over the longer term.

These Australian projects have benefited from international collaboration, to exchange innovative technologies and new ideas. Knowledge sharing and lessons learned have become a major output of all of the operational activities globally as well as the research being conducted.

A world class example anticipated to be the largest CCS project to date, is actually a domestic one, the soon to come online Gorgon Project managed by Chevron on the North West Shelf. This project aims to store 3-4 million tonnes of CO2 per annum when the storage operations commence, likely at the end of 2017.

This sits within a portfolio of new projects internationally that aim to accelerate deployment through new innovations in science and engineering, through sharing lessons learned to reduce risk, cost and uncertainty in deployment of CCS and demonstrating to government, industry and the public of the ability to deliver these large scale multi-disciplinary projects to reduce emissions in the future.

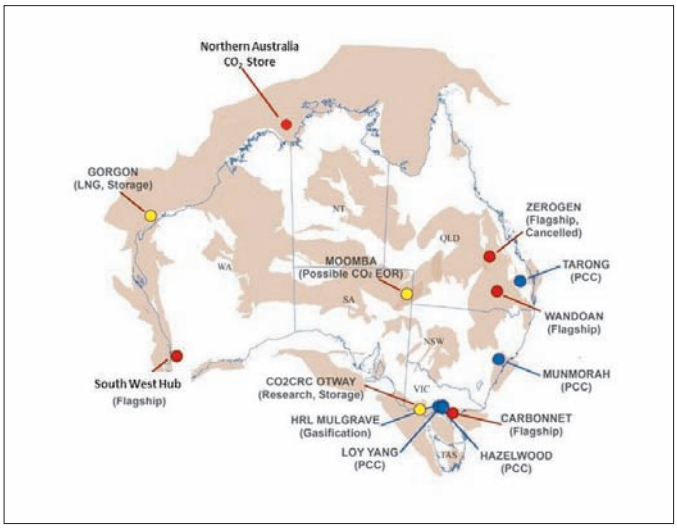

Figure 1 - Australian activities in CO2 capture and storage

The International Case for Emissions Reduction

The Paris Agreement following the 21st Conference of the Parties (COP21) in late 2015 has resulted in many countries committing to set plans and targets towards mitigating emissions that may adversely impact climate. To date, 195 countries have signed and 148 ratified the document to deliver long-term change. CCS is one of the tools being adopted to do this, but so far the introduction of CCS at a commercial scale has been perceived to be slow, complex and expensive.

However, new projects have been coming online globally and lessons have been learned, and shared, as to how to deliver these projects faster and cheaper in the future. A summary of projects by the Global Carbon Capture and Storage Institute (GCCSI) indicates that there are 22 large scale CCS projects that are either under construction or in operation currently. These projects are contributing to-

wards a CO2 emissions reduction of 40 million tonnes per annum.

Most relate to industrial processes such as natural gas processing (e.g. Gorgon, Sleipner), or combined with biofuel energy (e.g. Illinois Industrial Carbon Capture and Storage) or other industrial processes such as fertiliser manufacturing or hydrogen production.

These activities are in the majority as they produce large volumes of fairly high concentration and clean CO2 streams as a by-product of the industrial processes. However, in the area of power generation, the CO2 stream can be lower pressure, lower concentration and subject to a large number of co-contaminants (e.g. SOx or NOx) that can be more difficult and costly to handle.

The retrofit, construction and subsequent operation of the Boundary Dam Carbon Capture and Storage project that commenced in 2014 in Canada was a world first where CCS has been applied to a coal-fired power plant at commercial scale. The fit out of unit 3 enables 115 megawatts of power to be generated while storing up to 1.3 million tonnes of CO2 per annum in addition to clean up of SO2 and other impurities. Through 'learning by doing' at Boundary Dam, the project team has intimated that the next retrofit will be of the order of 30% less in terms of cost.

An associated carbon storage research centre, Aquistore, conducts independent research and monitoring to obtain the research benefits of observing and investigating how the CO2 behaves in the subsurface, and significant data exchange and knowledge sharing occurs through the activities being conducted there. This storage site also acts as a buffer for the plant during maintenance or changes in operation.

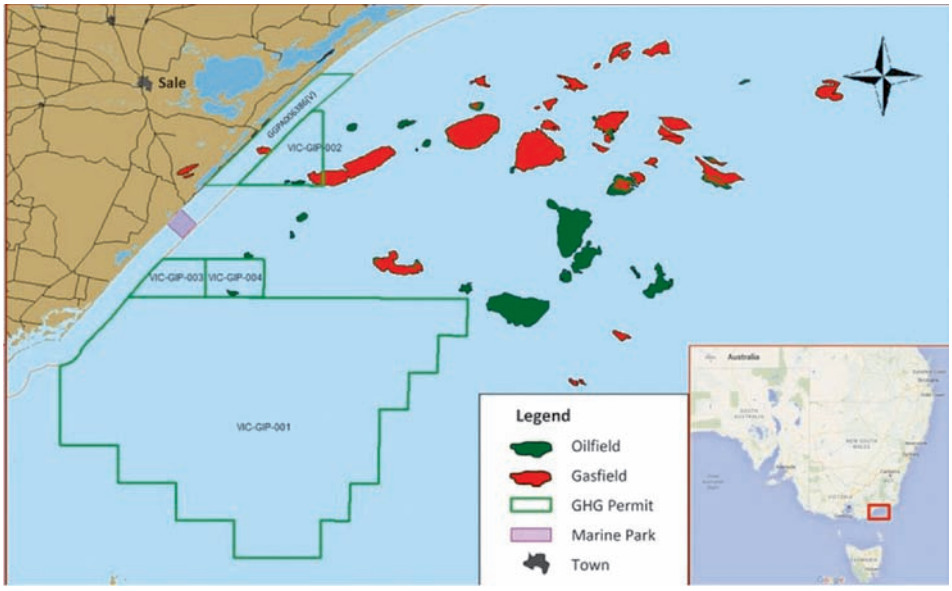

Figure 2 - Areas under investigation for carbon storage as part of the CarbonNet Project

The Australian Scene

There are currently four projects in Australia that are seeking to develop integrated commercial scale capture, transport and storage, while the CO2CRC Otway Project continues to conduct research in these areas (Figure 1). Each project is able to test different aspects of CCS deployment while conducting the prefeasibility activities to evaluate each site.

CarbonNet Project – Gippsland, Victoria

CarbonNet in Victoria is in an offshore environment, adjacent to oil and gas fields, where they are developing a site that will act as a sink for a range of different industries along the Latrobe Valley. CarbonNet manages a set of greenhouse gas assessment permits on behalf of the State of Victoria (Figure 2) and is addressing the identification of potential storage sites through a program of extensive scientific research and engineering studies.

The long-term aim is to be able to store up to 5 million tonnes per annum from brown coal and other industries using a hub model. Key considerations for the project relate to potential basin resource conflicts, with the oil and gas industry in adjacent permits. The community's ongoing interaction with the resource industry in this region can aid conversations to communicate the activities and develop a framework to obtain social license.

The geology of the area is fairly well known from oil and gas industry exploration, and typical reservoir-seal pairs have been identified that can store and trap the CO2 respectively.

Carbon Transport & Storage Company (CTSCo) – Surat Basin, Queensland

CTSCo is conducting a study phase to evaluate how CCS may aid black coal emissions reduction via a technical feasibility study. The activities in the Surat Basin will aid a range of emitters decide how best to manage their emissions in the future by evaluating the geology and what an integrated project might look like. The region is well used to geological investigations, including seismic survey and well drilling because of the proximity of large-scale resource evaluation for the coal seam gas and other conventional resource estimation.

The feasibility study is designed to aid decision making so that first CO2 storage could be demonstrated as soon as 2020/21. Baseline monitoring work on soil gas is already being established so that any natural emissions can be characterised prior to establishing any CO2 injection. The major consideration for this area in terms of basin resource conflict relates to groundwater, with the project located near the Great Artesian Basin, which can be managed through appropriate baseline and ongoing monitoring of aquifer pressure and water quality.

Evaluation of the storage capacity, containment security and injectivity are ongoing, with recent funding provided by the Australian Government through their CCS Research Development and Demonstration Fund aiding data collection and demonstration for the site.

South West Hub CCS Project – Southern Perth Basin, Western Australia

Located about 100km south of Perth, the South West Hub CCS Project (SW Hub) lies

within the Southern Perth Basin. There was little prior geological information for the region before the feasibility study began, but program proponents, the Western Australian Department of Mines & Petroleum (now WA Mines, Industry Regulation and Safety) have conducted an aggressive data collection program to obtain a range of information. Four wells, and an extensive 3D seismic survey have been complemented by a range of R&D projects to characterise the site and with respect to its storage capacity, containment security and injectivity.

This onshore site is a departure from the more conventional CCS geology being tested in the earlier examples (Figure 3). The sandstone storage interval has a large vertical thickness in excess of 1500m, overlain by a series of paleosols (fossil soil horizons) that are thinly interbedded but again vertically extensive (>200m). There is a degree of uncertainty as yet as to how that overlying interval may act as a barrier to CO2 and much further work is required to characterise the rock properties of that layer.

However, the performance of that layer may be less critical than first perceived, based on results of the static and dynamic modelling that has taken place, using the extensive data set available.

The base case dynamic model has shown that for the site, commercial quantities (i.e. 800,000 tonnes per annum) can be injected over a 30 year period into the deepest part of the storage interval, and only migrate about half way up that massive vertical thickness over a 500 year period, such that any reliance on a topseal becomes downgraded in importance (Figure 4).

Even when extreme cases are introduced to stretch the dynamic modelling, parameters such as increased injection volumes, reduced CO2 dissolution (by increasing formation fluid salinity) and reduced trapped gas saturation levels contribute to the CO2 migrating further vertically but the plume still does not reach the overlying paleosols (Figure 4).

This site starts to test non-ideal or less-than-perfect geological sites that are typically seen through an oil and gas industry prism. Increasingly sites that are non-ideal geologically should be evaluated to reduce the distance between source-sink of emissions, but this approach also furthers the understanding of more rapidly screening geological characteristics of future sites as perceived risks are downgraded in the future.

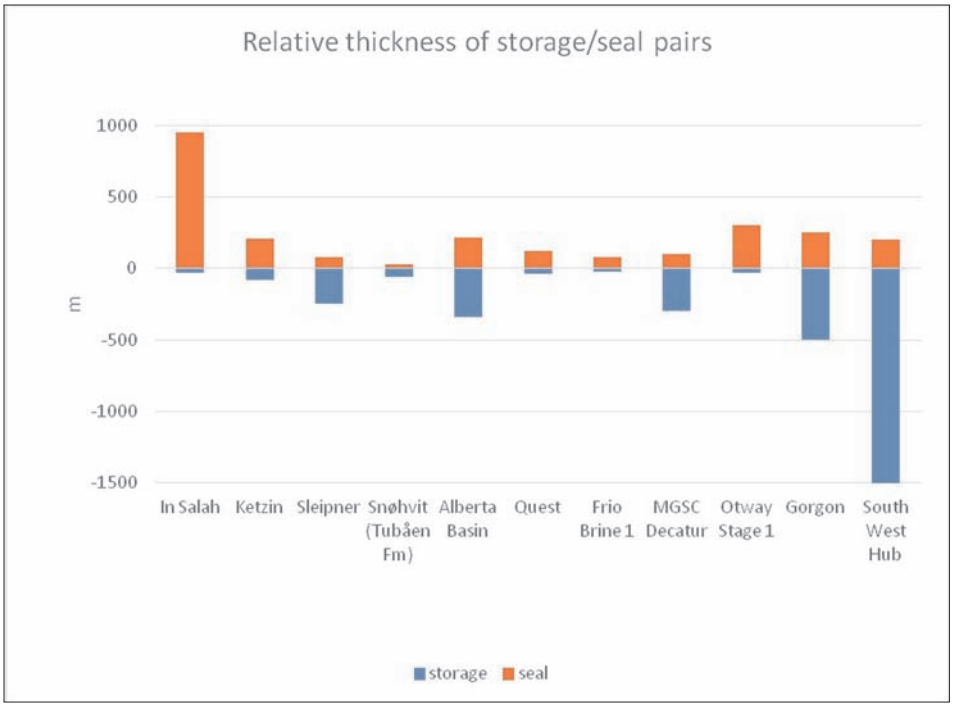

Figure 3 – Seal to storage formation thickness for a range of international projects, demonstrating the vast thickness of the storage interval at the SW Hub site

Northern Australia CO2 Store – Petrel Sub-Basin

The Petrel Sub-Basin has undergone a detailed evaluation by Geoscience Australia (GA) in recent years, to provide some background information on the region so that industry can begin to make some decisions about the potential of the region for geologi-

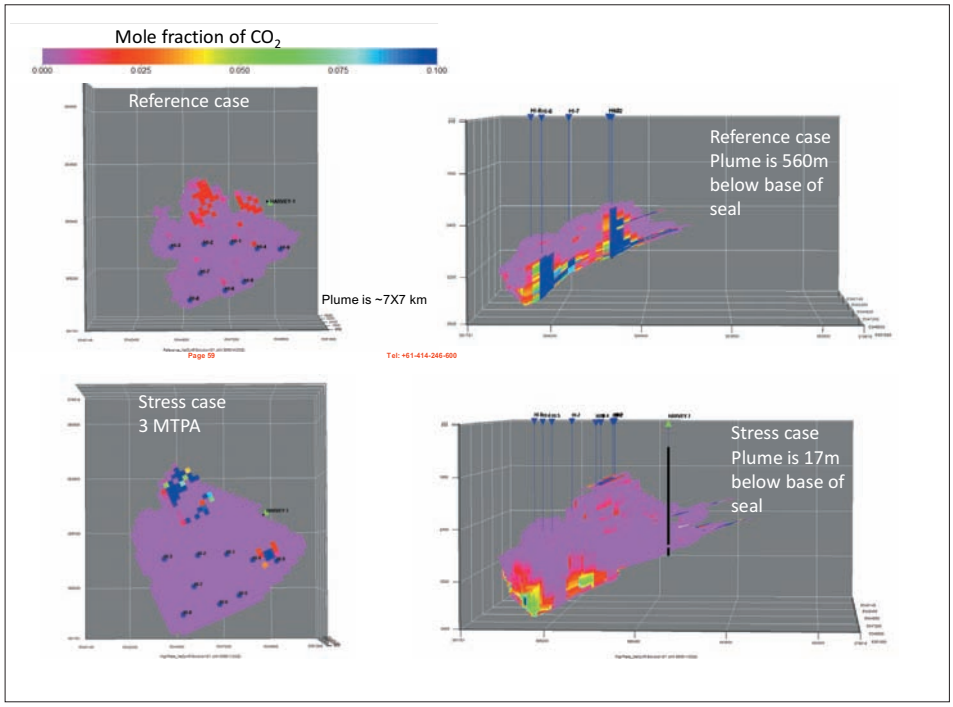

Figure 4 Examples of dynamic modelling of SW Hub. Upper figures of the reference case, using averaged data for CO2 gas saturation, 1 million tonnes per annum (MTPA) injection, 1000 year duration. Lower figures use a stress case of 3 MTPA, lower gas saturation and high salinity examples combined. From WA DMP and Odin Reservoir Consultants.

cal storage of CO2. Of the predominantly gas-rich offshore fields in the area, most have high levels of naturally occurring CO2 within the natural gas reservoirs, and that gas will have to be managed during future production operations. The fields contain from as low as 4 to almost 30% CO2, significantly higher than for the Gorgon project.

