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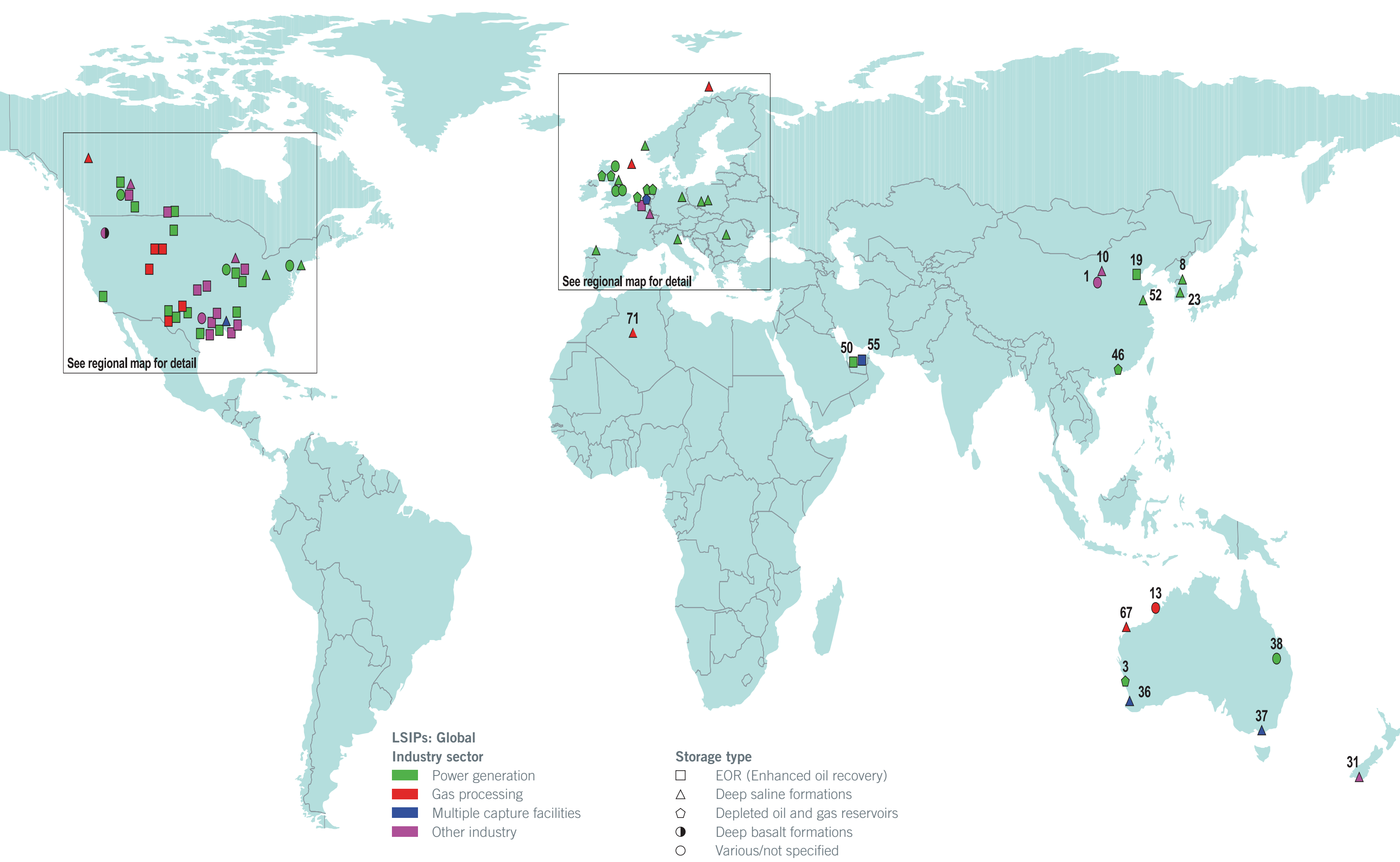

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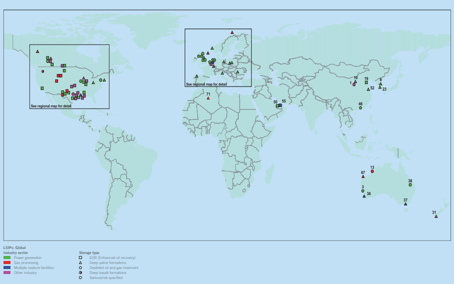
Front cover:
The 77 active or plannedlarge scale integrated CCS projects by industry sector, storage type and location from the Global Carbon Capture and Storage Institute Global Status of CCS 2010 report



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GCCSI Global Status of CCS 2010

The global commitment to carbon capture and storage (CCS) technologies remains strong, according to The Global Status of CCS: 2010 report released by the Global CCS Institute. The report identifies 234 active or planned CCS projects ranging across technologies, project types and sectors at the end of 2010, a net increase of 21 projects since the previous year. Seventy-seven are fully integrated, large-scale projects demonstrating the full CCS value chain.

The key findings of the report "highlight that governments and industry are still in the early stages of implementing largescale international programs to shorten the timeframe for the commercial deployment of CCS. These programs remain focused on the demonstration phase for developing and improving capture technologies in new industrial applications and proving the safe and secure long-term storage of CO2. This demonstration phase is likely to last for over a decade."

"In addition to this project activity governments continued to pursue the development of policy, regulatory and legal frameworks to support CCS projects," said the Institute's Interim CEO, John Hartwell. "Looking ahead, the Institute anticipates that during 2011 a number of projects will have completed concept definition studies and be in a position to move to the next stage of development."

Project developments are being driven by the significant support offered by governments across the globe. As much as $US40 billion could be available to have large-scale projects up and running this decade. The report identifies 25 large scale projects that governments have so far committed to support.

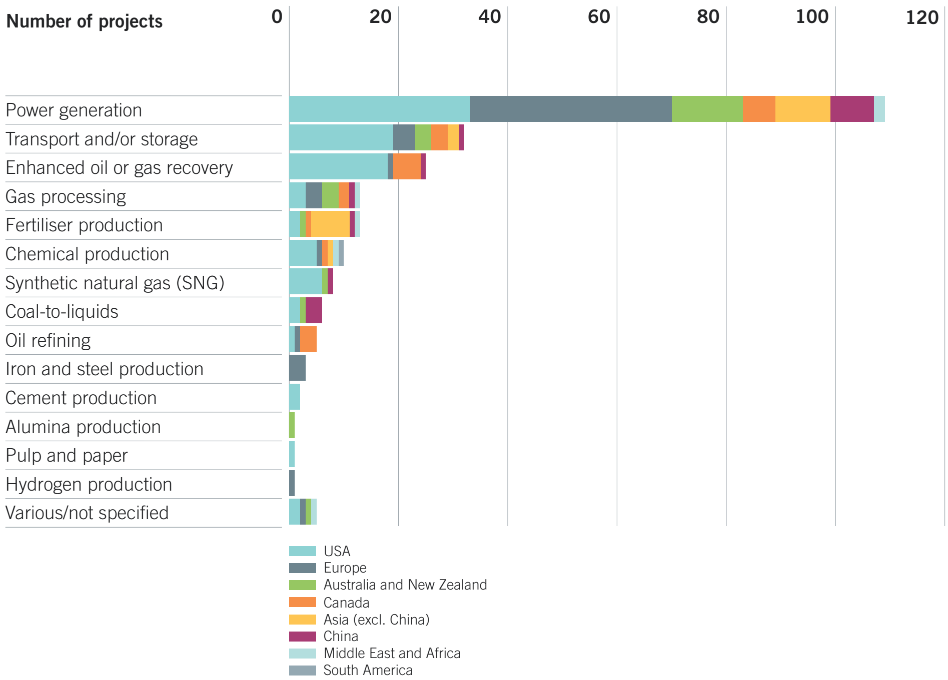
Two projects made final investment decisions recently: the Gorgon CO2 Injection Project in Australia, which when fully operational will be the largest carbon storage project in the world and the Southern Company integrated gasification combined cycle (IGCC) project in the United States, which will be the world's first large-scale CO2 capture project in the power sector.

The report also highlights areas where more work needs to be done to accelerate CCS, including greater characterisation of global storage options and reducing costs.

"It is reassuring that despite the challenges, governments and industry appear committed to finding solutions for commercially deploying CCS," said Hartwell.

According to the International Energy Agency (IEA), CCS will contribute 19 per cent of all emission reductions required by 2050.

"CCS is a critically important emissions reduction tool and a key part of a comprehensive global emissions reduction portfolio that also includes other low emission technologies," said Hartwell.



All active and planned projects by industry sector and by region (Source: Global Status of CCS: 2010 ©GCCSI)

Underpinning The Global Status of CCS: 2010 report's economic analysis is data from another document released by the Institute, the Economic Assessment of Carbon Capture and Storage Technologies.

Report summary

The report consolidates the current understanding of the level and nature (both public and private) of global CCS activities, as well as the major opportunities and challenges experienced by large-scale integrated projects (LSIPs). The report also seeks to assist domestic governments focus their responses to accelerate the demonstration phase of CCS in order to bring forward the point in time when CCS can be deployed commercially.

In Chapter 2, entitled '**Policy frameworks and public financial support**', the nature and scope of global public financial support for CCS demonstration is characterised. Although substantial programs for supporting CCS have been announced by governments, for many, the process of implementing the program and allocating support to specific projects is still underway. Input-based grant programs awarded on a competitive basis are the most prominent of policy mechanisms.

Chapter 3 entitled '**CCS projects**' gauges global CCS activity at the project level. Although it indicates a number of projects have been newly identified during the past year (across the various stages of the technology innovation chain), it also reveals that many previously commenced projects have been delayed or cancelled due to investment uncertainty or due to technological reasons. Another looming challenge for the CCS community is that, while the vast majority of planned LSIPs are located in developed regions and concentrated in the power sector, future emission growth challenges are increasingly found in the developing regions and other industry sectors.