The Australian Government's CCS RDD program awarded Shell Australia funding to utilise GA's earlier work build on it to address a range of ongoing uncertainties about the geology, and consider decisions surrounding the potential to locate a future stratigraphic well in the area to obtain new data. This project will elevate interest in the region from the perspective of supplying gas to new infrastructure like Inpex's onshore gas processing facility, Darwin, where long-term gas supply will be of interest.

Additional research on the behaviour of the geology with respect to geomechanical properties and migration and trapping behaviour of the gas in the potential storage intervals will be generated as a part of the program of work for the CCS RDD project, though novel approaches will be required in the absence of core materials from the region (Figure 5).

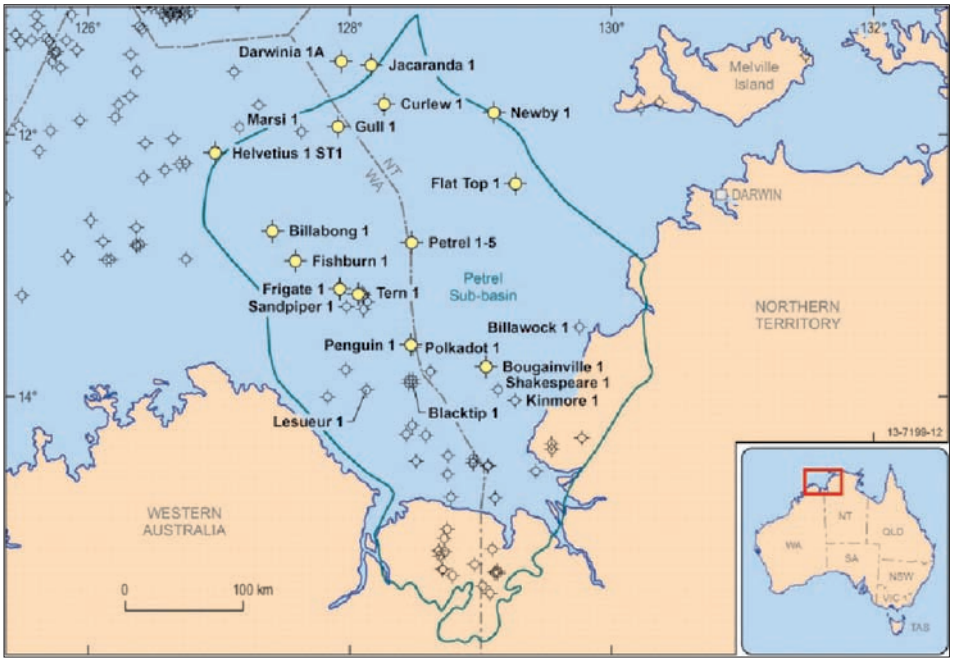

Figure 5 - Location map of region of interest. Wells shown have had core samples taken, however, only reference core remains. New data and materials will be required to reduce risk and uncertainty in developing a Northern Australia CO2 Store in this region

The Australian Portfolio of Projects

The examples above sit in an overall narrative for the projects currently in demonstration, evaluation, and near operational stage that have a broad range in characteristics, from onshore to offshore, have a range of additional basin resource conflicts or have increasingly uncertain or higher risk geological features (Table 1).

	Storage Type	Community Acceptance	Legislative Environment	Other extractive resources to be considered for impacts
Gippsland Basin	Conventional	Currently unknown	In place but untested	Oil and Gas fields
Onshore Otway Basin	Conventional	Good but at a small scale	Customised	Minimal (small gas fields)
Surat Basin CTSCo	Conventional but some reliance on residual trapping	Currently unknown	In place but untested	Coal Seam Gas Coal Great Artesian Basin
Southern Perth Basin	No thick regional shale layer, but high potential of residual trapping	Program ongoing for 5 years and well accepted	In progress and is indirectly being tested through the Barrow Island Act for Gorgon.	Minimal, no oil, gas, geothermal or potable water
Gorgon	Conventional – deep under Barrow island	Chevron as operators working in the area for decades	Barrow Island Act	Oil in upper zones, not in conflict with storage interval
Northern Australia CO_2 Store	Conventional	Fledgling project, data gathering	Unknown	Oil and gas in region

Table 1 - Range of variables at each of the sites participating in CCS storage evaluations currently

CarbonNet's Gippsland site sits in a region used to offshore oil and gas exploration, offshore drilling and production of oil and gas, and has geological formations that are typical of an oil and gas scenario: thinner reservoirs with reasonable to good porosity and permeability and thick, laterally extensive regional seal. This contrasts with the SW Hub's immensely thick storage interval but uncertain topseal.

Onshore and offshore examples are being developed, and the challenge to obtain social license and community expectations of projects are different for each of these potential projects. The CO2CRC Otway Project acts as a small scale test bed of activities to relate to the greater public during the development of commercial scale projects.

So currently, the portfolio of projects being developed in Australia demonstrate an interesting approach to examining a range of geological environments, community challenges and in many cases untested legislation to take these projects to the next level.

The past 10 years has been quite busy with respect to both the commercial scale activities as well as research and development in CCS; one can imagine that the next 10 years will bring some multi-million tonne per annum operating projects to Australia.

More information

CarbonNet:

earthresources.vic.gov.au

CTSCo:

ctsco.com.au

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Loy Yang post combustion carbon capture pilot plant: PICA project

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has collaborated with IHI Corporation (Japanese technology provider) to establish an amine based carbon dioxide capture facility.

By Sanger Huang, CSIRO Energy

The project name PICA is an acronym formed from the project technology focus and the names of the joint partners: PCC, CSIRO, IHI and AGL. The work is supported by BCIA (Brown Coal Innovation Australia) and Australian power generator and retailer AGL. Initial operation of the facility was conducted with 30wt% monoethanolamine (MEA). This was followed by the evaluation of the IHI absorption liquid under 24hr/day 7 days/week operation for 5000hr.

A further evaluation is currently underway evaluating a CSIRO developed absorption liquid for a further 5000hr. The work also includes atmospheric emissions measurements to determine the emissions profile of each amine based absorption liquid. Corrosion impacts of the amine on stainless steel metal will also be examined.

Overview

The PICA project is a research and demonstration of advanced PCC process technologies and assessment of two advanced liquid absorbents. A sophisticated pilot plant has been designed to evaluate the advanced amine process configuration. A special plant design feature includes flue gas pre-treatment, advance amine system, rich split and advance process control.

The pilot plant has been used to assess the performance of two advanced CO2 capture absorbents, IHI's absorption liquid ISOL-162 and CSIRO's CAL007, against the baseline MEA. The IHI and CSIRO absorption liquids will both undergo 5,000 hour duration campaigns to assess the robustness of the absorbents during extended operation with real flue gases. Gaseous emission and corrosion effects will be studied to evaluate the new process technologies and advanced absorbents development.

Figure 1: CSIRO's Aaron Cottrell and IHI Corporation's Jun Arakawa work on the PICA post-combustion capture project (Image: CSIRO)

Description of Loy Yang PICA PCC pilot plant

CSIRO have been supporting IHI's development of an amine based PCC pilot plant since 2014. The advanced process development includes the IHI advanced process and the so-called rich split configuration. The pilot plant was built and commissioned in Japan. It was then dismantled and shipped to Australia for evaluation with real flue gas at the AGL Loy Yang Power Station in the Latrobe Valley in Victoria in 2015.

It was the latest PCC pilot plant in Australia evaluating new and existing amine based technologies for CO2 capture from coal combustion flue gases.

Pilot Plant Features

Pre-treatment

Australian power stations are equipped with particulate removal systems but do not employ de-NOx and de-SOx technologies because of the low sulphur content of the coal and absence of regulation. Without pre-treatment, acid gases like SO2 will result in loss of effectiveness of the amine solution for CO2-capture and potentially lead to equipment degradation over time.

Therefore, a flue gas pre-treatment process is operated using mild caustic wash to remove acidic gases from the power station. The pre-treatment column can further remove residual particulates and prevent down-stream blockages.

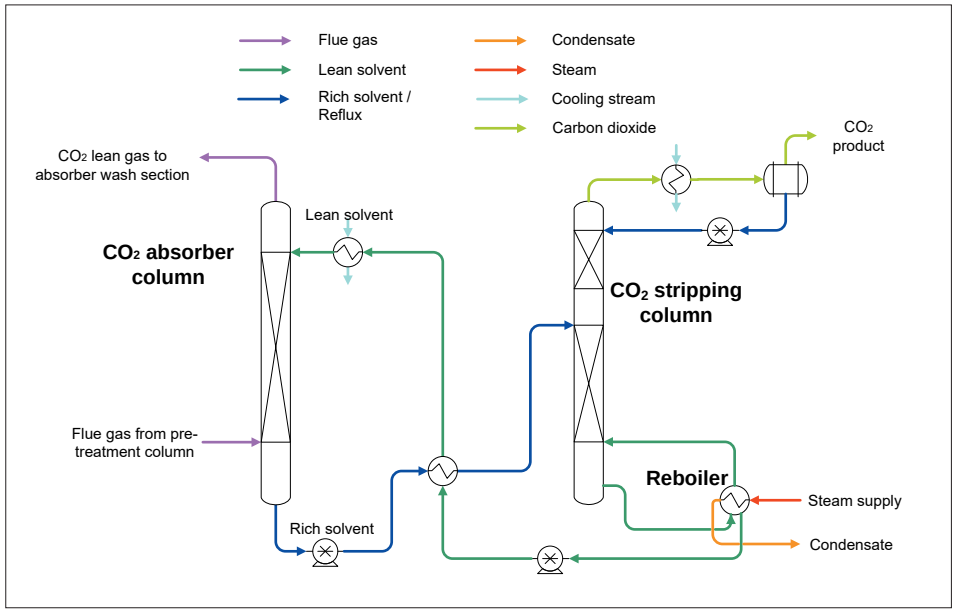

Figure 2: Process flow diagram of an amine based CO2 capture plant

Amine System

The pilot plant is designed to capture 0.5tpd of CO2. The amine system incorporates a standard absorber and stripping column design. An advanced flow configuration allows for effective heat transfer and heat recovery. IHI in house packing systems are installed in the columns to promote enhanced gas and liquid contact at lower pressure drop than conventional packing materials.

Both CSIRO and IHI have been developing the next generation of amine-based absorption liquids. Operation of the IHI amine solution in IHI advanced system with real flue gases has been proven effective in capturing CO2 at low energy consumption[1].

The CSIRO developed solvent is currently undergoing parametric operation, a study of the plant performance under various operating conditions. Further long term operation will provide information on the amine robustness and enable the investigation of degradation products.

Emission Study

The assessment of the gaseous emissions has become an integral aspect in the development of amine based post-combustion capture processes. Both IHI and CSIRO have specialized scientists and engineers utilising sophisticated equipment to study both gaseous and particulate emissions from the capture process.

Advanced Control

The control system uses Japanese PLC modules configured with IHI's in house control system program. The advanced IHI process is highly automated. CSIRO supports the design, modification and implementation of the control system and the integration of the communication to enable unattended operations.

The sophisticated process control configuration has allowed efficient operation in the plant. Besides standard plant checking, less staff attention is required during plant operation. Operation staff will be notified when there is an issue and can attend to site as required. This potentially reduces the cost of PCC implementation. Overall stability and robustness have been excellent over the 1st major liquid absorbent campaign under long hours of unattended operation. This is the 1st automated system of such scale in the Southern Hemisphere.

Rich Split

The rich split process configuration can reduce the energy consumption in the plant as demonstrated by CSIRO's previous pilot plant operation at Tarong power station in Queensland[2]. The CO2-rich absorption liquid coming from absorber is split into two streams.

The first stream goes through the lean rich heat exchanger to take up the heat from the lean absorption liquid. The second stream directly enters the top of the stripping column where it will be pre-heated by the vapour coming from the desorption column This reduces the quantity of water vapour in the product CO2-stream hence reducing total energy required from the reboiler.

Corrosion Coupons

The current CSIRO CAL007 campaign also includes a corrosion study. Various coupons were installed in the plant to understand the corrosion over a long term operation. These coupons will deliver valuable corrosion information to the CO2 capturing plant under real flue gas condition.

Operation with MEA and Advanced Absorbents

MEA, monoethanolamine, was used as a baseline for assessing the performance of the two advanced CO2 capture absorbents, IHI's absorption liquid ISOL-162 and CSIRO's CAL007. One short term campaign using MEA was completed prior testing each absorbent. MEA was demonstrated to be effective in capturing CO2 from the flue gas at Loy Yang A power station with pilot plant energy consumption in line with literature da-

1. Arakawa, Jun; Okuno, Shinya; Takano, Kenji; Yamanaka, Yasuro; Matsuyama, Toshiya; Feron, Paul; Cottrell, Aaron; Cousins, Ashleigh; Huang, Sanger; Davies Roland; Sertori, Paul; et al. Long Term Evaluation of Advanced PCC system for Coal-fired Power Plant. 8th International Conference on Clean Coal Technologies, (CCT-2017); Cagliari; 2017

2. Cousins A, Cottrell A, Lawson A, Huang S, Feron PHM, Model verification and evaluations of the rich-split process modification at an Australian-based post combustion CO2 capture pilot plant, Greenhouse Gases: Science and Technology 2, 329 – 345 (2012).

ta and modelling. The rich split process modification was successfully evaluated during MEA campaign with further evaluation to be conducted using CSIRO's CAL007.

Parametric operation and duration experiments for ISOL-162 were completed in March 2017. 5000 hours operation were conducted in this campaign to study the robustness of the absorbent and the formation of degradation products. ISOL-162 is shown as a promising CO2 absorbent from the preliminary data analysis.

Currently, CSIRO CAL007 is undergoing parametric condition study. The campaign will go through 5000hr of operation and the performance and robustness of the absorbent will be evaluated.

Conclusion

CSIRO has collaborated with IHI Corporation to design, build, commission and operate an amine-based CO2 capture pilot plant at AGL Loy Yang Power Station, Loy Yang, Victoria. The plant can capture 0.5 tpd of CO2 and has been operating in 24hr 7days a week mode.

The advanced IHI process configuration and rich split process show potential in energy reduction. Emission and corrosion assessment will provide further information for plant design and liquid absorbent development. Two different stages of MEA has provided consolidating information for comparison. The long term trial with 5000 cumulative operation hours has provided information on the performance and stability of the amines.

The CSIRO absorption liquid is currently undergoing parametric study and long term duration evaluation. All information above will provide valuable "research to commercialisation" information on the amine based CO2 capture process.