Chapter 4 entitled '**CO2 storage**' maps the status of efforts to better understand and assess viable storage sites with suitable geology, capacity and injectivity. In the longer term, as carbon constraints tighten, the associated investment in commercial CO2 capture plants and common user infrastructure will increasingly depend on access to suitable storage solutions.

Chapter 5 entitled '**CO2 networks for CCS**' gives an account of the status of CO2 networks for advancing CCS. This includes proposals for establishing new networks specifically for CCS, as well as leveraging off the existing CO2 infrastructure for EOR in North America. Overall, the benefits of a 'network' approach is influencing a significant share of proposed large-scale demonstration projects, though it could also introduce additional costs and risks.

Chapter 6 entitled '**Legal and regulatory developments**' provides an update on global progress in implementing frameworks to regulate demonstration projects as well as to support large-scale commercialisation of CCS solutions. Efforts are focused on how long-term liability is currently being addressed, treatment of associated property rights, post-closure site stewardship, and the increasingly important requirement by many sovereign governments for new coal-fired plants to be 'CCS ready'.

Chapter 7 entitled "**CCS costs and financing**' focuses on public information on costs that emerged during 2010. This includes three full technology comparison studies undertaken by the International Energy Agency (IEA), the United States Department of Energy (DoE) and WorleyParsons. In addition, costs from emerging projects are presented and contrasted. The challenges of uncertainty, both in technology and financing, arising from the initial large upfront investment costs for large-scale demonstrations continues to have an impact on the investment environment.

Chapter 8 entitled '**Regional CCS knowledge-sharing initiatives**' presents a review of regional CCS knowledge-sharing initiatives and their development from mid-2009 to late 2010. Specifically, it examines the frameworks established to collect and share knowledge created from publicly funded demonstration projects in a number of regions across the globe.

Finally, Chapter 9 entitled '**CCS public engagement**' summarises the vitally important approaches being employed to engage and inform the public in relation to CCS project developments. It highlights key themes and guidelines to help provide project proponents with an understanding of the factors affecting the development of effective public engagement strategies.

Economic Assessment of CCS technologies

Updating the findings of the original Foundation Report 2 of the Strategic Analysis of the Global Status of Carbon Capture and Storage published in 2009, the report presents a detailed analysis of the capture, transport and storage costs for power plants and a select range of industrial applications using 2010 data.

"Though minor changes in the costs of CCS across power generation and industrial applications have occurred, the costs of CCS still remain high," the report says." This is expected, given that it has only been 12 months since the initial Foundation Report Two, and major developments that have the potential to dramatically reduce the cost of CCS have not yet occurred."

"Despite the costs of CCS being high relative to traditional power generation and industrial facilities, it is important to consider that these traditional methods currently emit large amounts of CO2 into the atmosphere. Given the current and anticipated restrictions on facility emissions, these facilities will not be allowed to continue to operate as they have in the past."

"The high costs of CCS as identified in this study should be considered with other low emission technologies to allow consideration of approaches to low emission power and industrial production. Further, if CCS is compared against the anticipated cost that may be imposed on facilities for emitting CO2 it is likely to appear more competitive in a low carbon market."

Some of the finding of the updated modelling are:

• All of the coal-fired technologies showed a decrease in fuel costs related to the lower coal costs in 2010.

• For the reference cases, taking into account currently available technologies, the lowest levelised cost of electricity (LCOE) was for oxyfuel combustion at US$114/MWh, in contrast to 2009 where LCOE for natural gas-fired combined cycle (NGCC) technologies was the lowest at US$112/MWh. Consistent with the findings in 2009, the LCOE for pulverized coal (PC) supercritical and IGCC technologies were the greatest at US$131/MWh and US$125/MWh respectively.

• The percentage increases in costs that the application of CCS has over non-CCS facilities have remained relatively unchanged since 2009.

• There was an increase in the capital contribution to the LCOE for oxyfuel combustion with CCS, reflecting the inclusion of an additional purification process when capturing CO2.

• CO2 capture still represents the greatest contribution to the cost of CCS, with the majority of the cost increases being due to changes in the capture system.

Doanload the reports at:
www.globalccsinstitute.com

		Power generation				Industrial applications			
		PC supercritical & ultra supercritical*[1]	Oxyfuel combustion standard & ITM*[1]	IGCC	NGCC	Blast furnace steel production	Cement production	Natural gas processing	Fertiliser production
	Dimensions	US$/MWh	US$/MWh	US$/MWh	US$/MWh	US$/tonne steel	US$/tonne cement	US$/GJ natural gas	US$/tonne ammonia
Levelised cost of production	Without CCS*[2]	73-76	73-76*[3]	91	88	570-800	66-88	4.97	375
	With CCS FOAK*[3]	120-131	114-123	125	123	82	34	0.056	11
	With CCS NOAK*[4]	117-129	112-121	123	121	74	31	0.056	11
	% Increase over without CCS*[5]	61-76%	53-65%	37%	40%	10-14%	39-52%	1%	3%
Cost of CO_2 avoided*[6] ($/tonne CO_2)	FOAK	62-81	47-59	67	107	54	54	19	20
	NOAK	57-78	44-57	63	103	49	49	19	20
Cost of CO_2 captured ($/tonne CO_2)	FOAK	53-55	42-47	39	90	54	54	19	20
	NOAK	52	41-45	38	87	49	49	19	20

Summary results of the economic assessment of CCS technologies (Source: Economic Assessment of Carbon Capture and Storage Technologies ©GCCSI)
NOTES
1. The ultra-supercritical and ITM technologies are currently under development and are not commercially available. These technologies represent options with the potential for increasing the process efficiency and reducing costs.
2. Without CCS cost of production for industrial process are typical market prices for the commodities.
3. Oxyfuel combustion systems are not typically configured to operate in an air fired mode. Therefore, oxyfuel combustion without CCS is not an option. The values here are the PC without CCS value to be used as a reference for calculating the cost of CO2 avoided.
4. For industrial processes, levelised cost of production presented as cost increment above current costs.
5. Expressed with respect to current commodity prices of industrial processes.

Cuycha - carbon capture and neutralization

Cuycha, a Finnish company, has developed a process for capturing and converting CO_2 from flue gas into useful materials by reacting it with naturally occuring minerals.

By Ilkka Nurmia, CEO, Cuycha Innovation Oy

There are three natural sinks for the CO_2 in the atmosphere: oceans, green organisms, and rock weathering.

The first sink, oceans, is problematic because increasing amounts of CO_2 in the atmosphere will lead to the acidification of the oceans as this acidic gas dissolves into ocean water. This already endangers coral reefs, which are important to the whole ecosystem of oceans.

Green organisms, such as trees on land, are beneficial as long as the carbon they remove from the atmosphere is not allowed to return to it through rotting vegetation or forest fires. Most secure are aquatic green organisms such as algae, which use carbon to build shells from calcium carbonate. These shells will eventually sink onto the sea bottom and become stable minerals such as limestone.

The process of rock weathering starts with rain. Approximately 505,000 cubic kilometers (121,000 cu mi) of water falls as precipitation each year with 398, 000 cubic kilometers (95,000 cu mi) of it over oceans. Given the Earth's surface area, that means the globally-averaged annual precipitation is 990 millimeters (39 in) (Wikipedia: Global climatology).

This water is in equilibrium with the carbon dioxide content of the air at the temperature and atmospheric pressure prevailing in the location of the rainfall. The solubility of CO_2 in water at 150 C is 2,1 g/liter per bar of CO_2 pressure (www.engineeringtoolbox.com/gases-solubility-water).

Assuming that the precipitation takes place at sea level at 150 C and the concentration of CO_2 in the air is 390 parts per million in volume (Wikipedia: Carbon dioxide in Earth's atmosphere), this corresponds to a CO_2 concentration of 0,82 g per ton of rainwater.

The total amount of CO_2 in the rainwater falling on the land is then 88 million tons per year. This CO_2 does not end up in the ocean; it is converted into bicarbonate in the process of rock weathering. If all CO_2 is converted into bicarbonate, the concentration of the latter in the water would be 120 mg/L. Comparing this with the measured amount of bicarbonate in the St. Lawrence River water, 110 mg/L (Kirk-Othmer, Encyclopedia of Chemical Technology 4th Ed., Vol. 25, p.374, Wiley & Sons), indicates that the CO_2 in rainwater is indeed efficiently neutralized into bicarbonates. The bicarbonates formed in natural weathering flow in river water into the seas where coral polyps and other organisms use them as building material. This forms a CO_2 sink, which together with the photosynthesis in green plants removes CO_2 from the atmosphere.

Cuchya's process provides a simple way to direct our CO_2 emissions into this sink. The bicarbonates end up in the oceans but they do not cause acidification; on the contrary, this process offers a solution to the CO_2 problem through neutralizing the CO_2 with feldspar minerals into harmless bicarbonates.