Acknowledgement

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CO2CRC's Otway stage 3: CO2 storage management and subsurface M&V

The project is designed to provide M&V technology that does not need to be gold-plated, but fit-for-purpose and available on-demand. CO2CRC will be investigating subsurface monitoring methods that are spatially specific, continuous, unobtrusive and will 'raise a flag' if an issue is detected.

By Roy Anderson, CO2CRC

CO2CRC's decade without Loss Time Injury (LTI) benchmark has been maintained with their most intensive operational phase to date concluding without incident. Increased activity at CO2CRC's Otway Research Facility marks the start of the organisation's $49.5m Stage 3 Project - CO2 Storage Management and Subsurface M&V.

Frequently regulators require decades-long monitoring of CO2 storage sites, posing issues of cost, extended liability, and social licence to operate where current monitoring and verification (M&V) programs rely on regular and obtrusive surface-based surveillance.

CO2CRC will drill up to five injection and monitoring wells. Numerous monitoring technologies in different configurations will be tested. From subsurface seismic with fibre optic receivers, geophones in different deployment types, to pressure monitoring including above zone and at the injection interval. Regulatory frameworks will be developed for use by Australian regulators and for adoption internationally.

CO2CRC will provide a science and business case where the utilisation of existing downhole technology, of mature use in the Oil & Gas industry, and in combination with advances in geophysical predictive modelling can:

1. Provide risk targeted subsurface monitoring options to potentially replace more costly and invasive surface based monitoring techniques.

2. Reduce the frequency of land/ sea based monitoring acquisition during the operational phase of a CCS project.

3. Reduce the footprint of monitoring systems.

4. Reduce reaction time to analyze potential

events, through real-time/ on-demand monitoring capabilities, on development & containment of the plume.

At the end of April CO2CRC successfully finished drilling a new appraisal well, CRC-3, as part of the evaluation phase of the project.

CRC-3 was drilled to a depth of 1,667m targeting the same saline formation used in the Stage 2 experiments. The rig was onsite for 30 days and 127m of core was recovered at a 97% recovery rate.

The well was installed with fibre optics behind the casing and wireline logs were run as well as two water injection tests. The CRC-3 well was drilled early to reduce uncertainty and understand more about the geology.

Early results show that the targeted formation will be suitable for CO2 injection and the science team are working on the locations for the next four wells. CRC-3 is then planned to be used as the injector well.

CO2CRC's Otway project in Victoria has moved onto Phase 3 which will look at CO2 storage management and subsurface Monitoring & Verification

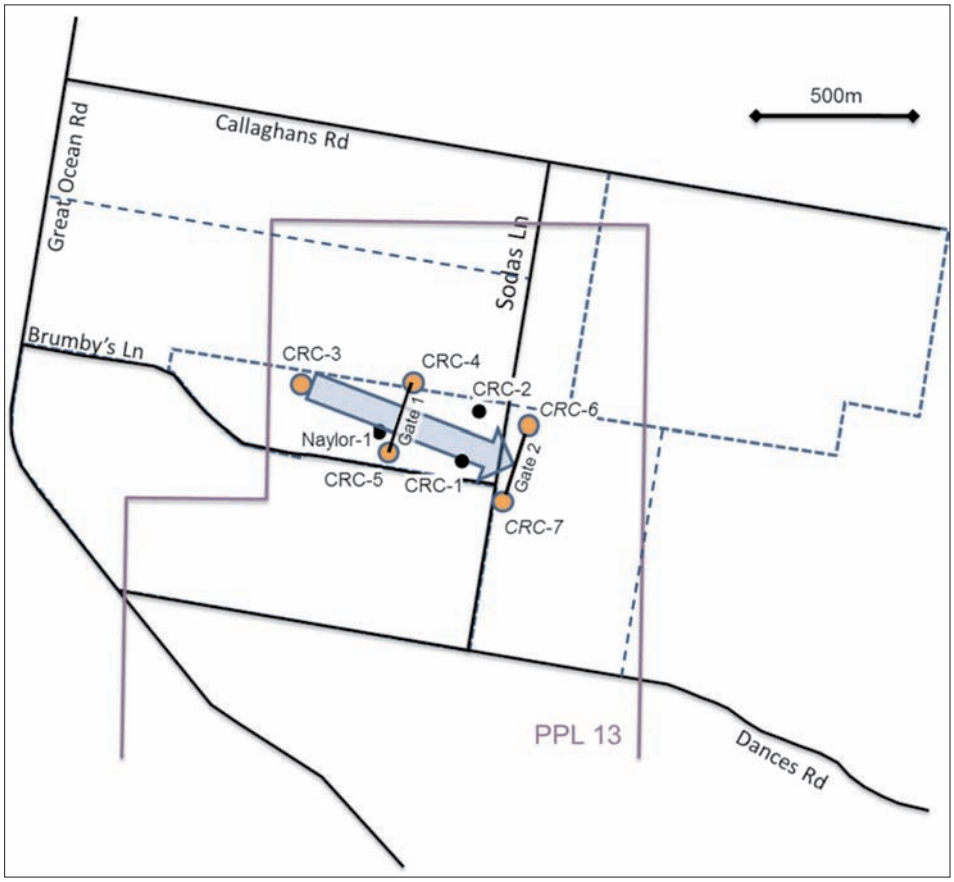

Figure 1: Preliminary injection and monitor well placement for the project within the existing Otway Research Facility. Black lines indicate roads, blue dashed lines property boundaries, and purple lines the PPL 13 petroleum tenement. Filled black circles indicate the location of the existing wells, orange are proposed wells. Blue arrow indicates CO2 migration direction (ESE) from the proposed CRC-3 injector.

CO2CRC will inject up to 40,000 tonnes and operate a subsurface monitoring array prior and during CO2 injection to:

- Benchmark performance of in-well pressure and seismic tools
- Develop deployment and operational processes for new technologies
- Establish minimum detection thresholds
- Improve operator response times to anomalies in plume development
- Provide visualised 4D evolution of plume through in-well seismic monitoring
- Validate pre-injection modelling of plume storage security.

By 2022, CO2CRC will have a validated a comprehensive suite of practical technologies, presenting industry with cost-effective options for the deployment and acquisition of CO2 M&V data that meets regulatory requirements.

More information

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The CarbonNet Project progresses to its next stage of development

The CarbonNet Project (CarbonNet) in Victoria, Australia, has successfully completed Stage 2 – Feasibility and progressed to Stage 3 – Project Development and Commercial Establishment.

By Ian Filby, Project Director, The CarbonNet Project

CarbonNet is investigating the potential for a commercial-scale multi user Carbon Capture and Storage (CCS) hub network, and in February 2017 received approval to move ahead following the review of a business case by the project's sponsors, the Victorian and Australian governments.

Stage 3 is scheduled to run until 2020 during which CarbonNet will undertake field activities and be readied for transition to the private sector. This staged gated development approach, adopted in 2012, is consistent with that proposed by the Zero Emissions Platform (ZEP 2014) in Europe and the Crown Estate 2016 in the United Kingdom for CCS transportation and storage hub developments.

Key Outcomes from Stage 2 - Feasibility

The project completed a comprehensive set of investigations during Stage 2 across the full CCS value chain delivering a range of important outcomes:

• CarbonNet has conducted a comprehensive geoscience evaluation programme and assessment of potential storage sites. The selection process has been subject to independent scientific peer reviews, and external assurance certification by Det Norske Veritas (DNV) under the Recommended Practise J203 for Geological Storage of Carbon Dioxide, resulting in a portfolio of three offshore sites, including a prioritised site being confirmed as technically feasible (GCCSI 2015).

• Due to the large amounts of pre-existing data from petroleum industry exploration, including wells and seismic surveys over the prioritised site, dynamic modelling scenarios have been subject to uncertainty and sensitivity analysis to provide greater than 90% confidence that the site can permanently contain at least 125 Mt CO_2 at up to 5 Mt pa (GCCSI 2016), refer Fig 1. These analyses have informed a draft Declaration of Storage application submitted to regulators for technical review.

• Australia has legislative and regulatory frameworks in place for CCS, and through applying the GCCSI's Regulatory Test Toolkit for Victoria (GCCSI 2013) it has been confirmed that these are fit for purpose to provide the community confidence, but require a range of issues to be addressed to enable practical commercial scale projects to be developed.

• Legal access to the portfolio of storage sites has been obtained through competitive regulatory acreage release processes, providing exclusive rights to explore and develop the storage sites. The prioritised site, Pelican, sits close to shore in both State and Commonwealth waters, refer Fig 2 below, representing the lowest cost site to start a CCS storage hub from.

• Feasibility studies across the full CCS chain have been completed to confirm technical integration viability with potential carbon capture plants (GCCSI 2016), connected at hubs to a transportation and storage network for which configuration options and capacity staging has been assessed (GCCSI 2017) Fig

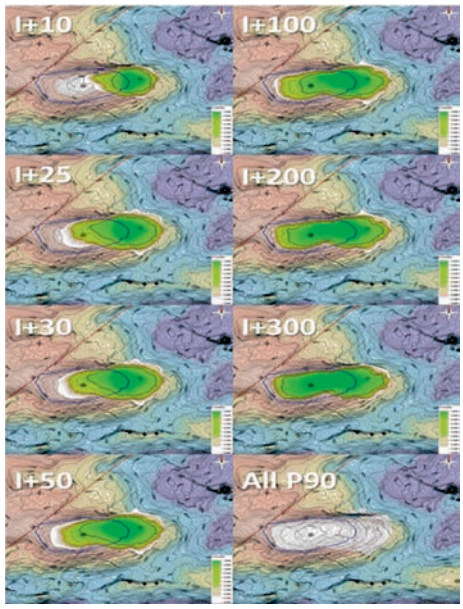


Figure 1 – Probability Mapping of CO2 Plumes at CarbonNet's Pelican Storage Site

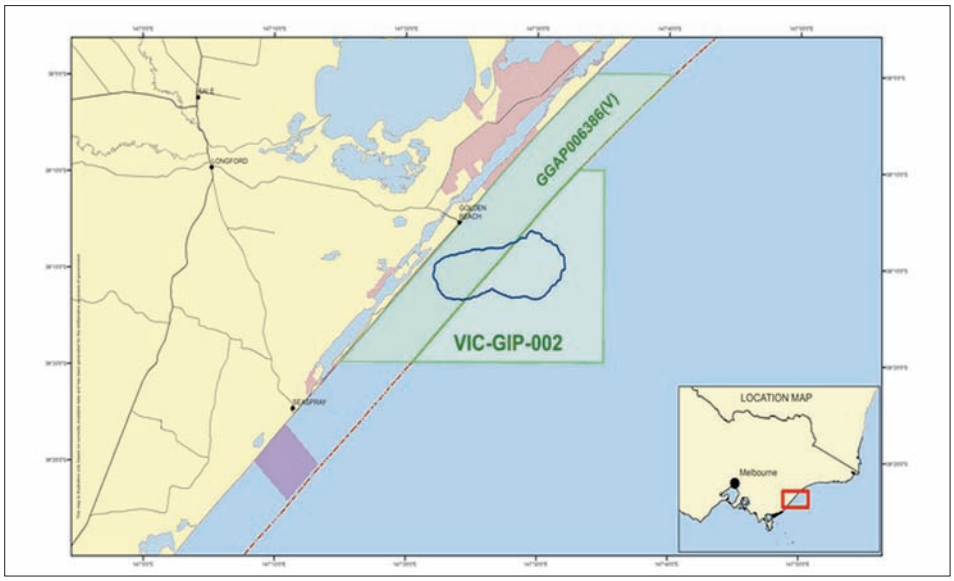
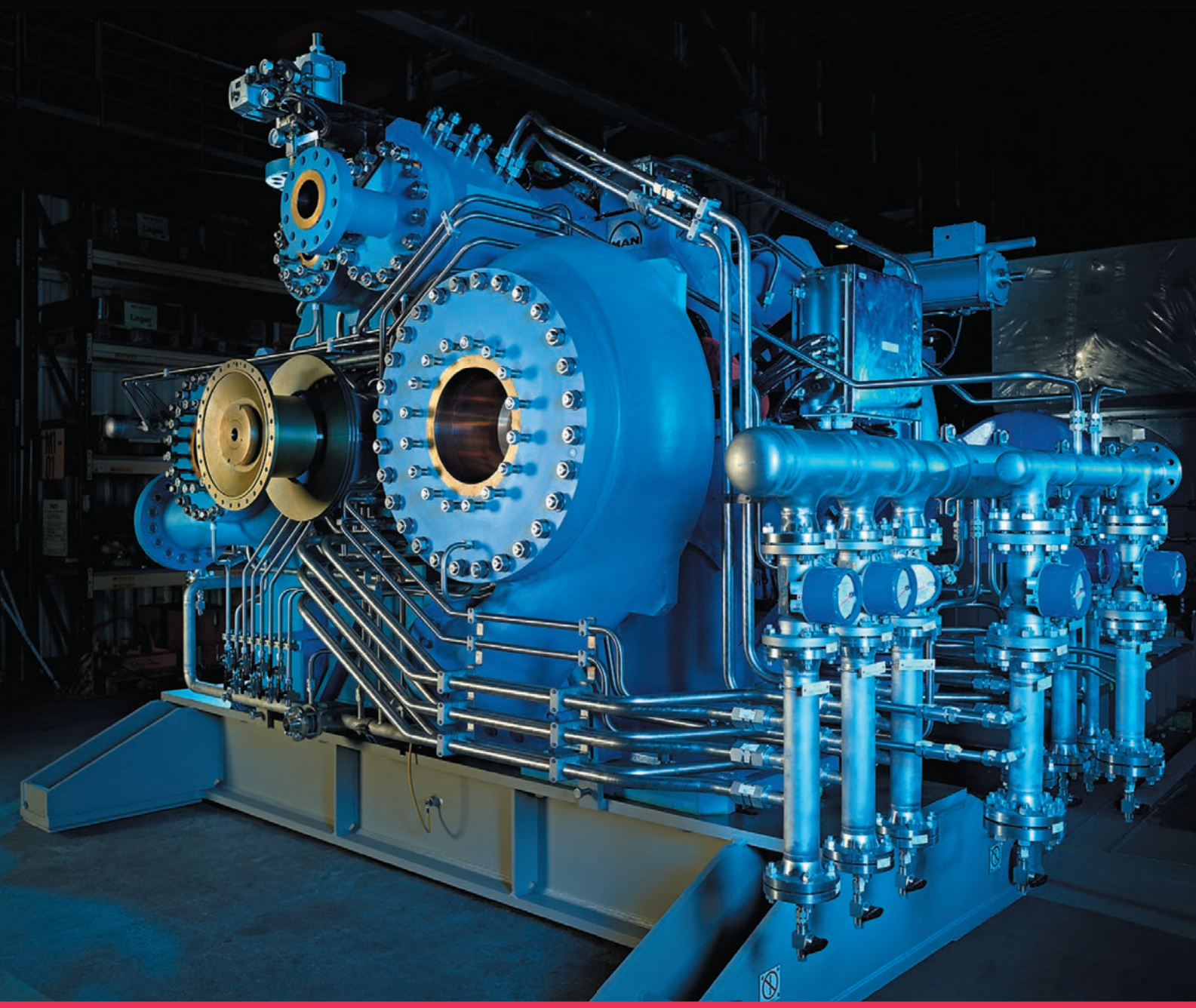


Figure 2- CarbonNet's Pelican Storage Site Location – Victoria, Gippsland.

Actions speak louder than words

High pressure CO_2 gas compression



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3. These studies included detailed thermodynamic modelling of the network, pipe wall thickness calculations, and construction methodology assessments.

• Environmental impact assessments have also been undertaken including consideration of potential air emissions consistent with the latest guidance for CO2 pipeline designs (GCCSI 2015) and independent ground water modelling at the storage site by CSIRO.

• Risk adjusted whole of life costings for the CO2 transport and storage assets has enabled a CCS fee for service model to be developed. The detailed financial modelling indicates CCS is potentially commercially viable for a number of industry sectors from $30/t CO2. Key to the viability of a CCS network will be in the economies of scale.

• The most prospective industries to base a CCS network in Gippsland around are new CTX (coal to products) projects producing hydrogen and/or urea, which have the potential to create significant economic activity, investment, export revenues, and local employment.

• Industry consultation has been undertaken to explore opportunities for industry involvement along the CCS value chain: from CO2 source/customers of a CCS network, to pipeline and storage developers/operators. Strong interest from some organisations, such as Kawasaki Heavy Industries, has provided important insights as to the preconditions to future investment decisions, along with opportunities to undertake collaboration studies.

• Engagement with stakeholders, in particular the local community, has been undertaken during the feasibility stage for initial field investigations which provides an important set of relationships to build upon. CarbonNet has also published an extensive set of knowledge share reports via the GCCSI to provide all stakeholders with access to information about the scientific studies undertaken. Through the procurement of the GipNet research assets to validate environmental monitoring technologies (GCCSI 2016), CarbonNet's research partners will build community confidence in CCS in Gippsland during the next stage.

Stage 3 - Project Development and Commercial Establishment

The next stage of CarbonNet's development will focus on a range of activities to ready it for transition to the private sector around 2020, similar to the pathway outlined in the ZEP report which emphasised the need for governments to de risk the early storage site appraisal steps and the identification of a 'market marker' .

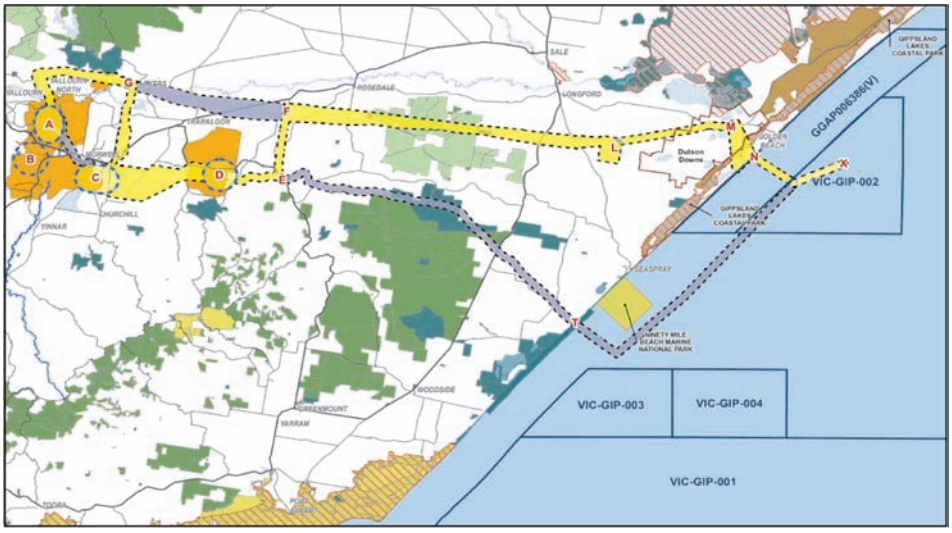

Figure 3- CarbonNet's CCS Network Hub Feasibility Options and GHG permits

A comprehensive Storage Site Appraisal Plan has been developed for the Pelican site, in conjunction with Schlumberger Carbon Services, to validate existing subsurface information and models. The Appraisal Plan has been verified by DNV that, if successfully completed, it would satisfy J203, and the needs of Australian legislative requirements for a future Injection Licence application. Key activities in this plan include:

• undertaking a marine seismic survey to further validate the geoscience models and

• drilling an offshore appraisal well to collect cores across key seals, validate reservoir injectivity, and ready the site for injection operations.

In order to undertake these field activities further extensive stakeholder engagement is required, as part of regulatory and environmental permitting. CarbonNet is well advanced in its planning for the first activity, the marine seismic survey, which is scheduled for the summer of 2017/18. The submission of an Environment Plan to regulators for the survey and release of a tender to secure the services of a suitable vessel is imminent.

The GipNet research initiative will also assist in de risking future Measurement, Monitoring and Verification (MMV) requirements and build community confidence in CCS. The GipNet research, which is supported by ANLEC R&D, will be coordinated by CarbonNet's lead research organisation - the CO2CRC. Researchers have procured their equipment and are progressing stakeholder engagement ahead of deploying environmental monitoring technologies for validation in the onshore and offshore environment from the summer of 2017/18.

These efforts to build confidence in the storage site are critical steps in the investment facilitation pathway, which include CarbonNet obtaining a Declaration of Storage and then Injection Licence for Pelican which can be novated, leased or sold to the private sector. The timing of a call for transportation and storage developers to come forward will be reliant on CarbonNet's progress, and the negotiation of term sheets with prospective CCS service customers. A whole of government approach to the investment facilitation pathway is needed, which CarbonNet is actively contributing towards through its sponsors, the Victorian and Australian governments.

Conclusion

CarbonNet has completed a robust and comprehensive suite of feasibility studies which demonstrate that CCS is technically feasible in Gippsland, and has secured legal access to a prioritised storage site, Pelican. CCS is commercially viable in some industry sectors, in particular new industries to produce hydrogen and/or urea. A commercial scale CCS network in Gippsland would be a key enabler of

such new industries which could bring significant economic activity, investment, export revenues, and local employment for which there is strong private sector interest. The investment facilitation pathway requires governments to continue to de risk key aspects of the CCS value chain, in particular storage through appraisal activities and regulatory permitting, ahead of investment decisions by the private sector.

CarbonNet continues to seek opportunities to collaborate with industry across the full CCS value chain and realise the significant economic opportunities that Victoria has to offer through CCS.

Background

The CarbonNet Project (CarbonNet) in Australia is investigating the potential for establishing a commercial scale, multi-user carbon capture and storage (CCS) network in Victoria's Gippsland region. The network could integrate multiple carbon dioxide (CO2) capture projects transporting CO2 via a common-use pipeline and injecting it deep into offshore underground storage sites in the offshore Gippsland Basin. CarbonNet aims to initially capture, transport and store up to five million tonnes of CO2 per annum, with the potential to increase capacity significantly over time.

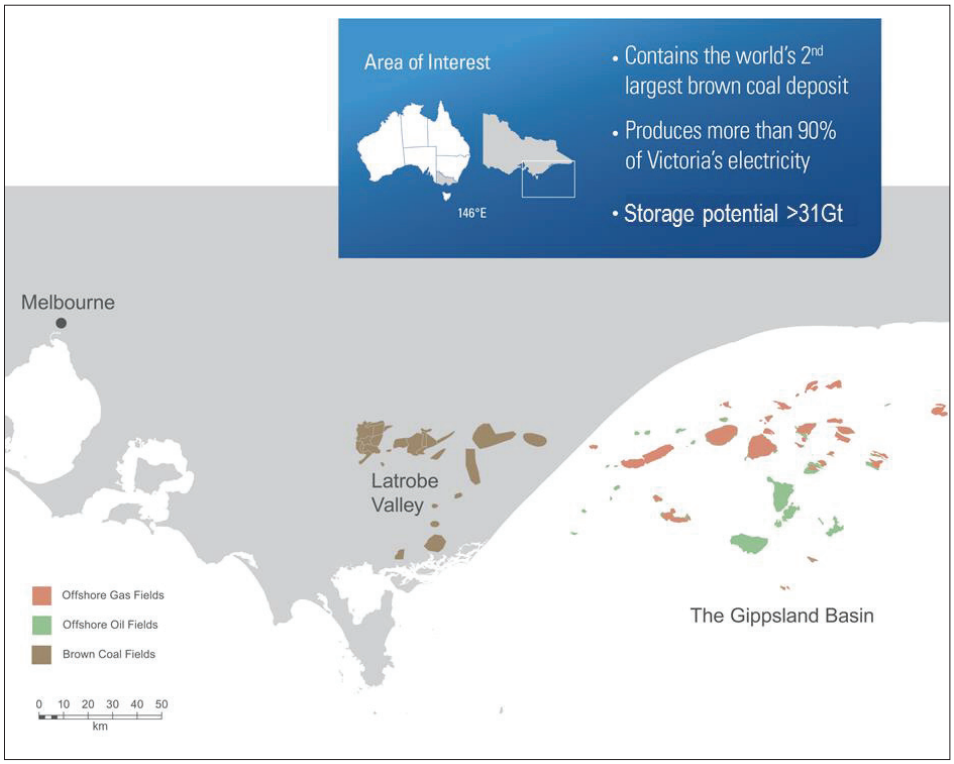

Figure 4 - The Offshore Gippsland Basin has storage potential of at least 31 Gigatonnes of CO2 (National Carbon Storage Taskforce 2009)

Funding and Support

CarbonNet was established in 2009 and has received joint funding from Victorian and Australian governments since 2010. In February 2012, the Australian government awarded CarbonNet CCS flagship status and, jointly with the Victorian government, provided a further $100 million in funding to the project which will continue through to 2020.

With the support of CarbonNet's lead research organisation the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), and major research funder - Australian National Low Emissions Coal Research & Development (ANLEC R&D), researchers from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and University of Melbourne are significantly advancing the prospectivity of commercial scale CCS in Victoria.

More information

earthresources.vic.gov.au

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Australian Deputy PM sees carbon capture tech potential at Imperial

Imperial's Australian collaborations and global lead in carbon capture research were the focus of a visit from Deputy Prime Minister Barnaby Joyce.

By Andrew Scheuber, Imperial

Mr Joyce, who also serves as Australia's Minister for Agriculture and Water Resources, was introduced to Imperial's research and innovation achievements, before touring the Carbon Capture Pilot Plant at Imperial's South Kensington Campus. He met experts including Dr Daryl Williams and Dr Bradley Ladewig – both Australians – and Dr Colin Hale.

As Australia commits to reducing its carbon emissions, Mr Joyce saw how carbon capture and storage can be part of the solution. He said: "A big reason we're here is because you're preeminent in this space."

Mr Joyce met Imperial's Provost James Stirling and Vice-Provost (Research) Nick Jennings, who discussed the College's research priorities and extensive Australian ties.

Professor Jennings spoke about the College's research, innovation and translation strenghts, student entrepreneurship and plans for White City.

He highlighted the 1,600-strong alumni community in Australia, including Australia's oldest working scientist 103 year-old Dr David Goodall, as well as Imperial's 110 Australian students.

The College's Australian research collaborations range "from cricket bat design to fighting antibiotic resistance," he said, resulting in more than 4,000 joint papers in the last five years.

Australia's Deputy Prime Minister Barnaby Joyce visited the Carbon Capture Pilot Plant at Imperial College London

Clean energy transition

The DPM was introduced to a group of students who work on the Carbon Capture Pilot Plant. These include exchange student Vanessa Gunner, who is working on a Masters between Imperial and the University of Melbourne, Australia-born undergraduate Elysia Lucas, and postdoctoral research associate Dr Lachlan Mason from Melbourne.

Chemical Engineering undergraduates Ivan Taptygin, Elise Shui, Kerissa Narine and Aireen Choo supported Senior Teaching Fellow Dr Colin Hale to demonstrate how the plant works, and some of their emergency training.

Dr Hale, Dr Williams, Dr Ladewig and their student team explained to the DPM how carbon capture and storage is an important technologically ready tool for de-carbonising current and future power and industrial sectors.

Dr Daryl Williams, Reader in Particle Science, said: "In the drive towards a low carbon economy, carbon capture from the flue gases emitted by coal fired power stations is a serious current option for reducing their CO2 emissions. The amine solvent capture technology for achieving this is demonstrated by Imperial's Carbon Capture Pilot Plant, and highlights future global opportunities for UK, Australian and international researchers striving to make coal cleaner."

Dr Bradley Ladewig, Senior Lecturer in Chemical Engineering, said: "Australia faces unique challenges in the transition to a clean energy future. Mr Joyce pointed out concerns around stability and reliability of supply, as well as emissions intensity, and was keenly interested to hear about the opportunities provided by carbon capture and storage.

"I was thrilled to see the high-level interest of the Australian government in the world-leading research we are conducting here at Imperial.

After his briefing from Dr Hale, Dr Williams and Dr Ladewig on the Carbon Capture Pilot Plant, the DPM said "You've taught me so much now, I think I can go home and build one."

As a parting gift, Mr Joyce – a big rugby fan – received an Imperial first XV shirt. He said "Tell the Rugby Club it'll get a good runaround."

More information

www.imperial.ac.uk

IEA Clean Coal Centre report: making CCS acceptable to the public

In a report for the IEA Clean Coal Centre, "Public outreach approaches for carbon capture and storage projects", Toby Lockwood found that awareness of CCS among the general public is low, and better-informed groups support other low-carbon technologies more than they do CCS.

How can CCS be made more acceptable to the public? Public opposition to carbon capture and storage (CCS) projects, whether real or potential, is often thought to be a significant barrier to its take up. And there have been a few high-profile cases where public activism has led to projects being cancelled. Now most CCS project developers have refined their communications approaches to try to overcome this hurdle.

CCS is often seen as an unsustainable climate change solution which lets fossil fuel companies continue business as usual. It can also be seen as poor value, and less technologically ready compared to the advances made in the renewables sector. However, CCS is more acceptable when it is presented as a 'bridging technology' to a fossil-free future, or as one component of a lower-carbon energy mix.

Some communities directly affected by CCS projects have expressed concerns about the health risk of leaking CO2, and the possibility of induced earthquake activity or water contamination. Many of these issues were raised during strong local opposition to demonstration projects in the Netherlands, Germany, and Poland.

Local concerns are also heavily dependent on the nature of the CCS project and may be less for offshore storage, enhanced oil recovery, or retrofit capture plant.

Several best practice guidelines for CCS communications have been developed, including:

- identify key local stakeholders and evaluate local demographics and attitudes;

- engage as early as possible – ideally before the site is finalised;

- actively seek and respond to public feedback;

- tailor key messages to the audience and emphasise community benefits; and

- act transparently to build and maintain public trust.

Effective engagement campaigns have used dedicated teams and worked with more trusted stakeholders such as non-governmental organisations and research institutes. Informal gatherings with several information stands encouraging one-to-one contact are a popular approach to public consultation.