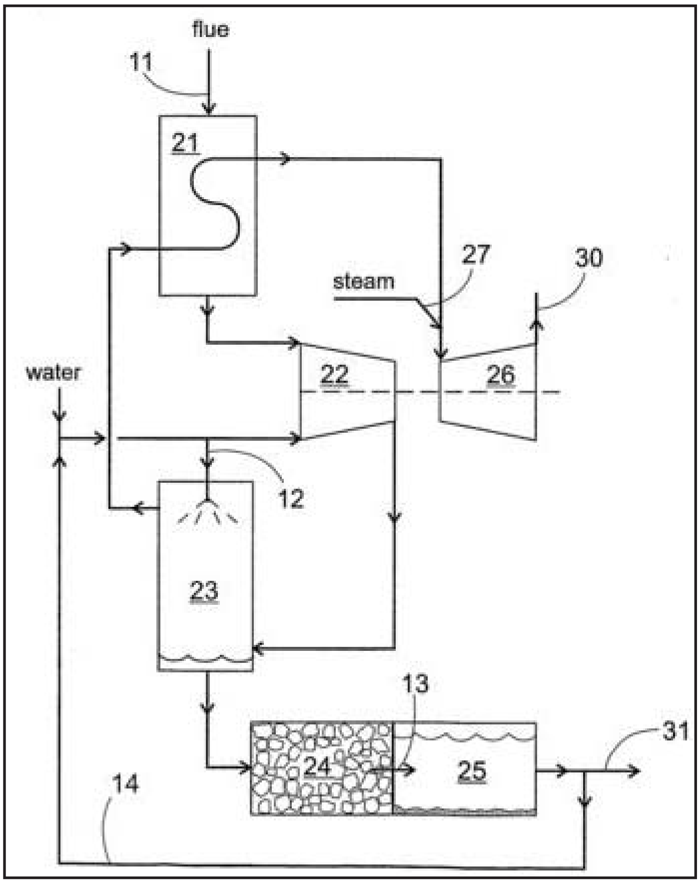


Figure 1 - the CCN process

Using feldspars to neutralize CO2

Feldspars ($KAlSi_3O_8$ - $NaAlSi_3O_8$ - $CaAl_2Si_2O_8$) are a group of rock-forming tectosilicate minerals which make up as much as 60% of the Earth's crust (Wikipedia: Feldspar). The above formulas are those of potassium-aluminum feldspar (orthoclase), sodium-aluminum feldspar (albite), and calcium-aluminum feldspar (anorthite). Pure anorthite is able to neutralize ca. 320 kg CO_2 per ton while the neutralizing ability of other feldspars varies between 150 and 300 kg CO_2 per ton depending on their anorthite content.

The aluminum content of feldspars varies from approximately 10 % in orthoclase and albite to 19 % in anorthite. The most efficient feldspar in the neutralizing process is anorthite: its weathering follows the reaction

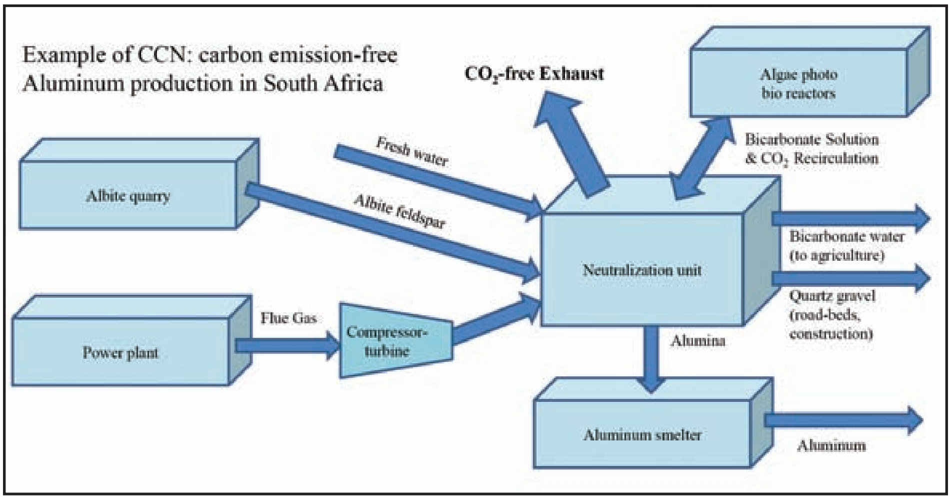
$$CaAl_2Si_2O_8 + 2CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^- + 2SiO_2 + 2Al(OH)_3 .$$

The aluminum in anorthite is liberated as aluminum hydroxide, $Al(OH)_3$. This is easily converted into aluminum oxide (alumina), Al_2O_3 .

The neutralization of one ton of carbon dioxide with anorthite produces about one ton of alumina plus 1,3 tons of quartz. Pure quartz sand sells for about US$ 70-300 per ton.

Alumina is a major commodity. It is used in the ceramics industry and aluminum produc-tion and its price is about US$ 300 per ton.

The logistics of this new way are determined by the amount of feldspar required. Taking a coal-fired power plant as an example, one ton of coal contains about 80 % of



carbon and will produce 2,9 tons of CO2, which will require 9,2 tons of anorthite and theoretically produce about 3 tons of alumina.

Using albite feldspar the neutralization of the CO2 from the combustion of one ton of coal will require 17,3 tons of feldspar and again produce 3 tons of alumina.

Neutralizing the CO2 from a ton of coal requires about ten tons of anorthite to be mined and shipped to the neutralization process. However, even ignoring the value of the quartz sand and other byproducts, the alumina produced corresponds to ca. $3000 for each ton of coal and $ 300 for each ton of anorthite. Thermal coal costs about $100 per ton, yet coal is often transported by rail for hundreds of kilometers. It follows that the main economic aspect in the neutralization of CO2 with feldspar is the value of the alumina produced. In other words, we are discussing a revolutionary way of alumina production and not just a way to neutralize CO2 .

New power plants, cement factories, etc., can be located close to feldspar formations, or a pipeline can be used to ship the CO2 from them to the feldspar mine for neutralization.

The CCN process

The CCN process begins with the capture of CO2 from flue gases. In current technology this requires either energy-consuming separation technology or oxygen combustion with the expense and energy consumption of an air separation unit.

In our technology the CO2 is captured from flue gas by washing the latter with water. The method has been patented (Finnish patent 121216 and WO 2010/000937). The neutralization process has been studied at the Chemistry Department, University of Jyväskylä. It is illustrated in Fig. 1.

Flue gas at normal pressure is cooled in a heat exchanger 21 and pressurized in turbo- compressor 22 (Fig. 1), preferably equipped with water injection, to ca. 5 bar.

If the flue gas contains 16 % CO2 , the CO2 partial pressure at a total pressure of 5 bar is 0,8 bar. A ton of water at +50 will dissolve 2.4 kg of CO2 from the gas. The dissolution takes place in column 23 into which cold water is sprayed from connection 12. The flue gas exiting from column 23 is warmed in heat exchanger 21 and expanded in turbine 26 to recover part of the compression energy.

The CO2 solution exiting from column 23 is passed into neutralization tank 24 filled with crushed feldspar. From there the neutralized solution passes into settling tank 25, where the insoluble aluminum compounds settle. The solution can then exit the process or it can be recycled into the CO2 dissolution process.

In order to keep the amount of water needed for the dissolution within reasonable limits, the partial pressure of CO2 should be sufficiently high, in practice at or above 0.4 bar.

The amount of water required in the process can be reduced by recycling a part of the bicarbonate solution formed back to the neutralization process. The dissolution and neutralization processes can also be combined to take place in one container filled with crushed rock. If air with an oxygen content of 40 % produced according to our patent 111187 is used in the combustion process, the flue gas will contain ca.30 % CO2 and its partial pressure at a total pressure of 5 bar will be 1.5 bar. One ton of water at +50 will now dissolve 4,5 kg of CO2 .

Besides alumina and quartz sand, other possible byproducts in the neutralization include lithium. Instead of replacing other cations in feldspars it tends to form lithium-aluminum silicate, spodumene, LiAl(SiO3)2. One ton of spodumene can neutralize about 240 kg CO2 , and in addition to aluminum it would yield ca. 200 kg of lithium carbonate. The carbonate costs about US$ 10 /kg.

Our process differs from so-called carbonization, where CO2 is neutralized with carbonate minerals such as limestone. Carbonates are much less plentiful than silicates in the Earth's crust and they yield no valuable byproducts in the neutralization. Carbonization also mobilizes large quantities of carbon from the carbonate minerals.

In summary, our method offers a double opportunity: we can simultaneously convert acidic CO2 into harmless bicarbonates and utilize the enormous quantities of aluminum in silicate minerals. This can be done without expensive chemicals or crippling amounts of energy.

CCN project in South Africa

Representatives from Cuycha Innovation will be traveling to the Republic of South Africa in one week to start a massive CCN-project with CircleLink Holdings (circlelinkholdings.net) and other strategic partners. The consortium being formed is committed to producing the first low/zero-emission plant using Cuycha's CCN-process. South Africa was selected for the government's strong support of innovative new technologies with positive ecological impact. Discussions are underway and a meeting is planned with the Industrial Development Corporation (www.idc.co.za) in South Africa to provide the necessary funding for the project. The consortium will of course be totally BEE & BBBEE compliant.

Besides building the first CCN pilot plant, the project will test many new ideas to minimize, or totally remove, other harmful by-products of industry and convert them to useful commodities for additional revenue.

Interest in the CCN-process has already spread to neighboring Botswana and a similar project may soon be started there.

More information

Cuyha Innovation Oy was founded in 2004 by renowned nuclear physicist Matti Nurmia to manage and develop his inventions. Most of Dr. Nurmia's inventions relate to energy production and environmental issues.

In February of 2010, Dr. Nurmia decided to concentrate his energy into inventing and passed the leadership of the company to his son.

Ilkka Nurmia took over as CEO on Feb. 21, 2010.

Ilkka Nurmia, CEO
Cuycha Innovation Oy
ilkka.nurmia@cuycha.com

Tees Valley CCS Network

An Element Energy study has looked at the logistics of implementing a shared CCS pipeline network in the Tees Valley to connect major CO2 emitters in one of the UK's largest industrial clusters.

By Harsh Pershad, Element Energy (harsh.pershad@element-energy.co.uk)

Worldwide, more than half of the CO2 that would need to be stored to meet IEA targets would most cost-effectively be transported in pipeline networks that integrate multiple sources[1]. A number of businesses and regions around the North Sea have been developing concepts for a CCS network[2].

The challenges and opportunities for building these shared CO2 pipeline networks are illustrated in a recent study of the potential for a Tees Valley CCS network[3]. The study was led by Element Energy with contribution from Carbon Counts and Newcastle University, and funded by the One North East Regional Development Agency and the North East Process Industries Cluster.