They can be supplemented with visits to key individuals. Information centres placed in key locations and participation in popular local events are proven means to engage with the community at large.

Many of the public concerns about CCS are because people do not trust in the permanency of CO2 storage. This can be countered through improved communication and visualisation of the storage process for a non-technical audience, including accurately scaled diagrams, rock samples, and simple experiments. Details of CO2 monitoring campaigns and contingency plans should be appropriately addressed while not heightening perceptions of risk.

A number of CCS projects have engaged successfully with the public, including Shell's Peterhead project in the UK and Quest in Canada, communications work led by the Ciuden Research Institute for the Compostilla and Hontomin projects in Spain, SaskPower's Aquistore project in Canada, and the work of Japan CCS at Tomakomai.

These projects focused on reaching as much of the affected communities as possible, encouraged participation with local businesses, and incorporated educational activities in local schools. Some also employed more widespread publicity campaigns. The first FutureGen project in the USA is interesting as it achieved active local support from an early stage, thanks to the use of a competition for the site selection and fostering a sense of unity with the local community.

Such methods to promote local acceptance of CCS projects are well established, and strong local opposition centred on a public health risk is no longer considered a major barrier.

However, the relative absence of CCS from the wider public debate around climate change arguably presents a greater challenge for communicators, as greater political support for the technology must ultimately be backed by adequate public acceptance.

This task will require wider-reaching information campaigns, more educational work, and the development of stronger non-technical arguments. CCS proponents have increasingly focused on applications with more unique value propositions than power generation, such as use in industrial processes or achieving 'negative emissions' with biomass combustion.

Other recommendations for broader outreach include:

- emphasis on climate change urgency and the role of CCS in deeper CO2 cuts;

- better use of existing projects to showcase CCS as a currently viable technology;

- emphasis on the cost reduction potential of post-demonstration phase plant; and

- better collaboration between industry, academia, and government to formulate a consistent message which is aligned with policy and scientific consensus.

More information

www.iea-coal.org.uk

UK paper calls for more CCS funding

The paper, titled 'Making the most of our geological resources', outlines the need for a new Catapult organisation in the North of England to launch the drive towards CCS, supporting heavy industry.

The call for further investment in Carbon Capture and Storage (CCS) comes in a new working paper by IPPR North as part of the Northern Energy Taskforce and has been welcomed by the University of Sheffield.

The paper says CCS and shale gas fracking both have the potential to offer some economic benefits, and benefits that could be realised in and for the North. But each runs the risk of being presented as a panacea and needs to be considered in a wider context.

"If the North of England is to secure both economic and environmental benefits, now and into the future, these two technologies might best be considered as mutually beneficial and selfreinforcing with CCS the higher priority in the longer term."

"As regards the development of CCS, the establishment of combined authorities and the new Northern mayors presents an opportunity for these devolved powers to take a lead and establish CCS as a key Northern climate change technology, facilitating jobs and growth of its own accord and offering new opportunities to establish a hydrogen economy too."

"The government's new Industrial Strategy and in particular its 'sector deals' process, presents a great opportunity to realise a successful northern CCS sector. The North needs to take this opportunity."

"Leading with CCS, albeit requiring significant long-term investment in comparison with shale gas extraction, presents the most rational way for the region and the UK government to support any further efforts on the extraction of shale gas."

Expertise in the North

The University of Sheffield is a leading centre for research into the area of Carbon Capture and Storage and operates the UK's main national pilot-scale facilities for clean use of fossil and biomass fuels with CCS. It also hosts the £6m UK Carbon Capture and Storage Research Centre (UKCCSRC) in partnership with five other core research organisations.

Other notable linked centres of expertise include the University's Advanced Manufacturing Research Centre (AMRC) with associated apprentice training, and the extensive Energy 2050 research institute, one of the largest university energy research programmes in the country.

Professor Mohamed Pourkashanian, Head of Energy Research at the University of Sheffield and Director of the PACT National Facility on CCS, said: "We look forward to the Government's delayed CCS Strategy following the cancellation of the previous programme. We strongly support IPPR North's call for a new CCS Catapult, to support our heavy industry in the switch to a low carbon future."

"The facilities and organisations already established at the University of Sheffield make it an ideal core around which to form such an organisation and to deliver CCS clusters on Teeside, Humberside and in the North West that will ensure long-term, low carbon jobs for the 21st century."

Recommendations

If the government is to retain its manifesto commitment to pursue onshore shale gas extraction, then the Northern Energy Taskforce calls on the relevant secretaries of state to do four things:

1. Re-instate or update support for CCS technology, to include consideration of a CATAPULT Centre for CCS in the North. This should be funded by the Department for Business, Energy and Industrial Strategy as part of their wider industrial strategy programme. It should be delivered by local actors in region, as a partnership between relevant Local Economic Partnerships, those in industry, universities and research institutions. This needs to be established over the next parliament to ensure that the UK does not lose its opportunity to lead the work in CCS technology.

2. To lay out a clear, consistent and universally applied regulatory framework for shale gas extraction, under the auspices of the Environment Agency. A consultation should take place between the Department for Business, Energy and Industrial Strategy and the Environment Agency to ensure the latter has the necessary regulatory tools to fully conduct its role and appropriately regulate these areas.

3. To ensure that shale gas use displaces, rather than adds to imported gas consumption, as argued by the Committee on Climate Change (2016). This will be the responsibility of a wide range of stakeholders. Plans from central and government and industry to transition away from fossil fuels should not be halted or slowed by the availability of onshore gas and any downward effect on prices it may have. Utilising the receipts from shale gas extraction as in the next recommendation will support this.

4. To establish a Sovereign Wealth Fund to 'bank' the benefits of government revenues on shale gas and use them to forward fund the continued development of the energy system of the North, as well as offering individual and community benefits. Current proposals for a Sovereign Wealth Fund aim to pool a certain proportion of receipts from shale gas revenues before redistributing this in the form of community grants and direct payments to residents in areas of extraction (HMTreasury, 2016).

We propose that this model be extended, to fund other low carbon technologies as well and, in particular, to fund CCS projects. However, it is not possible to wait until receipts are collected and banked before building this vital infrastructure. For this reason, this investment should be made up front with the expectation it will later be offset by shale gas revenues.

More information

Download the report from:

www.ippr.org

www.energy2050.ac.uk

Bellona: the coal dinosaurs bow out of a low carbon Rotterdam

As the coal dinosaurs bow out of a low carbon Rotterdam, a focus on CO2 transport and storage gives better opportunities for the port, new low carbon industrials and workers.

Engie and Uniper, two major European electricity generators, officially opened the giant Maasvlakte coal power plant in Rotterdam last year. Before the plant was ever built, the plan was to attach CO2 capture and storage to the facility – the ROAD CCS project would have prevented 1.1 million tonnes of CO2 entering the atmosphere every year.

Under a low carbon price and high political uncertainty over the future of coal generation in the Netherlands, however, the French and German energy giants will pull the plug on the ROAD CCS project. Less than 2 years after the Paris climate agreement's adoption, aiming to limit global warming to under 2 °C, Europe has lost its last proposed coal CCS project.

E.On's coal fired power plant on the Maasvlakte, Rotterdam. On the right the old power plant and on the left the new. (Photo: Zandcee / Wikimedia Commons)

Today Engie's coal plants alone produce emissions equivalent to nearly half of France's entire emissions, while Uniper, the bad bank of E.ON, is still building new coal plants in the largest CO2 emitter in Europe, Germany. Uniper and Engie look to be companies with no plan to stick around when climate policies begin to bite.

"It's not surprising that the project has been cancelled – the reason it's taken so long is that the coal utility companies kept hoping the Dutch government would do it, so they would avoid any blame and could claim they tried. Surely to their disappointment, the Dutch government has however made it clear it is serious about industrial decarbonisation and CCS, so they had their hand forced. Those companies actively worked to block any ambitious EU policies that could provide the necessary framework for CCS to become operational in Europe." says Jonas Helseth, Director of Bellona Europa.

Rotterdam hosts one of Europe's largest industrial hubs, with large CO2 emissions to match. The port, companies and workers all need a climate solution – CO2 transport and storage will be a big part of it, involving many of the industries in the region. The prospect of the cancellation of ROAD will be clear to all those making plans to decarbonise the Rotterdam port. Focusing development on CO2 transport and storage networks will be crucial to aid as many industries as possible to deeply decarbonise. The ROAD project would have built a large CO2 capture facility, with a small CO2 transport and storage component; now effort can be focused where the biggest commercial and climate rewards lie, developing Rotterdam into Europe's CO2 hub.

The port is in an ideal space to take advantage of refocusing the ROAD project on CO2 infrastructure and CO2 storage first. The port area plan has space set aside for CO2 shipping, low capture cost CO2 is readily available, existing CO2 pipelines feeding local greenhouses are eager to expand and an offshore CO2 store is ready and waiting to be filled. Rotterdam is pivotally located as a gateway for European industrial emissions to the North Sea: the giant industries of the Ruhr will need access to North Sea CO2 storage sites.

Reframing the project components of the ROAD project into a solution for industrial decarbonisation of the region will offer an opportunity to create a carbon capture hub which could help decarbonise local and regional industries. Along with creating jobs and sustainable economic development in the region, the project will link up to existing Projects of Common Interest of the EU and act as a gateway to huge CO2 offshore storage resource of the North Sea (read more on the development of CCS in the Rotterdam region here). Rotterdam, the Netherlands and the whole industrial region will be able to tackle their industrial emissions preserve industrial jobs and attract new investment.

Bellona calls on the Commission and Member States to support a rapid re-design of the project to ensure these benefits for both local communities and the region.

More information

www.bellona.org

road2020.nl/en

Fast-track CO2 transport and storage for Europe

An integrated CO2 transport and permanent storage network, as sophisticated as that of the existing natural gas industry, will be required in Europe by 2050 in order to deeply decarbonise industry. We need to start building it now says a report from the European Zero Emission Technology and Innovation Platform (ZEP).

The network will take at least 30 years to build. We had planned to start 5 years ago, however today we do not expect to start first CO2 transport and injection before 2020.

All of the actions set out in the report will be needed to reach the 'well-below' 2 °C target of COP21. Indeed, reaching the 1.5 °C or a less than 2 °C warming target requires deep decarbonisation of all possible sources as rapidly as possible, in addition to accelerating all the renewable energy and energy efficiency breakthroughs promised. A disastrous 4 °C warming will be the inevitable result of current INDCs and limited plans to implement; energy efficiency, process changes, renewable energy, and electro-mobility.

The report is about action, commitment and no regrets. Carbon Capture and Storage (CCS), a key climate change mitigation technology, is one of the ten actions of the European Strategic Energy Technology Plan (SET-Plan). The potential for CCS to significantly reduce the cost of decarbonisation is widely recognised in several markets by industry, analysts, and academics, if not yet by politicians.

CCS requires major investment in infrastructure with confidence that a reward for decarbonisation will be forthcoming. Building a completely new network based service industry to maturity will take time, investment, commitment from all stakeholders, and clear direction from Governments. Ensuring the delivery of a public/private success story for CCS will require consistent government action, committed industry cooperation, shared best practise, and active support of NGO's on behalf of a responsible society.

The report underlines the urgency for coordinated action now. The process from identification of an eligible geological storage site to first CO2 injection involves a range of timeframes, always including several investment

Recommendations

The report identifies 8 key activities, requiring consistent and concurrent progress, including a number of immediate actions for 2017. This will require the European Commission and 'first mover' Member States (MSs) to establish a co-ordination, governance and delivery framework to deploy the "bow wave" of early projects and enabling infrastructure utilising public/private partnerships and organisations that can undertake market making functions.

1. Open access to information: All high potential permanent geological storage locations in first mover MSs need to be identified. EC and these MSs to ensure processes/regulations for access to relevant data. MSs to establish or mandate responsible national organisations to gather and analyse licence-holder data in full cooperation with license-holders in order to evaluate and rank all storage structures whilst at the same time respecting confidentiality and commerciality of data to a practical and reasonable extent. Regularly and systematically evaluating CO2 storage potential will become an obligation for all licence-holders.

2. Storage appraisal: High ranking structures need full evaluation and certification. Evaluation is conducted by Exploration and Production (E&P) licence-holder in partnership with mandated existing or new national organisation using EC standards and methods (to be defined). Licence-holders declare intent to store or waive their rights. Combination of certification and intent to store wins mothballing support where necessary.

3. Strategic planning: EC establish a coalition of CCS first mover Member States. Formalise complementary planning responsibilities at regional, national, interregional and EC levels aligned with 2050 decarbonisation targets and aggregated national roadmaps. Use these to support PCI (Projects of Common Interest) applications for example.

4. Market Structure: National organisations need to be mandated to execute the plans and to fulfil CO2 transport, hub and storage duties from the delivery points at sites capturing CO2 up to and including the storage locations as market makers. In 2017 a working group is required comprising EC, first mover MSs and the finance sector (e.g. EIB) to deliver regulation, financial support and governance mechanisms to underpin these entities.

5. Regulation: Build on recent reviews of the CCS and ETS Directives to identify existing policy barriers to the delivery of CCS infrastructure. Update policy and law to accelerate development of CCS and any complementary technologies and initiatives. These legal and policy updates should enshrine the actions identified here under the activities: Market Structure, Strategic Planning, Storage Appraisal, and Incentives.

6. Incentives: Member States to substantially fund the first flagship projects to meet the 'first injection by 2020' date (initially planned for 2015). Establish a working group comprising EC and first mover MSs to establish or adapt existing funding mechanisms for: pre-FID storage appraisal, transport and PCI feasibility, and industrial cluster development. Continue to review and evaluate EU financial support mechanisms which may facilitate the delivery of CCS infrastructure.

7. Politics and communication: EC and MSs to communicate a single clear message, supported by industry and public authorities regarding the imperative and unavoidable role of CCS in achieving National and International climate obligations, including the Paris Agreement. The message underpins policy and justifies targets and expectations for fuel burning power generation, industries, households and transport and confirms the role of CCS alongside renewables.

8. Technology: Capture, transport, injection and storage technologies must be shared and optimised. EC and MSs set up information and technology sharing platforms and acceleration initiatives. By sharing human, physical, and IT resources the costs of CCS infrastructure may be reduced by introducing 'economies of scale'.

years prior to injection operations.

A well-characterised pressure-depleted gas field is expected to take less time to appraise, permit, design and construct, than the same process for a deep saline aquifer, which could take ten years or more. However, there are underground geological structures that could be permitted and converted to CO2 injection in less than ten years, for example some already appraised aquifers, and a number of depleted oil and gas fields.

A snowballing effect should take place where the permitting and developing of one store makes permitting neighbouring stores much quicker. Timelines will shorten further once the initial enabling infrastructure is in place, with the process of connecting storage sites and extending infrastructure back to multiple sources and regions becoming a 'production line'. There will still be storage sites and infrastructure elements that will take longer to appraise and develop than others, but the system will become mature enough to cope with a range of delivery times.