Tees Valley manufacturing industries are critical to the overall prosperity of the North East of England. Recent years have seen regional inward investment of more than £800m from international businesses and further investment worth £8 billion pounds is under consideration. However, the future prosperity of the Tees Valley is threatened by rising CO2 prices within the EU emissions trading scheme (ETS). Nearly forty wealth generating businesses in the Tees Valley emit more than 50,000 tCO2/year and eight of these are forecast to emit on average more than 1 million tonnes (1 Mt) of CO2 each year. If the impacts of future CO2 prices and regulation are not addressed it is possible that business will be unable to continue as usual for some of these 'carbon-intensive' industries. Inaction could lead to reduced competitiveness, profitability and viability of these carbon intensive businesses. Some businesses will relocate production to jurisdictions with less stringent environmental legislation to reduce costs. This would significantly undermine the economy of the Tees Valley and North East of England, and the objective of climate mitigation policies upon which the ETS is founded.

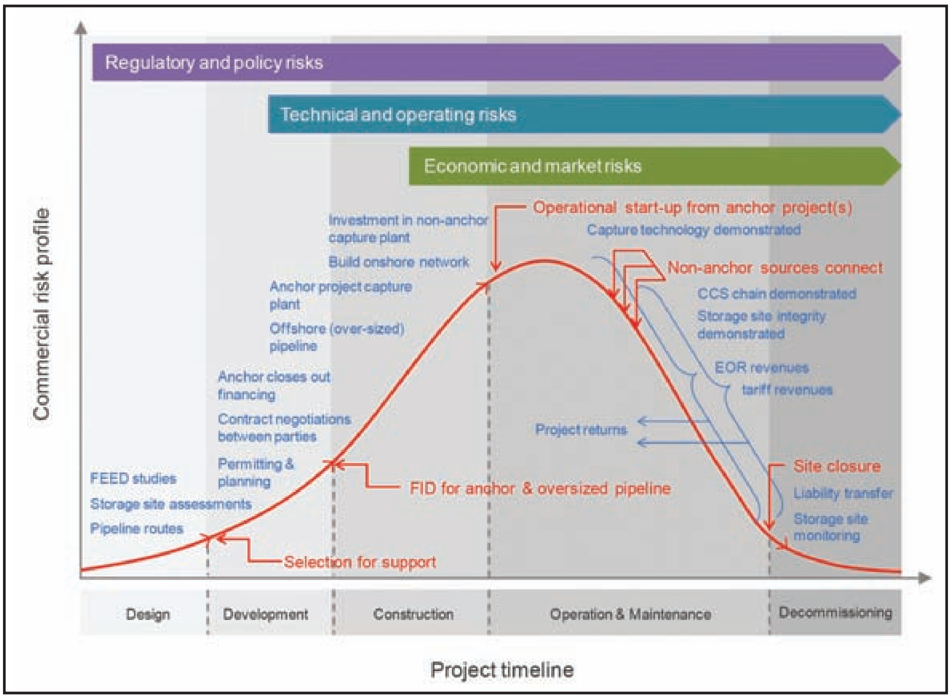


Figure 1 – Commercial risks for a CCS 'network' across the project lifecycle

A parallel engineering study has identified extensive technical potential for CO2 capture at nearly forty sites in the Tees Valley – densely clustered within a few kilometres of each other[4]. Stakeholders in the region are familiar with CCS technologies and several key emitters consider that they could deploy CO2 capture facilities in the period 2018 2030.

A range of CO2 transport options can be developed to various levels of ambition/capacity to connect capture with storage offshore. An integrated pipeline network could transport CO2 from a range of sources through a common hub and offshore pipeline much more cost-effectively and conveniently than would be the case if each emitter built their own dedicated pipeline. Indeed it is unlikely any point-to-point solution would be economically viable. CO2 transport by ship is also technically feasible as suitable port facilities exist in the Tees Valley.

UK and European public funding for CCS demonstration provides an early window of opportunity to develop a 'future-proofed' CO2 pipeline network in the period 2015 to 2020.

Both public and private investors in a

Description	Metric	Anchor Only	Small	Medium	Large
Environmental effectiveness	$MtCO_2$/yr captured	5	14	22	26
Financeability	Combined capex for capture, transport and storage	£650 m	£1.8 bn	£3.0 bn	£4.2 bn
Cost effectiveness	Average capture cost £/tCO_2 abated	£18	£25	£29	£36
	Transport £/t CO_2	£12	£7.30	£7.40	£7.40
	Storage £/t CO_2	£14	£13	£12	£12
	Total £/tCO_2 abated	£44	£45	£48	£55
Flexibility and stability	Ratio of sites capturing CO_2: sites not capturing	1:35	5:30	8:27	35:0
	Ratio of CO_2 emissions captured: emissions not captured	5:21	14:12	22:4	26:0
Lead time / complexity	Number of sources connecting	1	5	8	35

Table 1 Key performance indicators of different scales for the Tees Valley CCS network

1 Element Energy et al. (2010) CO2 pipeline infrastructure: An analysis of global challenges and opportunities, for the IEA Greenhouse Gas R&D Programme.
2 Element Energy et al. (2010) One North Sea: A study of cross-border transport and storage.
3 Element Energy and Carbon Counts (2010) Developing a CCS network in the Tees Valley Region.
4 Amec (2010) Engineering Design and Capture Technologies for Carbon Capture and Storage in the Tees Valley. Technical report 1620 1752 Rev A.

CCS network will consider opportunity costs of investment, and will have diverse priorities for investment criteria including:

- Overall economic and strategic benefit (value at risk, replicability, alignment with wider objectives).
- Environmental benefit (i.e. how much CO2 abatement is likely).
- Costs (e.g. up-front, ongoing, financing costs, costs of service, and the difference between system costs and expected carbon prices).
- Flexibility (e.g. incorporating additional CO2 supply or connection to alternative storage sites).
- Robustness of investment case (e.g. if utilisation falls below expectations).
- Overall complexity (e.g. planning issues, requirement for regulation).
- The ability of stakeholders to agree on system design and business models and deliver infrastructure in a timely manner.

The most compelling opportunity for strategic infrastructure investment will clearly represent the relative weighting of these factors, so there is no unequivocally best option for the scale of a network. Key performance indicators for different networks are listed in Table 1. The systematic economic analysis and stakeholder engagement carried out in this study suggest that either a 'Small' or 'Medium' scale CCS network at Tees Valley is likely to offer the most value-for-money in terms of strategic infrastructure investment:

The capital requirement for the onshore pipeline network (£10s of millions) falls within the range of typical investments made in infrastructure in Teesside, and could potentially be shared between sources, and phased so that capacity matches demand. Up-front investment in a future-proofed offshore pipeline may add up to £200 million in costs; too large and risky for any single entity to take on, especially on its own balance sheet, whilst the risk presented by low –utilisation and other factors mean it will be particularly difficult to attract significant sums of private finance, especially at commercial rates.

Investment in a CCS network must proceed along a challenging critical path. Important milestones include (i) selection of projects for CCS demonstration; (ii) reaching a final investment decision for anchor projects, sizing of the offshore pipeline and storage strategy; (iii) construction of infrastructure; (iv) sequential connection of emitters to the network; (v) in the long term, handover of the storage site back to the State.

There is a wide range of risks across the life-cycle of a CCS 'network' project in addition to the risks for underlying anchor and subsequent capture and storage projects. Developers will need to demonstrate that they have

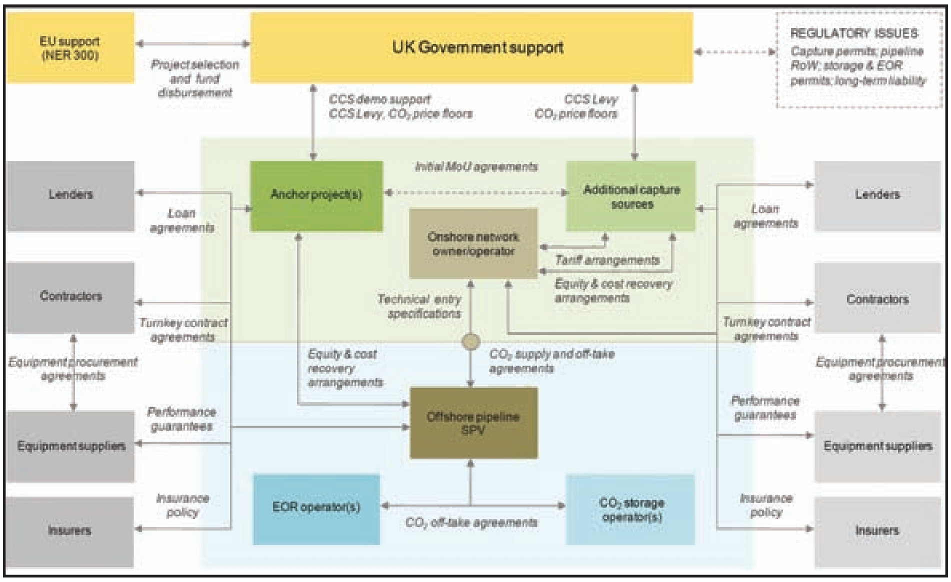


Figure 2 Contractual linkages for a potential CCS network

taken steps to understand, limit and manage policy, regulatory, technical, market, economic and reputational risks – even those that may occur towards the end of the project life. Failure to address any of these issues will likely result in no investment from commercial sources, and would also undermine the case for public investment.

The finance community has considerable experience of structuring finance for pipelines in the oil and gas, waste and water sectors. A proposal for contractual linkages for a potential CCS network is shown in Figure 1.

The key issue is the embryonic of CCS technology, the novelty of commercial arrangements, and the fundamental economic case for investment. Key messages from discussions with capital providers are

1. Equity investment will be essential in some form – either through direct investment by companies or through investment into a special purpose vehicle.
2. Government support will be critical in providing additional sources of finance and/or in underwriting debt (e.g. as lender of last resort)
3. Only the public sector can address some of the key policy, market and regulatory risks.
4. Multilateral lending agencies such as the European Investment Bank (EIB) are well positioned to provide financial support to projects, subject to the presentation of a robust business case along the lines of points 1-3 above;
5. Private debt from project finance houses or infrastructure funds may be available if the conditions outlined points 1-3 and/or point 4 above are met. This likely to be in limited amounts in the early stages of the technology (e.g. 5-10% of project investment costs), and subject to the robustness of the business case.
6. Private equity and venture are not really suitably capitalised and structured to take on investments in CCS at the current time.
7. Revenues from CO2-enhanced oil recovery may improve the viability of the business case, However the oil industry has shown only limited interest in developing this option to date.

Whilst a range of options exist for structuring an investment – including government and single-entity led developments – a Joint Venture special purpose vehicle established by regional operators appears to be the most viable near-term approach for taking the project forward, where:

- The role of the public sector is to provide access to grant funding and reduce policy risks, market risks and regulatory risks across the CCS chain.
- Large power and industrial emitters in the Tees Valley provide equity finance to develop most of the onshore pipeline network and support future-proofing of the offshore pipeline.
- A limited amount of debt finance is obtained e.g. from multilateral lending institutions.
- Initial investments are later refinanced to reduce costs as risks decrease.

The report makes a number of recommendations for the stakeholders who wish to develop further the opportunity to develop CCS networks. These cover optimal organisation and strategy, reducing risks, supporting the business cases for anchor projects and assisting with the optimal formulation of national and European energy, climate and CCS-specific policies, public and NGO engagement, and on harmonising specification.

Copies of the report can be obtained by contacting the author.

CCS legal and policy – Mar / Apr 2011

February saw the passing of the deadline for the submission to DECC of NER300 funding applications by prospective CCS Project Sponsors. Since the deadline a combination of press releases by some of the applicants plus announcements by DECC have produced an apparently clear picture of which protagonists are genuinely competing to develop the UK's first CCS projects. But how much does this really reveal about what the final demonstration projects might look like and particularly, to what degree infrastructure sharing might feature?

It is safe to assume that, in order to actually develop any of these putative projects, the project sponsors will wish to receive financial support from DECC's Demonstration Programme as well as the EC's NER300 fund. This being the case, those projects which satisfy DECC's criteria to receive funding from its Programme as well as the EC criteria for NER300 funding have the greatest potential of ever coming to fruition.

The attitude of both DECC and the EC with respect to encouraging infrastructure sharing, as evinced in their respective criteria, will therefore have a large influence on the potential project developers' desire to instigate and develop the relationships that are essential if shared infrastructure projects are to develop.

DECC's final selection criteria have not yet been published and shall not be until after the announcement of the next Budget on 23 March. We do however have Further Guidance regarding the Delivery of Projects 2-4 published by DECC's OCCS in December 2010. This follows on from DECC's Clean Coal Industrial Strategy published in March 2010 and the change in policy regarding infrastructure sharing between the two is marked and important.

In the March document, DECC expressed its understanding of the considerable potential cost savings and other merits offered by projects sharing infrastructure and its enthusiasm to encourage project developers to come forward with innovative solutions that reduced cost or enhanced delivery. It went on to expound a rationale leading to the conclusion that: '[infrastructure sharing] will be taken into account in the assessment of projects when weighing overall delivery of non-monetary objectives against price and value for money.'

The Further Guidance document also addresses the sharing of infrastructure. It follows what is apparently the same rationale as the March document (often in verbatim terms) based upon the same premises and, perplexingly, concludes that: '[infrastructure sharing] will not be taken into account in the assessment of projects under the UK Programme when weighing overall delivery of non-monetary objectives against price and value for money.'

The reduced likelihood of collaborative working between project developers that this contradictory 'about-face' is likely to engender is lamentable. It also appears detrimental to some of the stated key aims of the CCS Demonstration Programme.

One of the UK Government's principal stated objectives in supporting CCS demonstration is to build experience in the transport and injection of CO_2 in a way that is relevant to the development of the industry in the UK and that will develop skills and expertise within the UK that are exportable to the international market. This incorporates DECC's overarching objective: 'To prove the CCS technologies most relevant to UK deployment both technically and economically so that they are ready for commercial deployment by 2020'.

These objectives should be achieved more fully by projects which share infrastructure than those that do not; experience in the design of a CO_2 transportation and storage system incorporating multiple incoming streams and multiple sinks offers the potential to attain a far greater, and potentially more valuable, understanding of the networked system model that, given the reductions in cost to be achieved by networked infrastructure, is likely to become prevalent as the CCS industry develops.

Another aim of the Programme is to develop suitable commercial models and contractual frameworks across the CCS chain. Expertise in the formulation and drafting of the arrangements and agreements required to regulate the complicated relationships created when projects share infrastructure, and the associated provision of professional services, has a potential value which, if the CCS industry develops internationally as predicted, should greatly exceed that of similar expertise that is applicable to point-to-point projects alone.

DECC believes that in order to have the best chance of achieving its overarching objective it must provide the UK with experience of a range of alternative CCS technologies and approaches and that it must support projects that are affordable and offer best value for money. A cluster of projects, incorporating multiple emitters, capturing CO_2 in different ways, working collaboratively to share transport and storage infrastructure should not only demonstrate the same number of capture technologies as if the projects had been developed independently but should also deliver expertise in the technical and commercial challenges of networking CO_2 infrastructure and all at a cost considerably below that of developing each project on a stand-alone basis.

Calum Hughes, Yellow Wood Energy

Europe's approach

For its part, the EC has chosen to adopt an approach towards infrastructure sharing that is subtly different to that of DECC. In the 'Procedures Manual for the technical and financial Due Diligence assessment under the NER 300 process' released in March the EC also makes a brief but significant mention of 'partner' projects sharing infrastructure.

Like DECC, the EC has encouraged the submission of shared infrastructure projects for its funding scheme. However, unlike DECC, the EC has explicitly allowed infrastructure costs to be apportioned between projects which propose to share that infrastructure and have instructed the EIB to use these apportioned figures in its evaluation of applicant projects and the calculation of the project's Cost Per Unit Performance ('CPUP') that is central to the selection of the projects that will receive NER300 fund support.

As a caveat to this opportunity, the EC has stipulated that any applicant adopting a 'partner project' approach in order to increase their chances of receiving NER300 funding must provide evidence that it can fund the CO2 transportation and storage funding its project requires in the event that the projects with which it is proposing to share infrastructure are not selected to receive NER 300 funding and it is placed in a position where it must fund independently all of its project's infrastructure.

'Partner project' bids

If my conjecture above is correct and the putative UK CCS projects shall, in any event, have to ask DECC to fund the short-fall remaining in their project coffers once they have secured the NER300 funding, then applying for that funding on a shared infrastructure basis could be a double-edged sword. If two projects which might share infrastructure were to bid on a 'partner' basis into the NER300 competition then they should have lower CPUPs and therefore a greater chance of success. However, if they were to have bid independently and both succeed then they would bring in to the UK a greater aggregate amount of the EC fund monies. Depending upon the way in which the projects were finally developed this may have an effect upon the amount of funding required from DECC to achieve its 2-4 Programme goals.

Whatever the reasons for the differing approaches of DECC and the EC, and DECC's apparent change of heart towards their evaluation of the benefits of shared infrastructure, they will have had an effect upon the level of enthusiasm the UK's NER300 applicants will have shown towards the forming of 'partner project' relationships to aid their chances of success in the European competition. It shall be interesting to see what DECC's final policy on this issue is once the NER300 bids are finalised and the budget is out of the way.

Calum Hughes is Principal Consultant in CCS Projects, Regulation and Policy at energy consultancy Yellow Wood Energy.

Statoil and Bellona - debate over Mongstad delay

In a web article on March 1, Bellona claimed that Statoil is "exaggerating the challenges with CO2 capture at Norway's Mongstad plant" in order to delay the project. Statoil responded on its Norwegain website by calling the claims "unnacceptable".

The debate centres on claims by Statoil that there is a need for more knowledge about possible effects on health and the environment by using amine technology.

The Norwegian Petroleum and Energy Ministry wrote in a statement that the government wants to consider a number of technologies for the capture of CO2 emissions from the gas powered plant at Mongstad.

"This delay is, as far as we can understand, completely unnecessary. There has not been any new information on the case which may provide a basis for such a decision," says Bellona's Erlend Fjøsna.

Bellona says it is very critical of the fact that the Government so far has trusted Statoil´s allegations and not consulted its own environmental experts in the Norwegian Climate and Pollution Agency (Klif).

"Klif can not see that developments in knowledge of the risk of hazardous emissions from amine-based technology have given any greater cause for concern, rather, new knowledge indicates that the risk of the formation and spread of nitrosamines are less than previously thought," the agency wrote in a letter to the Ministry of Environment.

Bellona also claims that a range of international experts are critical of Statoil's approach.

"Through our international network we register that not only researchers and bureaucrats, but also other energy companies are frustrated about Statoil reducing its ambitions. People question the chance of Mongstad to be part of the first generation CCS demonstration projects," says Paal Frisvold, chairman of Bellona Europa and a member of the EU Zero Emission Fossil Fuel Power Plant Technology Platform (ZEP).

"The gas-fired power plant at Mongstad is now operational and releasing all of its CO2 into the atmosphere. The original plan was to have CO2 capture technology in place in in 2014 – but that later became 2018, and now the deadline is a pie in the sky," says Bellona.

Statoil's response

According to Statoil, Bellona falsely claimed that it has submitted wrong scientific evidence to the Oil&Energy Department (OED).

"The group has initiated several research projects to improve knowledge of risks associated with health and environmental effects, where several national and international companies and research institutions are involved. Statoil denies that the company misinformed the OED," says Statoil.