The most immediate need is to identify the first few enabling pieces of infrastructure from source to sink that can quickly be expanded and extended. This has already been done over the last ten years for a number of prospective projects (Rotterdam/P18, White Rose/Endurance, Grangemouth/Goldeneye, and in Norway) but delivery has not been forthcoming. The EU and its Member States have also invested innovation funding and research time over many years, and now have the collective capability to act to deliver this infrastructure.

These projects must be kick started urgently through substantial public funding by governments. These will be flagship projects for Europe and funds must be committed, without risk of removal, such as happened with the cancellation of the UK CCS Commercialisation Programme in 2015. Clear communication and the establishment of long-term policy frameworks by Member State Governments will help to underpin investor confidence, facilitating the establishment of public/private partnerships.

Furthermore, the communication from Governments to the general public will help to answer questions on how and why CCS is needed in the context of National and EU mandated climate change targets, as well as communicating the accompanying socio-economic benefits, such as job creation.

An open information flow should allow every Member State to play a role and benefit from the information generated at various stages of each project and shared on a non-discriminatory basis. Organisations and information sharing platforms already exist to enable this, with information covering technology, materials, manpower, expertise, data and analysis, permitting process, commissioning, operations and maintenance. If properly leveraged this information sharing may enable time saving short cuts particularly for first expansions and extensions.

Key activities

This report examines each of these activities, identify actions, and propose a framework of responsibility by identifying opportunities for removing barriers to progress. It builds on the ongoing work of the TWG Transport & Storage and the TWG Policy and Financing, in addition to the work of the UK Cost Reduction Task Force, and current ZEP work on hubs and clusters.

Delaying the immediate development of CO2 geological storage will have long reaching effects on the speed, cost and viability of economy wide deep decarbonisation in line with the 2 °C goal of the Paris agreement. CO2 storage and the transport networks that connect emitters cannot be realised overnight. CO2 storage development takes time, with exploration, characterisation and development all required to provide safe, permanent, CO2 stores.

A steady build out rate is necessary to build up the skills and services sectors necessary to construct and maintain the required number CO2 storage sites. Delay will leave insufficient time, not only for the required CO2 storage development, but also CO2 transport networks to connect distant CO2 sources, endangering continued industrial production and employment, or restricting decarbonisation ambition. The E&P industry is already accelerating the decommissioning of oil and gas infrastructure that can be re-used to transport, inject and store CO2.

Delay and the resulting limited access to CO2 transport and storage will have direct and long term implications, such as reduced decarbonisation optionality and increased risk of non-delivery of decarbonisation. Strategic industries such as steel manufacture and their employees may be left without feasible decarbonisation avenues, undermining national and European political support for climate ambition.

The result will be a global warming beyond the 2 °C target or an even greater reliance on direct atmospheric CO2 removal by Bio-CCS or air capture-CCS techniques that will have a huge impact on other valuable resources, and still need CO2 transport and storage to the same extent as CCS.

Action now on CO2 storage development allows for a steady build out pace of CO2 storage sites and CO2 transport and CO2 capture, lowering costs and increasing success rates for infrastructure planning and public engagement. Immediate deployment gives a significant upside of "rapid decarbonisation insurance potential" – in the case of increasingly adverse climate change, CO2 capture deployment can be accelerated more rapidly as infrastructure is established.

First movers will be the founders of CO2 networks, benefiting from inward investment, technology, and service development along with the creation of a new export sector. The operation of a CO2 storage industry in a country or offshore territory would be a potential export service for countries requiring take off of CO2 from emitting sectors but lacking local CO2 storage capacity. Access to CO2 storage will increase certainty for investment and redevelopment in local carbon intensive industries, retaining the social licence for these sectors in a deeply decarbonised future. The presence of accessible CO2 transport and storage will be a requirement in attracting emerging low carbon investments such as decarbonised hydrogen production for heat and transport.

Regions with aging and declining hydrocarbon extraction industries can redevelop with a new CO2 storage economy, retaining high skilled jobs and services sectors by building on existing infrastructure and industries. Early movers in planning and development of CO2 storage will benefit from the preservation and reuse of existing fossil infrastructure, such as wells, platforms and gas pipelines.

CO2 storage will be required to grow into a global industry. The IEA estimates that by 2050, ≈70% of CO2 will be captured and stored in non-OECD countries. The development of CO2 storage technologies and expertise in Europe will give local companies access to a new global market.

More information

Download the full report:

www.zeroemissionsplatform.eu

Projects and policy news

Suspension of gasification operations at Kemper

www.southerncompany.com

Southern Company and Mississippi Power are immediately suspending start-up and operations activities involving the lignite gasification portion of the Kemper County energy facility.

The combined cycle plant has been serving customers with reliable and affordable electricity for almost three years. The facility will continue to operate using natural gas pending the Mississippi Public Service Commission's decision on future operations.

This action is being taken to preserve the safety and health of the workforce and safety of the facility, while still retaining the necessary workforce to operate the combined cycle power plant.

"We are committed to ensuring the ongoing focus and safety of employees while we consider the future of the project, including any possible actions that may be taken by the Commission," said Southern Company Chairman, President and CEO Thomas A. Fanning. "We believe this decision is in the best interests of our employees, customers, investors and all other stakeholders."

Southern Company and Mississippi Power believe this is the appropriate step to manage costs given the economics of the project and the Commission's intent to establish a settlement docket to address Kemper-related matters including the future operation of the gasifier portion of the project.

The company says it will fully participate in a proposed settlement docket to be established by the Commission on July 6. The company will make any future announcements as to the status of the project based on the outcome of that process or future Commission action.

Southern Company and Mississippi Power's Kemper project has suspended operation of the gasification portion of the facility, putting the CCS project in doubt (Image ©Mississippi Power)

Developments on the ROAD Project

www.zeroemissionsplatform.eu

The Dutch Government announced that the ENGIE Group and Uniper Energy will withdraw from the ROAD Carbon Capture and Storage (CCS) project in Rotterdam.

Commenting on the news, Dr Graeme Sweeney, Chairman of the Zero Emissions Platform, said, "ZEP strongly supports the efforts, led by the Port of Rotterdam, to identify the path to collecting and transporting CO2, which can then be stored in gas fields under the North Sea."

"As highlighted in our 5th annual Market Economics report, CCS is key to decarbonising the heat, energy-intensive industry, gas and refining sectors. The latest developments present a valuable opportunity to unlock the potential of Rotterdam's industrial zones to become a key CCS cluster."

"The Dutch government has also clearly expressed its continued dedication to CCS deployment. The technology has been identified as key to achieving national climate change targets in the Dutch Energy and Climate Plan. The Netherlands are also already in the process of developing a roadmap designed to identify the path to large-scale CCS deployment."

"The development of the joint SET Plan Implementation Plan, the four CO2 transport projects submitted as Projects of Common Interest (PCI) under the Connecting Europe facility as well as the recent developments in Norway are a testament to the building momentum on CCS."

"It is now crucial for European Member States to express their support for delivering the CCS cluster in Rotterdam, which could play an important role in decarbonizing Europe's regions, notably the heavilyindustrialized Ruhr area. Similarly, the Commission must also assume a coordinating role and ensure that the ROAD project retains its potential as a stepping stone for enabling industrial decarbonisation in Northwestern Europe."

Chinese and Norwegian companies collaborate on CCS

www.tcmda.com

TCM has signed a four-party Memorandum of Understanding to further progress carbon capture collaboration between Norwegian and Chinese Companies.

TCM has already signed a formal collaboration agreement with the UK-China (Guangdong) CCUS Centre (GDCCUSC) and the four-party MoU - which also includes China Resources Power and Innovation Norway in China - paves the the way for an even broader collaboration between two countries heavily

involved in carbon capture as a critical climate mitigation tool.

"The work carried out at Technology Centre Mongstad (TCM) to test, verify and demonstrate CO2 capture technologies in a large scale format is a key element in our CCS strategy. Cooperation is the only way to facilitate a broad global dissemination and deployment of CCS technologies. Therefore I highly appreciate the cooperation between TCM and Guangdong project", says Norway's Minister of Petroleum and Energy Terje Søviknes who witnessed the signing in Beijing Energy Club.

The Guangdong Offshore CCUS demonstration project (GOCCUS) phase I will be based on the coal-fired units of CRP Group (China Resources Power) Haifeng Plant. The demonstration project will be built in the country's first multi-technology open platform of international carbon capture technologies, and also the first middle-scale CCUS testing and demonstration project in South China. In stage II, a large-scale CCUS demonstration project will be designed and constructed based on unit 3 and unit 4 of the plant, with capacity of 1 million tons captured per annum.

TCMs genuine knowledge and competence accumulated through the years of planning, construction and operations is in global demand, and TCM now offers sharing this experience more broadly. TCM is now expanding its role a global competence center by entering into collaboration agreements with relevant companies and institutions in Norway and abroad.

The collaboration with GDCCUSC may include themes related to emissions, measurements, permits and authority dialogue; flue gas composition vs capture processes, test campaign designs, analytical methods and analysis, plant design, operational experience, open source data and baselines and training of operators. The planned test center in China will be about 1/10 size of TCM. The collaboration may in the future bring technology vendors from Guangdong test center to TCM as the last step before scale-up.

Funding available for Australian projects

www.cleanenergyfinancecorp.com.au

CO2CRC welcomed the announcement by the Hon. Josh Frydenberg, Commonwealth Minister for the Environment and Energy, that carbon capture and storage will now be eligible for funding by the Clean Energy Finance Corporation (CEFC).

Until now the CEFC Act considered carbon capture and storage a "prohibited technology" and ineligible for investment.

"The change in legislation is an important step forward for carbon capture and storage to become a real option for industries such as cement, steel, oil, gas and coal to significantly reduce their greenhouse emissions in Australia," said Tania Constable, CEO CO2CRC.

The CEFC is a $10 billion fund established to facilitate increased flows of finance into Australian based renewable energy, energy efficiency and low emissions technologies.

The International Energy Agency has stated that limiting global warming to below two degrees, as agreed at the Paris climate conference, will not be possible without CCS. This CEFC legislative change further demonstrates Australia's commitment to achieve this ambitious target.

CO2CRC is focusing on driving down the cost and securing more efficient operational monitoring, legislative and regulatory outcomes to enable CCS for industry in Australia.

CO2 Capture Project Annual Report

www.co2captureproject.org

The CCP (CO2 Capture Project) has published its latest Annual Report covering the key programme activities delivered during 2016.

Having been founded in 2000 to advance technologies for CO2 capture and geological storage, CCP is currently in its fourth phase of activity. The 2016 Annual Report summarises the main activities delivered by the organisation's Capture, Storage, Monitoring & Verification, Policy & Incentives and Communications Teams. Highlights of the new Report include:

• progress on the novel capture technologies project, including molten carbonate fuel

cells and high-pressure solvent absorption

• conclusions of the natural gas treating study

• latest update on the well sealing experiment at Mont Terri

• conclusion of the study into transitioning CO2 EOR to CO2 storage

CCP Chairman, Jonathan Forsyth, comments: "CCP is delighted to publish its Annual Report for 2016, which reflects the busy year we had and the fact that we are now well underway in our fourth phase of activity. Our aim is to orientate our programme to provide our members with what they need in regard to future CCS development in the face of potential societal needs and legislative requirements. I hope that the Report provides all readers with an interesting overview of some of the main projects we have been involved in."

Acorn project wins EU funding to progress CCS in the UK

www.pale-blu.com
www.co2deepstore.com

The Acorn project, a full chain small scale carbon capture and storage project in North East Scotland, has received support from the EU.

The project, being developed by CO2DeepStore, has been approved for funding under Advancing CCS Technologies (ACT), a part of the ERA-NET programme, to progress feasibility studies in 2017 and 2018. Pale Blue Dot Energy is leading the ACT study consortium which also includes Scottish Carbon Capture & Storage, Bellona (Norway), Liverpool University and Radboud University (Netherlands).

Acorn provides a low-cost entry point for CCS in the UK, by enabling a small-scale project, from which an extensive CCS network could be developed. The project will capture industrial carbon dioxide (CO2) emissions from the St Fergus gas processing plant and transport it for permanent storage deep beneath the North Sea, using existing redundant oil and gas infrastructure which is currently under threat of decommissioning.

St Fergus will be a future hub for CCS, its multiple pipelines taking CO2 by pipeline from Central Scotland and CO2 shipping import via Peterhead Harbour to North Sea storage sites.

Alan James, Managing Director of Pale Blue Dot Energy, said, "This is a significant endorsement for this innovative project, the benefits of which have been seen by the nine EU member states involved in the evaluation. We look forward to progressing the feasibility phase and working with stakeholders to move the project towards development."

Professor Stuart Haszeldine, SCCS Director, said, "Funding for the Acorn CCS project is an important first step towards decarbonising industry in Scotland as part of the UK's overall efforts. Several years of work, by SCCS, Pale Blue Dot Energy and others, have confirmed the benefits of re-using legacy engineering equipment, pipelines and well-understood geological storage. This has already been evaluated with £100 million of public funding."

"In all of Europe, north-east Scotland is the location where CCS can be built most rapidly, with low-cost CO2 transport and very secure storage sites. Acorn also lights a path to sustainable offshore engineering and employment for many decades into the future. Becoming a careful early mover in this new industry can help us win a place in the business of CO2 storage for the UK and mainland Europe."

UK Committee on Climate Change warns of delays

www.theccc.org.uk

The UK's transition to a resilient, low-carbon economy is in danger of being derailed by a lack of Government action on climate change, the Committee on Climate Change says.

The inaction is making it difficult for businesses and the UK public to grasp the opportunities of the transition.

Good progress has been made to date but continued progress depends on significant new measures. Greenhouse gas emissions are about 42% lower than in 1990, around half way to the 2050 commitment to reduce emissions by at least 80% on 1990 levels.

As emissions have fallen since 1990, GDP has increased by more than 65% over the same period and total household energy bills have fallen compared to 2008 when the Climate Change Act was passed.

Action has also been taken to address the risks from climate change. There have been important steps to fund and improve river and coastal flood defences and to improve the resilience of energy, transport and water infrastructure to severe weather.

However, progress is stalling. Since 2012, emissions reductions have been largely confined to the power sector, whilst emissions from transport and the UK's building stock are rising. The overall state of our natural environment is worsening, reducing its resilience to climate change. Recent storms show that national infrastructure remains vulnerable to severe weather. Ten years after the 2007 floods important lessons remain, and the risks of surface water flooding in our towns and cities have still not been tackled.

Effective new strategies and new policies are urgently needed to ensure emissions continue to fall in line with the commitments agreed by Parliament (by at least 50% by 2025 and 57% by 2030 on 1990 levels), and that key risks to homes, businesses, and the natural environment are addressed.

The findings are part of the Committee's statutory 2017 Report to Parliament. The report sets out the CCC's latest independent assessment of UK action to reduce greenhouse gas emissions and to prepare for the impacts of climate change.

In particular, the CCC recommends that the Government:

Urgently delivers a plan to continue reducing emissions across the economy. It is no longer justified or wise to delay the publication of the emissions reduction plan required by law.

The plan must address the gap between Parliament's agreed targets and the impact of existing policies, including: plans to bring forward additional low-carbon electricity generation through the 2020s; accelerate the uptake of electric vehicles; provide a path for the uptake of low-carbon heat and set out a strategy for deploying carbon capture and storage technology.

Strengthens the UK's National Adaptation Programme (NAP) in the first half of 2018. The new programme, which drives action to prepare for climate change impacts, must address priority areas: flood risks to homes and businesses, risks to the natural environment, including to soils and biodiversity, and risks to human health and wellbeing from higher temperatures. The next NAP must be more ambitious, with policies that make a measurable difference and with clearer mechanisms to track progress.

International events will also influence UK actions. New climate change plans need to consider the risks and opportunities that may arise from the decision to leave the EU. Despite the announcement from the Federal Government of the United States that it intends to withdraw from the Paris Agreement, subsequent statements from the UK, China, India, the EU, several US states and cities and many others make it clear that the global transition to a low-carbon economy will continue.

CCC Chairman, Lord Deben, said, "The impact of climate change on our lives and those of our children is clearer than ever. The UK has shown global leadership on climate change, but progress will stall at home without urgent further action."

"New plans, for a new Parliament, are needed as a matter of urgency to meet our legal commitments, grasp the opportunities offered by the global low-carbon transition, and protect people, businesses and the environment from the impacts of a changing climate."

Japan needs CCS to tackle climate change

Japan will only meet its climate change obligations by intensifying the deployment of carbon capture and storage (CCS), experts meeting in Tokyo have heard.

Speaking at the Japan CCS Forum in Tokyo, Global CCS Institute Asia Pacific General Manager, Alex Zapantis, said Japan is facing the same unpredictable emissions future as the rest of the world.

"Countries around the world are trying to reduce their reliance on fossil fuels while increasing their dependence on renewables. This is great but it isn't going to get us to where we need to be unless all technologies are given equal incentivisation. Policy parity is the trigger to meet targets."

Mr Zapantis said Japan had a lot to be proud of as the birthplace of the Kyoto Protocol which lay the foundations for the Paris 2 degree targets.

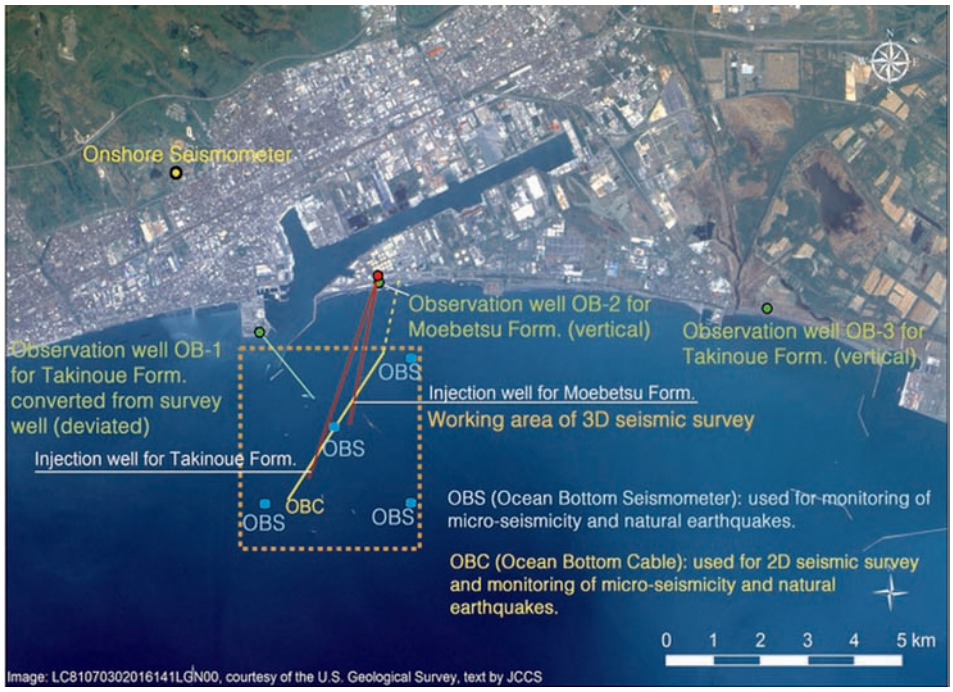
"The sad reality, however, is that we are still off-track to meeting those targets, and a wealth of international scientific evidence proves that those targets cannot be met without CCS."

Japan's greenhouse gas emissions are 2.8 per cent of the world total and although they are reducing through reductions in electricity consumption, a large amount of coal-fired generating capacity - much of it currently under construction - will make targets unattainable unless CCS is deployed.

Mr Zapantis said like the rest of the world, CCS deployment was badly needed across Japan's industrial sector which emits 0.41 billion tonnes of CO2 emissions per annum.

"CCS is the only technology capable of taking emissions from industries such as steel, chemicals, and fertiliser, and burying it in the 146 billion tonnes of underground storage capacity Japan has at its disposal."

"These industries are fundamental to keeping economies afloat and jobs alive. We believe there is a new economy waiting which will be driven by the intelligent and environmentally sensitive use of fossil fuels. It will be underpinned by using old resources in new ways. CSS will be a primary energy anchor in this new economy."



The Tomakomai CCS Project will capture more than 300,000 tonnes of CO2 by 2020 (Image Japan CCS)

Mr Zapantis said Japan was showing how this new economy could be created through the work that companies like Kawasaki are doing in Australia to develop hydrogen production.

"Japan realises the enormous hydrogen opportunity that lies ahead in transport, especially in heavy transport where batteries cannot be a sole solution for a long time.

The Japan CCS Forum has gathered more than 200 leaders from government, industry and academia to discuss CCS development in Japan.

New analysis from the International Energy Agency (IEA) confirms that CCS remains critical for an orderly energy transition.

Speaking at the Forum, IEA CCS Unit Head, Juho Lipponen, said CCS was a safe, proven, versatile technology whose time has come.

"CCS is a unique clean technology capable of bridging the gap between the continued fossil fuel use in power generation and industry, and a pathway to achieving globally-agreed climate goals."

The IEA's latest Energy Technology Perspectives publication confirms that the more ambitious the climate goal, the more CCS is required".

There are currently 17 large-scale CCS projects around the world including Japan's Tomakomai CCS Facility, Asia's first full-cycle CCS plant which will capture more than 300,000 tonnes of CO2 by 2020.

Five additional commercial CCS facilities are poised to commence operations in the next 12-18 months.

More information

www.globalccsinstitute.com

www.japanccs.com

Capture and utilisation news

New test campaign at Technology Centre Mongstad

www.tcmda.com

A new test campaign named MEA-3 has started at TCM containing a number of sub-projects focusing on CO2 capture, emissions to air and model predictive controlled operations.

The sub-project on model predictive control (MPC) (also known as modern or advanced process control) is a CLIMIT Demo project with Cybernetica, Sintef and NTNU. Test activities for this sub-project started on June 12th. The MEA campaign will run until December 2017, and most of the results will be openly available.

"TCM has long worked to reduce the cost of carbon capture. This project will contribute further to this, by automating more of the operations," said Managing director Roy Vardheim.

Plant automation is based on model predictive control, commonly used in other industries such as oil refining and petrochemicals. MPC is an overarching control system that can read plant data and calculate the optimum set point to several regulators simultaneously. The MPC technology to be used in this project was developed by Cybernetica.

NTNU, SINTEF and Cybernetica will assist with the practical implementation at Tiller and TCM. The dynamic process model that becomes part of the tool has been developed in the doctoral thesis of Nina Enaasen Flø now working for TCM.

With this tool one can move faster from one test run to another, have more effective test campaigns, more efficient operations and thereby reduce energy consumption by 3-5 percent. The tool compares estimates from the model with actual process measurements in the plant and make corrections if necessary. Especially when changing parameters it is much to gain from automation.

The project represents a continuation of the good working relationship between TCM and CCS environment in Trondheim. Prior to the TCM test, the tool was tested in SINTEF's pilot plant at Tiller in Trondheim. Hanne Kvamsdal from Sintef is prosject leader for DOCPCC.

Some of the most influential players in the carbon capture community; SINTEF, NTNU, Engie, Road, Uniper, TNO and TCM are collaborating in the second CLIMIT Demo sub-project named Aerosolve. The project connects SINTEF's Tiller facility, TCM and the full-scale ROAD project and will develop understanding and solutions directly applicable at industrial scale.

One of the most important research topics in post combustion CO2 capture is to control the emissions of amine and amine degradation products to the atmosphere. Aerosol-related emissions to air from amine absorbers for CO2 capture is a topic of increasing interest and concern.

It is commonly known that flue gas pre-treatment, absorber configuration, operating conditions and solvent selection are factors that can minimize these emissions, but there is currently limited theoretical and experimental understanding of the physical/chemical mechanisms involved in the process and certainly insufficient knowledge to allow the techno-economic optimization of aerosol control at industrial scale.

There are also contradictory results reported in literature as to e.g. effect of various pretreatment options. Establishment of reliable continuous measurement methodology for absorber aerosols and online process monitoring is needed in order to increase the availability of high quality data, underpin model validation, assess the effectiveness of abatement options, such as the use of wet electrostatic precipitators and Brownian diffusion filter techniques, and ultimately deliver reliable process monitoring and control.

Validated theoretical models and generic tools for flue gas pre-treatment design will be important tools for future process optimization of design. Therefore, it is of importance to demonstrate suitable treatment options under real and relevant conditions. This work will lead to the insights how to develop and operate CO2 capture plants with emission levels within the given emission permits.

CO2 Solutions Valorisation Carbone Québec Project

www.co2solutions.com

The project committee has announced the first major steps in its deployment.

The objective of the VCQ project is to promote the development and demonstration of commercially viable solutions to capture and reuse CO2 in added-value applications. The project is centred on the Corporation's industry-leading enzymatic CO2 capture technology.

By mobilizing various partners, policy makers, academics and industrialists, the VCQ project will address climate change by reducing GHG emissions, while creating opportunities and growth within this new sector of the economy for the value-added reuse of CO2.

The VCQ management committee is now pleased to announce the first major steps in the deployment of this ambitious program. The following purchase orders were issued this past week for:

1. Move and upgrade of the CO2 capture unit: The 10 tpd capture unit, which CO2 Solutions successfully demonstrated during a 2,500 hour semi-autonomous extended run, will be moved from its Valleyfield location to the new VCQ testing centre located at the Parachem facilities in Montreal. The unit, which represents a contribution by the Corporation towards the VCQ project, will also be upgraded to incorporate the Corporation's most recent technology developments. It is anticipated that the upgraded unit will be operational by early Q3 2017.

2) First CO2 conversion technology selected: In collaboration with the scientific committee, a technology to convert CO2 into acetic acid, is the first technology selected to become part of the VCQ project. Acetic acid is an important industrial commodity used in the production of PTA (purified terephthalic acid), which itself is a raw material for the production of polyesters. It is anticipated that the acetic acid conversion unit will be operational by early Q4 2017.

In addition, the Corporation's Rotating Packed Bed (RPB) equipment that was being tested at the University of North Dakota EERC centre earlier in 2016, is now being relocated to the Montreal testing site. It will be included in a second, 10 tpd small footprint capture unit, showcasing the latest development in reducing equipment size for CO2 capture. Once commissioned, foreseen for later in the project, two capture units will be operational at the VCQ site.

Statoil evaluating new CO2 storage project in Norwegian waters

Gassnova has assigned Statoil to evaluate the development of carbon storage on the Norwegian continental shelf (NCS). This will be the first storage site in the world receiving CO2 from several industrial sources.

The storage project is part of Norwegian authorities' efforts to develop full-scale carbon capture and storage in Norway. It will capture CO2 from three onshore industrial facilities in Eastern Norway and transport CO2 by ship from the capture area to a receiving plant onshore located on the west-coast of Norway. At the receiving plant CO2 will be pumped over from the ship to tanks onshore, prior to being sent through pipelines on the seabed to several injection wells east of the Troll field on the NCS. There are several possible locations for the receiving plant, and the final choice will be based on criteria such as safety, costs and expansion flexibility.

Gassnova has previously been awarded the assignments for carbon capture and transportation in the project. The storage solution to be evaluated by Statoil will have the potential to receive CO2 from both Norwegian and European emission sources.

CO2 will be sent through pipelines to several injection wells east of the Troll field (pictured) for permanent storage. (Photo: Harald Pettersen / Statoil)

"Carbon capture and storage (CCS) is an important tool to reduce carbon emissions and to achieve the global climate targets as defined in the Paris Agreement. The CCS project that has been assigned to us will require an entirely new collaboration model with carbon capture from several industrial sources, carbon transportation by ships, and carbon storage 1000-2000 metres below the seabed. In addition, this may be the start of the world's first CCS network across national borders. Much work remains, but if we are successful, this may open new business opportunities both for Statoil, our collaboration partners and Norwegian industry," says Irene Rummelhoff, Statoil's executive vice president for New Energy Solutions.

The results of studies performed in 2016 show that it is technically feasible to realise a carbon capture and storage chain in Norway. The next phase of the project, which Statoil has been assigned to perform, will involve concept and pre-engineering studies in order to evaluate the possibilities in more detail, and to get accurate cost estimates towards a possible investment decision. An investment decision for project implementation is expected to be made by the Norwegian Parliament in 2019.

The technologies for carbon capture and storage in geological formations are known and established. There are 21 full-scale carbon capture and storage projects worldwide in the development or operations phase. Statoil's CCS projects at Sleipner and Snøhvit are among these, and have given Statoil more than 20 years of operational carbon storage experience.

"The next big tasks are developing technology, regulations and general commercial conditions that may stimulate an extensive roll-out of CCS," says Rummelhoff.

The Norwegian CCS project will be a collaboration project between onshore industry, government authorities and companies with offshore expertise, such as Statoil.

"Collaboration and sharing of knowledge are essential to accelerating the development of a market for carbon capture and storage. It is therefore important that we collaborate with other industrial players that can and will help implement projects and qualify CCS as an important climate tool," says Rummelhoff.

Future carbon storage may also help realise a hydrogen market. Hydrogen produced from natural gas generates CO2 as a by-product, and with a value chain for CO capture, transportation and storage it will be possible to further examine a full-scale value chain for hydrogen, which is a low-carbon energy solution with potentials within both power, heating and transportation.

More information

www.statoil.com

www.gassnova.no

Pioneering 'fingerprint' test will build confidence in geological storage of CO2

A test developed by Scottish scientists to check for leaks from carbon capture and storage sites has been used for the first time to investigate an alleged leak from CO2 injected underground at a farm in Saskatchewan, Canada.

Researchers from Scottish Carbon Capture & Storage (SCCS) have developed a way to measure tiny traces of inactive natural gases, known as noble gases, found in CO2. These noble gases vary depending on whether the CO2 is from just below ground or deep below, enabling scientists to fingerprint a sample and pinpoint its source.