Statoil also refutes that it has submitted misleading information about its dispersal modeling.

"Proper dispersion models will first be established when the concept is more clear," the company says. "Statoil has assumed a 'worst case' scenario, and when a full-scale plant is established it will work with more realistic assumptions concerning the dispersion modeling. Statoil therefore denies that the company misinformed the ministry.

In addition, Bellona proposed that NOx-reducing measures on the CHP should be installed.

"The cogeneration plant at Mongstad (owned and operated by DONG) is already equipped with technology that reduces NOx emissions down to less than 5ppm (parts per million). Unreacted amines, which react with nitrogen oxides in the atmosphere, are released anyway. Statoil rejects the claim that NOx purification will eliminate the problem, as the technology is not relevant to the chemical reactions in the atmosphere."

"Research conducted by reputable companies and research organisations have identified gaps in knowledge related to the formation of nitramines and nitrosamines in amine-based CO2 capture, which can cause cancer of the surroundings. We therefore maintain our view that as a result of this knowledge gap there are still uncertainties about the use of amine technology in a full-scale CO2 capture plant at Mongstad," said Eli Aamot, Statoil's research director for renewable energy.

"To increase the probability of success in establishing a carbon capture at Mongstad, Statoil has therefore recommended that it be opened to alternative technologies in addition to the amine-based technology," said Kurt Georgsen, director of the full-scale plant at Mongstad.

Bellona responds below.

Bellona - needless postponement at Mongstad

In its response to Bellona's challenges, Statoil fails to adress the crucial issues. We therefore reiterate our claim that Statoil does not have adequate scientific basis for delaying the Mongstad CCS project.

By Gøril Tjetland and Erlend Fjøsna, Bellona

In a Carbon Capture Journal web article (see above) published March 8th, Statoil describes Bellona's claims about the delay at Mongstad as "unacceptable".

Statoil's response, published also on their web site shows, however, that its accusations against Bellona are groundless. Statoil criticises Bellona for basing it`s document "Preparatory note for meeting with the Norwegian Minister of Environment" (hereafter referred to as the Bellona document) dated the 27th of February on false scientific data. However, Bellonas document is referring to the data used in Statoils own application for emission permits related to the Test Centre in Mongstad .

Statoil fails to answer one of the critical issues raised in Bellona's challenge, namely that Statoil has based their application for emission permits related to the TCM on a single unrepresentative test sample.

Further, Statoil does not comment on the fact that their own studies clearly state that reductions of NOx emissions may be a solution to reduce or avoid potentially harmful amine discharges to air.

In this comment, Bellona wishes to adress Statoils concerns and review 1) the scientific basis for HSE concerns, 2) the atmosperic dispersion modelling, and 3) NOx reduction technology.

The scientific basis for HSE concerns

In Bellona's document the scientific basis for the application for emission permits related to the Test Centre in Mongstad is questioned. This application is an important document as it is used as the basis for the amount of amines that can be released to the atmosphere from a full-scale CCS plant at Mongstad. Bellona questions three specific scientific data in the application, namely 1) the method used to estimate ground concentrations of amine levels 2) the test sample the TCM emission permit is based on 3) the assumed amount of transformation for methylamine and nitramines.

In Statoils response they respond only to two of these issues: the method used to estimate ground concentrations of amine levels, and the assumed amount of transformation for methylamine and nitramines. In Bellona's document it is requested that results e.g. from the ADA study (empirical data from experiments that indicates the amount of transformation for methylamine and nitramines) and the NILU simulation (a method to estimate dispersion and subsequent ground concentrations of amine levels) are used as the scientific basis for the application for emission permits. Statoil refers to the same studies in their letter to OED and in their response to Bellona's document, but these are nevertheless not used as the basis in the application for emission permits.

The third scientific basis which Bellona questions in the Bellona document, namely the test sample the TCM emission permit is based on, is not addressed or responded to by Statoil at all. Bellona welcomes a response to this issue, as it is critical to the calculation of emissions.

The Norwegian Climate and Pollution Agency in their letter "Knowledge status for amine emissions from CO2-capture" confirms that the scientific basis Statoil have taken for dimetylamine levels is incorrect. Statoil claim that relatively large amounts of dietylamines were detected at Risavika and Longannet in 2009, but Aker Clean Carbon, which runs the pilots, shows that only one sample from Risavika and no samples from Longannet contains dietylamines. Later samples have not shown any measurable dimetylamin levels. The sample used by Statoil as the scientific basis for the TCM emission application is the one sample from Risavika which contains dietylamine, possibly caused by contaminations in the test set-up.

NOx reduction

Again the Bellona document is based on Statoil's TCM emission permit application. Statoil informs that the NOx reduction technology installed at the cogeneration plant at Mongstad to this date has achieved to reduce the NOx emissions down to less than 5ppm, which is very good news. However, Bellona refuse the claim by Statoils research director for renewable energy, Eli Aamot when she says in the Carbon Capture Journal the 8th of March 2011 that "Statoil rejects the claim that NOx purification will eliminate the problem, as the technology is not relevant to the chemical reactions in the atmosphere." On the contrary, results from Statoil own studies on degradation rates by Pedersen, Sjøvoll and Fostås presented at the IEA GHG workshop February 2010 showed that nitrosamines may form from DEA (DEA is an impurity or a result of NOx induced degradation of the most commonly used amine MEA). In fact, one of this study's proposed solutions to avoid potentially harmful amines in the atmosphere were to remove NOx.

Also worth mentioning are studies by e.g. Attalla and Azzi (CSIRO study 2009) which indicate that secondary amines are reactive in the presence of NOx to form nitrosamines and other nitro products. The conditions in the flue, with high temperatures and turbulent mixing of gases, is likely to increase reactions with NOx as compared to in the atmosphere where among other studies the ADA-study shows that the effect is very low. A decreased level of NOx in the flue gas could therefore reduce the amounts of nitrosamines and other nitro products released to the atmosphere.

Emissions of amines to the atmosphere can be reduced

Bellona does agree that the health-related aspects of the amine capture process must be taken very seriously, but the concerns raised by Statoil are grossly out of proportion. There is strong scientific basis for concluding that the risks associated with CO2 capture using amines at Mongstad are manageable, and that a range of measures can and will be taken to control the level of emission.

A letter from SINTEF, "Carbon capture and storage of gas-fired power station fluegases in Norway", dated the 4th of March concludes that "SINTEF scientists believe that it will be possible to deal with questions regarding effects on health through technology development and improved knowledge, without having to postpone the construction of a full-scale gas-fired plant with CO2 scrubbing".

NER 300: Inventory of CCS applications

By February 9th, candidate projects to the EU funding scheme NER300 had to submit their proposals to their respective Member States. Here is a list of the 18 candidate projects Bellona is aware of so far, among which nine are located in the UK. **By Lorelei Limousin, Bellona**

Bellona Europa does not aspire to unveil the official list of CCS projects, which have applied to the NER300 funding since not all the Member States have disclosed their respective list of applicants. They will, however, need to communicate the number of applicants in each category of the NER300 to the Commission by March 9th.

The NER300 is the world's largest CCS funding mechanism: the European Commission will grant 300 million EU emission unit allowances (EUAs) – today worth about €4.5bn– to fund at least eight CCS projects and 34 renewable energy projects.

The projects had to submit the formal proposals to their respective Member States by February 9th. From then on, the Member States have three more months to decide which projects they want to support, and by how much they want to co-fund them.

Illustration of the CCS demonstration units at Vattenfall's Jänschwalde project

The overwhelming number of UK applications

Showing once again its lead on the CCS development in Europe, the UK was the first country to announce the list of projects, which includes five projects for innovative renewable and nine CCS projects. Nonetheless, each country will be allowed a maximum of three projects according to the rules for the NER300.

Following the UK government's decision to open the national CCS competition to gas power plants, there are two projects out of nine involving gas power plants, one using post-combustion CO2 capture in **Peterhead** entered by SSE in Scotland, and one **Hatfield** project.

The CCS projects on coal-fired power plant in the UK are the following: **Longannet** (located in Scotland, developed by Scottish Power and the sole remaining contender in the UK competition for a first CCS demonstration project), the **Drax** project in Sulby (entered by Drax and Alstom), the **Lynemouth** project (Alcan, Progressive Energy), the pre-combustion project in **Eston Grange** (Progressive Energy), one **Hatfield** project developed by Powerfuel, one in **Hunterston** by Ayrshire Power, and one IGCC plant with a capacity of 430MW in **Killingholme** (Humber) developed by C.Gen.

Applicant CCS projects in other European countries

In Netherlands, the choice is still to be made between three plants, depending on the outcome of the discussions on the CO2 storage site. Two candidates would operate in the Northern seaport of **Eemshaven** (one based on 10% biomass, developed by RWE, another being as IGCC plant developed by Vattenfall) whereas the third one has been developed by Pegasus/SEQ in **Rotterdam** - presumably at a hydrogen manufacturing plant.

Other countries have received applications for a single CCS project:

* In Italy, the post-combustion CCS project in **Porto Tolle** aims at capturing and storing parts of the CO2 from a new 660MW coal-fired unit. (There are still doubts about an Italian industrial project on a refinery).

* The single CCS bid from Spain is the OXYCFB300 in **Compostilla**, based on an oxy-combustion plant, with CO2 storage in a saline aquifer.

* The French candidate is the industrial project developed by ArcelorMittal at its **Florange** steelworks in northern France.

* In Germany, the **Jänschwalde** project, which also runs the competition has demonstrated the combination of of oxyfuel and post-combustion capture technologies so far

* As for Poland, the **Belchatow** power plant consists in a 250MW capture plant at a new coal-fired unit, using an amines-based capture technology.

* In Romania, the **Turceni** power plant relies on a post-combustion capture facility, plans to store the captured CO2 from a newly modernised lignite-fired unit of 330MW in one of the deep saline aquifers in the area.