The technique, developed by scientists at the University of Edinburgh, has been conclusively used to investigate an alleged leak from CO2 injected underground at a farm in Saskatchewan, Canada. The test showed that high levels of CO2 recorded on the farm arose from nearby wetlands and were not leaking from a CCS site at the nearby Weyburn Oil Field.

While studies have shown that small amounts of CO2 seepage carry no significant threat to human health, the new test will allow scientists and storage site developers to reassure residents that CO2 storage sites are secure.

The technique will be useful in countries, such as Canada and the USA, where onshore CO2 storage is already underway. In the UK, which has ample offshore CO2 storage, scientists are researching how this test can be combined with other offshore monitoring methods.

Dr Stuart Gilfillan of the University of Edinburgh's School of GeoSciences, who led the study, said, "Carbon capture and storage is an essential means to curb emissions of greenhouse gases, which is needed to limit global warming to 2°C, as internationally agreed recently in Paris."

"Securely storing captured CO2 is critical to its success and our method of identifying any leaks should give assurance to local communities. Our work provides a simple way to easily and unambiguously spot leaks from future storage sites, using the fingerprint of noble gases that the CO2 picks up during storage."

The study has been published in the International Journal of Greenhouse Gas Control and was funded by the Natural Environment Research Council and SCCS.

Stuart Gilfillan and Jerry Sherk Sampling in Saskatchewan (Photo: Stuart Gilfillan)

More information

www.sccs.org.uk

Enhancing CO2 storage capacity with brine production

The controlled production of brine from saline aquifers beneath the North Sea can greatly increase the amount of carbon dioxide that can be injected for storage according to research.

A multi-disciplinary project, funded by the Energy Technologies Institute (ETI), has studied how brine production, more often associated with oil and gas operations, can enhance the storage potential of saline aquifers already identified as ideal CO2 stores.

The project, Impact of brine production on aquifer storage (ETI ref CC2010), was funded by the ETI as part of its CCS programme. The overall objective was to produce a cost-benefit analysis of brine production using exemplar stores from the CO2Stored database and the UK Storage Appraisal Project (UKSAP).

The project findings, which were presented at All-Energy 2017 on 11 May, also highlight other key benefits of using brine production alongside CO2 storage, including the opportunity to convert smaller aquifers into economically viable stores.

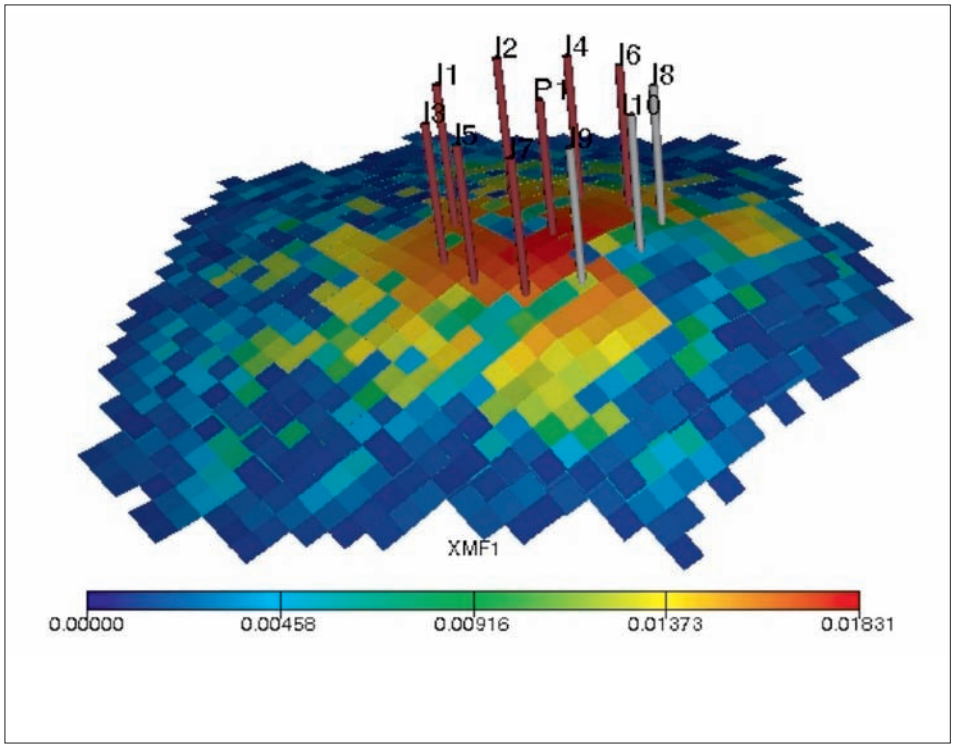
It may also give certain storage sites a longer lifespan by allowing operators to increase the injection rate at a later date as new CO2 sources come on stream.

The UK has some of the world's best geological CO2 storage, up to 2.5km below the North Sea, which can be utilised in carbon capture and storage (CCS) projects to help the UK meet legally binding carbon targets.

These storage sites have already been identified by CO2Stored, the UK's offshore storage atlas, which led from the ETI's UK Storage Appraisal Project.

The project team was led by Scottish Carbon Capture & Storage (SCCS) partner, Heriot-Watt University, and included researchers from energy consultancy, Element Energy, along with scientists and engineers from Durham University and T2 Petroleum.

Professor Eric Mackay, of Heriot-Watt University and principal investigator on the project, said: "We studied a set of potential CO2 stores, identified from the UK's offshore storage atlas, to assess the value of brine production in terms of both increasing CO2 storage capacity and bringing down the unit cost of storage. Our findings suggest an eightfold increase in capacity is possible, plus a host of other benefits for a developing CCS industry in the UK."



Project modelling showing the distribution of injected CO2 within a Bunter sandstone dome structure

"Our study has identified a variety of strategic benefits of brine production for both policymakers and storage operators," said Emrah Durusut, of Element Energy.

"In addition to increasing storage capacity and achieving lower minimum unit costs at certain aquifers, brine production can also increase optionality for storage operators and allow operators to better utilise their existing storage assets within a defined licence area."

The project recommends further work that would support the development of CCS in the UK, including an assessment of how much economic value brine production would bring when CO2 stores are handed over to a "competent authority" for longer-term operations and/or monitoring.

A full report on findings will be released by the ETI later this year.

More information

www.sccs.org.uk
ciccs.hw.ac.uk
www.element-energy.co.uk

ETI: enough storage capacity for UK until at least 2050

The Energy Technologies Institute (ETI) has published a new report which confirms that large scale storage sites using shared infrastructure and existing low risk technologies would provide the lowest cost route to developing carbon capture and storage (CCS) in the UK.

"Taking stock of UK CO2" highlights what has been learnt since the Government cancelled its two CCS demonstration projects at the end of 2015. It shows that the UK has more than enough potential CO2 storage sites to meet its needs out to 2050 and a substantial number of these sites have already been fully or partially appraised.

Based on the appraisal work carried out to date (by ETI and other parties) which covers a broad range of the types of stores available, there appears to be no significant technical barrier that would limit the CCS industry developing at scale in the UK from a number of strategic shoreline hubs.

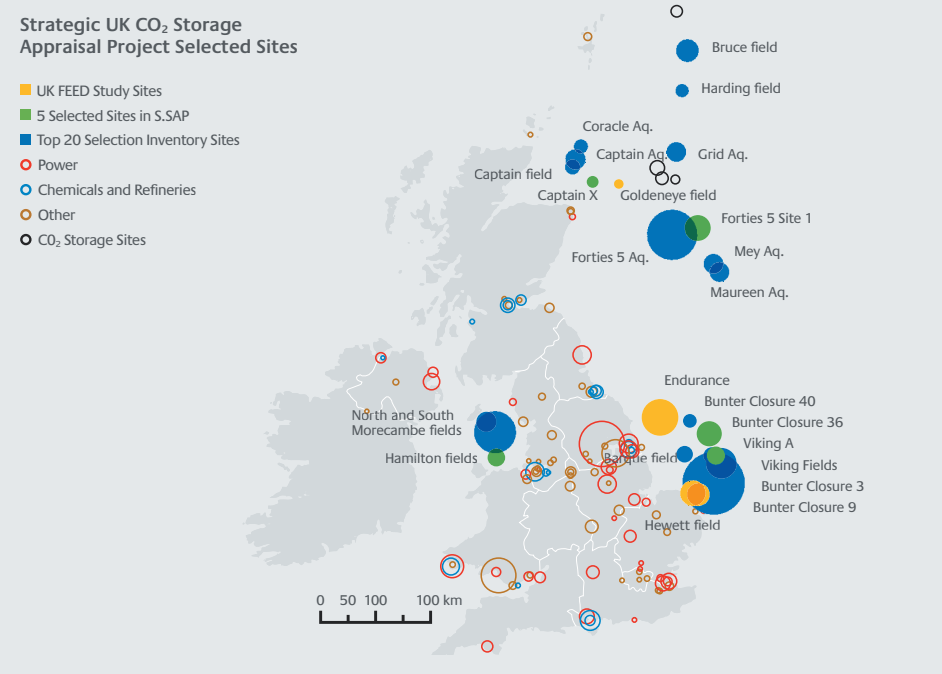
The east coast of England has been identified as a prime location for CCS deployment as it has a large emissions base, there are good sites for large new low carbon power stations and industry and it is close to large, low cost offshore storage sites.

Once shared infrastructure has been developed then the decarbonisation of industry by CCS can be rolled out at an attractive cost and the generation of hydrogen and negative emissions developed.

Recently concluded ETI research by a partnership between Heriot Watt and Durham Universities, Element Energy and T2 Petroleum Technology shows that brine production can increase storage capacity and injection rates cost effectively.

Dennis Gammer, Strategy Manager at ETI, said, "Following the closure of the Government's CCS commercialisation competition, we have reassessed options for developing the UK's possible CCS transport and storage infrastructure and found that there is no shortage of potential storage sites, either fully or partially appraised."

"Any attractive CCS projects to developers and the government will need to realise economies of scale at, or relatively shortly after start-up, and because of this are most likely to be large gas power stations delivering strategic infrastructure to enable the later tie-in of industrial emissions."



Major UK CO2 storage sites and point emitters over 0.1MT/a, with coal and industrial plant closures removed. From DEFRA National Atmospheric Emissions Inventory (online). NAEI Point Source data 2014 (viewed 31/5/2017). Available at http://naei.defra.gov.uk/ ©Crown 2017

"For some potential matches of emitter and store options to start small and build quickly may reduce the size of any initial commitment at risk and this offers an additional approach to building a CCS network."

Achieving the UK's legally binding 2050 carbon targets without deploying any CCS is very likely to result in substantially higher costs. Based on ETI systems modelling delaying its implementation adds an estimated £1-2bn a year throughout the 2020s to the otherwise lowest cost options for an energy system reducing carbon emissions.

CCS is particularly attractive as it is suitable for power generation, the capture of industrial emissions, providing new low carbon energy supplies (eg hydrogen) through the gasification of various feedstocks and delivering "negative emissions" (the removal of CO2 from the atmosphere) when used in combination with Bioenergy (BECCS).

Professor Stuart Haszeldine, Scottish Carbon Capture & Storage Director, said, "We welcome the ETI's findings and, in fact, would go further and suggest that the UK's CO2 storage capacity could accept UK greenhouse gas emissions from industry, heat and power well beyond 2050 to 2100, or even 2200. This can create jobs and protect UK businesses against inevitable rises in carbon prices from our trading partners in Europe, the USA and China."

More information

www.eti.co.uk

Transport and storage news

U.S. DOE to invest $12m in carbon storage research

www.netl.doe.gov

The U.S. Department of Energy's Office of Fossil Energy (FE) has made $12 million available to advance new geological carbon storage projects that enable safe, cost-effective, and permanent geologic storage of carbon dioxide.

Two funding opportunities under FE's Carbon Storage Program will advance the development and validation of storage technologies associated with enhanced oil recovery operations or injection into a saline reservoir.

Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico ($8 million)

This funding opportunity will facilitate offshore geologic CO2 storage in the Gulf of Mexico by combining the capabilities and experience of industry, academia, and government into one or more partnership(s).

The partnership(s) will develop and validate key technologies and best practices to ensure safe, long-term, economically viable carbon storage in offshore environments. The knowledge created by the successful partnership(s) will form the basis for planning offshore carbon-storage projects. More information about this FOA is available here.

Technology Development to Ensure Environmentally Sustainable CO2 Injection Operations ($4 million)

This funding opportunity will address key knowledge and experience gaps in carbon storage technology. Advancing capabilities to assess CO2 stored in the deep subsurface is critical in ensuring secure and verifiable storage, while reducing long-term operational cost.

This FOA seeks projects that will quantify the limits of detection and thresholds of uncertainty, and will develop modeling and monitoring methods, technologies, and tools to detect stored CO2 and assess CO2 plume boundaries over time within a target reservoir. A more detailed description of this FOA is available here.

GroundMetrics awarded contract for subsurface CO2 monitoring

www.groundmetrics.com

GroundMetrics will be monitoring CO2 in the subsurface through a new project selected for award by the US Department of Energy (DOE).

GroundMetrics already uses its propriety resistivity sensors and software to address many applications on the oilfield, including Enhanced Oil Recovery (CO2 and steam). But the same electromagnetic imaging technology can also be used to map the CO2 injected for carbon capture and storage (CCS).

The International Energy Agency estimates that CCS technology offers the potential to lessen net CO2 emissions by up to 85-95% compared to the same process without CCS. However, there have been delays in CCS deployment in part due the lack of a regulatory framework for long-term liability for negative impacts of any leakages from underground storage facilities. This means that effective monitoring, verification, and accounting (MVA) for CO2 is critical to the initiation and success of these projects.

CO2 is also extremely useful for the Enhanced Oil Recovery (EOR) process and industry-wide, CO2 injection represents 30% of total production costs on EOR fields. There is a need to image the CO2 injection profile in the reservoir to ensure the gas stays in the target zone and to optimize the EOR process by monitoring areal and vertical sweep efficiency.

In partnership with DOE, GroundMetrics will develop a continuous monitoring system to measure resistivity changes. If the test is successful, it will allow oil companies and sequestration managers to better monitor CO2 saturation, allowing them to improve operational efficiency and efficacy, verify MVA, and maximize oilfield productivity.

The effort is a part of an ongoing collaboration with DOE and the forth grant using GroundMetrics technology to monitor CO2 dating back to June 2012.

"By seeing what's really going on underground, this technology will advance both carbon sequestration and Enhanced Oil Recovery," said George Eiskamp, CEO at GroundMetrics. "Imaging CO2 gives operators the data and insights they need to make the critical decisions that are vital to the success of any project. When you can measure something, you can manage it better."

GroundMetrics is a full-services survey and monitoring company and the world leader in the development of land-based electromagnetic / resistivity sensor systems.

The development of a new type of sensor technology for the US Department of Defense began in 2001 by GroundMetrics' sister company QUASAR Federal Systems (QFS), a hardcore electromagnetic R&D contractor. The technology was licensed exclusively to GroundMetrics for commercial purposes in 2010.