For more information go to:
www.bellona.org
ec.europa.eu/clima/funding/ner300

California CCS Panel recommendations

The panel's report provides recommendations for resolving legal, regulatory and financial issues that currently impede the building of CCS facilities in California.

California's CCS Review Panel, formed by state agencies with representatives from industry, academia and environmental organizations, issued recommendations for implementing CCS projects on January 14, 2011 after a year-long study of key issues involved with the technology.

Important Key Findings contained in the report make it clear that CCS must be part of California's low carbon future:

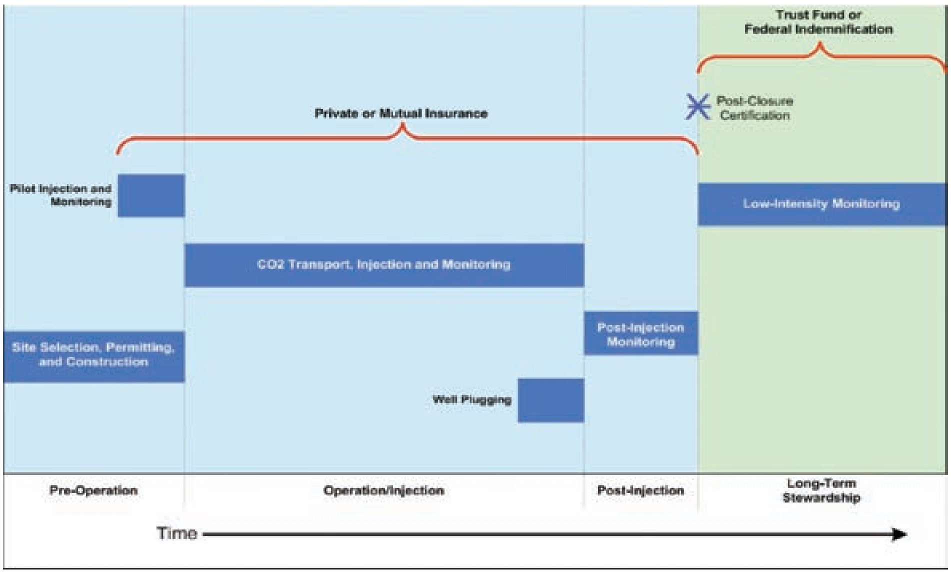
• There is a public benefit from long-term geologic storage of CO2 as a strategy for reducing greenhouse gas emissions to the atmosphere as required by California law.

• Technology currently exists for the safe and effective capture, transport, and geological storage of CO2 from power plants and other large industrial facilities.

Among the panel's Recommendations are suggestions for:

• Recognizing CO2 emission reductions achieved through CCS for meeting California's requirements for greenhouse gas emission reductions under AB32.

• Designating lead regulatory agencies for different aspects of CCS oversight (i.e., the Energy Commission as the lead agency for environmental review, the Division of Oil, Gas & Geothermal Resources for oversight of subsurface activities, the State Fire Marshall as responsible for CO2 pipelines, etc.).



Lifecycle of a geological storage project (Source: California CCS Panel recommendations)

Of particular importance to the coalition are the recommendations to accelerate the deployment of CCS:

• To ensure that CCS can play a role in meeting California's requirements for greenhouse gas emission reductions:

• The state should recognize appropriately regulated CCS as a measure that can safely and effectively reduce atmospheric emissions of CO2 from relevant stationary sources, including power plants and other industrial sources.

• The state should evaluate a variety of different types of incentives for early CCS projects in California and consider implementing those that are most cost-effective.

The report can be downloaded at: www.caccscoalition.com

Policy, company and regulation news

Enel opens CCS pilot in Brindisi

www.enel.com

Enel has inaugurated the first pilot plant in Italy for capturing and storing carbon dioxide at its Federico II power plant in Brindisi.

Joining Enel CEO and General Manager Fulvio Conti for the ceremony were the EU Energy Commissioner, Gunther Oettinger, the Italian Minister for Environment, Land and Sea, Stefania Prestigiacomo, the President of the Brindisi Province, Massimo Ferrarese, and the mayor of Brindisi Domenico Mennitti.

The pilot plant in Brindisi is part of joint activities set forth by the strategic agreement signed with ENI in 2008. It will be able to treat 10,000 cubic meters per hour of fumes from the Federico II coal plant, separating out 2.5 metric tons of carbon dioxide (CO2) per hour, up to a maximum of 8,000 metric tons per year, equivalent to the CO2 absorbed by around 800,000 trees or a 10 Km2 forest.

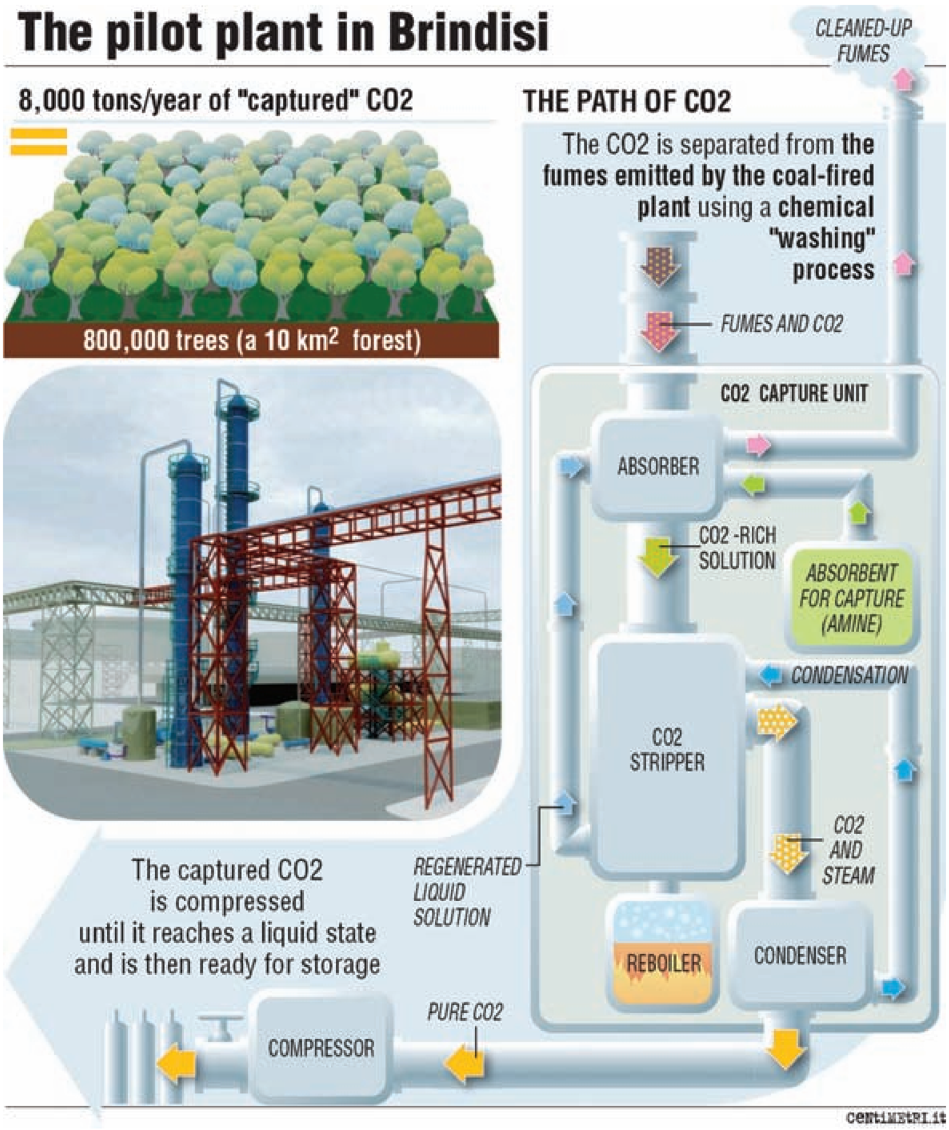
The development of the capture project is part of a combined Enel and ENI project aimed at testing the first integrated Italian pilot. CO2 released by the Brindisi power plant will be transported at the ENI/Stogit site in Cortemaggiore where it will be injected and permanently stored underground thus acquiring useful know-how to design future applications of such technology or a larger scale.

The pilot storage plant is expected to be operational by 2012. The design stage has been completed and Enel and ENI are awaiting for the final authorizations. In the meantime basic monitoring has already been carried out for some months to assess existing CO2 levels in the area under examination.

The tests in Brindisi will help Enel gain more experience in designing and operating post-combustion carbon capture plants, in streamlining the process and in assessing its environmental impact, thereby improving Enel's know-how. The first application on an industrial scale will be at Enel's new coal plant in Porto Tolle (Rovigo). The plant will treat 810 thousand cubic meters of fumes per hour (40% of those from one of three 660 MW units operating at the plant), separating up to 1 million metric tons of CO2 per year, which will be stored in a saline aquifer deep below the Adriatic Sea.

The European Union granted Enel 100 million euros in funding through the European Recovery Programme for Energy for its pilot project in Brindisi and for preliminary work on the Porto Tolle plant.

The "Federico II" thermal power play plays a key role in the generation of electricity in Italy. It is made up of four 660 MW coal-fired units with a total installed capacity of 2,640 MW. Its use of sophisticated pollution abatement equipment and its receipt of the ISO 14001 environmental certification make it one of the most efficient and clean plants running. The plant started operations in 1997.



International experts to guide CCS regulatory review in Alberta

www.energy.alberta.ca

A panel of experts will help guide a carbon capture and storage Regulatory Framework Assessment in the Canadian province of Alberta.

The assessment will examine in detail the environmental, safety and assurance processes for carbon capture and storage (CCS) that exist and determine what, if any, new processes need to be put in place for commercial scale deployment of this technology.

The six-member expert panel will be co-chaired by Stefan Bachu, scientist for CO2 Storage with Alberta Innovates Technology Futures and Don Thompson, President of the Oil Sands Developers Group. Bachu co-shares the 2007 Nobel Peace Prize that was awarded to the Intergovernmental Panel on Climate Change.

The panel will report back to the Minister of Energy in the autumn of 2012.

The review will look at the existing regulatory regime in Alberta as well as CCS frameworks from other jurisdictions, and focus on a number of areas including regulatory, environmental, geological and technical considerations as well as measuring, monitoring and verification requirements.

"This is the first step in creating a world-class regulatory framework that will ensure carbon capture and storage activities are properly managed in Alberta," said Ron Liepert, provincial Minister of Energy. "We are very fortunate to have this dynamic group of people, who bring substantial international expertise in developing energy and environmental policy, guide this initiative."

In addition to the expert panel, which will provide advice and peer review findings, a steering committee will oversee the process and guide the scope of the review. Working groups will develop recommendations for the steering committee's consideration. The remaining expert panel, steering committee and working group members represent a broad range of expertise from the scientific, academic, regulatory, industry and public administration fields.

Alberta government concludes CCS agreement with Enhance Energy

www.energy.alberta.ca

The Alberta government has successfully negotiated a contract with Enhance Energy for the Alberta Carbon Trunk Line (ACTL) project.

Enhance will build the Alberta Carbon Trunk Line (ACTL), a pipeline which will deliver carbon dioxide captured from a refinery, to be used for enhanced oil recovery from existing conventional oil fields.

The ACTL project is receiving $495 million under the Government of Alberta's Carbon Capture and Storage Funding Act. Engineering and procurement are currently underway and construction is set to begin in 2012.

A contract with North West Upgrading / Canadian Natural Resources Limited (CNRL) Partnership will lead to construction of a new bitumen refinery in Alberta's Industrial Heartland, northeast of Edmonton, as part of the government's bitumen royalty-in-kind (BRIK) initiative.

"This new refinery and CO2 pipeline will significantly advance Alberta's capacity for refining bitumen into value-added products and increase recoveries from Alberta's conventional oil reserves," said Premier Ed Stelmach. "These projects underline Alberta's commitment to responsible, cleaner energy production."

Construction of Phase One of the bitumen refinery is targeted for completion in mid 2014. It will process for market 37,500 barrels daily of Crown bitumen in addition to 12,500 barrels per day of bitumen from Canadian Natural Resources Limited (CNRL). The refinery will process the Crown's bitumen for a processing fee which will result in the Crown receiving higher revenues created by the higher-priced refined bitumen products. The two projects will create about 10,000 jobs during construction, plus associated spinoff employment.

During this first stage, the refinery will produce more than 5.5 million litres/day of ultra-low sulphur diesel while capturing over three thousand tonnes of CO2 daily. Enhance Energy will then transport the CO2 via the

In Fort Saskatchewan on February 16th, Energy Minister Ron Liepert announced the agreement with North West Upgrading/CNRL for BRIK and the Alberta Carbon Trunk Line (ACTL) which will capture CO2 from the refinery and ship it south for use in Enhanced Oil Recovery (EOR) Photo ©Government of Alberta

240-km ACTL pipeline to conventional oil recovery projects throughout central Alberta where it will be injected into oil reservoirs to make the tough-to-extract oil flow more freely.

"These projects are a win-win for Albertans," Energy Minister Ron Liepert said. "They represent a major step forward in producing value-added products while at the same time reducing greenhouse gas emissions. The potential of the enhanced conventional oil recovery ensures on-going jobs, investment and activity in surrounding communities."

Alberta's Carbon Capture and Storage Development Council estimated in 2009 that sufficient enhanced oil recovery capacity exists in Alberta to potentially store 450 megatonnes of CO2 and produce an additional 1.4-billion barrels of oil from conventional reservoirs throughout the province, potentially generating up to $25 billion in additional provincial royalties and taxes. Approximately 18 per cent of conventional reserves in place are recovered using current technology. Injecting solvents, such as CO2 into the reservoirs can increase total recovery rates to 26 per cent.

AEP Mountaineer project to receive GCCSI funding

www.aep.com

American Electric Power will receive funding from the Global CCS Institute to support installation of its commercial-scale Mountaineer coal-fired CCS project.

The Global CCS Institute will provide AUS $4 million (US $4.01 million) to support the initial engineering and characterization phase of AEP's commercial-scale installation of a CCS system using Alstom's chilled ammonia process to capture at least 90 percent of the carbon dioxide from 235 megawatts of Mountaineer's 1,300 megawatts of capacity.

The captured carbon dioxide, approximately 1.5 million metric tons per year, will be treated and compressed, then injected into suitable geologic formations for permanent storage approximately 1.5 miles below the surface. The system will begin commercial operation in 2015.

AEP and Alstom began operating a smaller-scale validation of the chilled-ammonia technology at Mountaineer in September 2009. That system captures up to 90 percent of the carbon dioxide from a slipstream of flue gas equivalent to 20 megawatts of generating capacity and stores it underground.

Global CCS Institute releases regulatory toolkit

www.globalccsinstitute.com

The Global CCS Institute has released a toolkit on ensuring best practice regulations and permitting processes around carbon capture and storage projects, providing a blueprint for nations seeking to roll out the technology.

The Institute commissioned the toolkit, which was produced by the University of Edinburgh on behalf of the Scottish Government, as part of its role to accelerate the commercial deployment of CCS globally.

"The Scottish Government used a mock CCS project to test our own regulations and identify any streamlining opportunities and challenges that lie ahead," said Scottish Energy Minister Jim Mather. "It is therefore appropriate that we have taken the lead in sharing this experience with other nations and regions."

The toolkit has been endorsed by the European Union, which through its CCS Demonstration Project Network will encourage member states to use the tool to test their domestic regulatory regimes. Romania has expressed interest in using the toolkit to test rules around its demonstration project.

"This toolkit reflects the growing global commitment to CCS and will help jurisdictions around the world deploy this leading-edge technology," said Ron Liepert, Energy Minister for the Province of Alberta, Canada. "We've heard time and time again from experts around the globe that this technology is a safe and effective way to reduce CO2 emissions in the atmosphere."

Bob Pegler, Global CCS Institute General Manager – Europe, said the release of the toolkit marks a significant step in the Institute's efforts to share knowledge and best practice globally.

"The toolkit is a very practical, much needed tool for governments implementing CCS," he said. "It can help governments easily and effectively test the adequacy of their regulatory regimes, ensuring that CO2 transported with minimal disruption to communities and that it is safely and securely store underground. It's a good tool for coordination and testing the interdependence of numerous CCS regulatory processes."

SMF report explores £6.5bn CCS sector

www.specialmetalsforum.com

UK-based Special Metals Forum (SMF), in partnership with National Metals Technology Centre (NAMTEC), has published its first report into Carbon Capture and Storage.

The report, launched at the Advanced Manufacturing Technology Centre in Sheffield by UK Deputy Prime Minister Nick Clegg, investigates the opportunities available for UK businesses to capitalise on this £6.5bn niche sector.

The seminar focused on the opportunities for manufacturing companies, including the supply of corrosion-resistant materials, advanced manufacturing processes and increased demand for off-the-shelf products. Speakers covered a range of topics from the technological challenges of CCS right through to material implications and Carbon Dioxide pumping systems.

Presentations were given by power plant operators, industry leaders and academics from Norway, Germany, Switzerland and the UK. These included Professor Mohamed Pourkashanian from the Centre for Low Carbon Futures, Rachel Crisp from the Department for Energy and Climate Change, Peter Barnard from Doosan Babcock, Mervyn Sambles from Fluor, Peter Birtles, Chair of the Special Metals Forum, Philip Sharman from Alstom and Sabine Sulzer from Sulzer Pumps.

Clegg said: "In order to grow, our economy must diversify, reducing its reliance on financial services and making the most of our expertise. The green economy has the potential to be an integral part of our economy, as well as being vital to the battle against climate change.

"I am delighted that this report identifies the opportunities in carbon capture and storage, and look forward to seeing how it is exploited to create jobs and growth in the UK."

The report, Carbon Capture & Storage: Technology, Materials and Key Players, also includes a directory of organisations involved in metals manufacturing, treatment and supply who have interest in and capabilities relevant to the emerging field of CCS.

DOE offers CCS science program

www.recsco2.org

The U.S. Department of Energy's (DOE) Research Experience in Carbon Sequestration (RECS) program offers graduates and early career professionals an intensive tutorial course on the subject.

Supported by the Office of Fossil Energy (FE), the program is currently accepting applications for RECS 2011, scheduled for June 5-15, in Birmingham, AL, and the deadline to apply is April 15.

An intensive science-based program, RECS 2011 will combine classroom instruction with group exercises and field activities at a geologic storage test site and visits to a power plant and the Nation Carbon Capture Center. Topics cover the range of CCS deployment issues, and participants will gain hands-on experience designing a carbon storage pilot project and analyzing carbon dioxide (CO2) capture technologies. RECS faculty is comprised of globally recognized scientists and industry leaders.

Founded in 2004, RECS was the first program to offer an intensive program on CCS systems to young scientists and engineers, and it has become the premier summer research experience for students and young professionals interested in this area. The program's mission is to foster and advance education, scientific research, professional training and career networks in the emerging CCS technology field.

Applicants should be early career professionals, Ph.D. or masters students with backgrounds in geology, chemistry, hydrology, physics, engineering, climate science and related fields. Participants are expected to attend the full program. Enrollment is limited to 30 participants and applicants are welcome from throughout the U.S. and all countries.

RECS 2011, a collaboration between EnTech Strategies, Southern Company and SECARB-Ed, is supported by DOE FE and the National Energy Technology Laboratory. Other sponsors have included Alstom, American Electric Power and the American Coalition for Clean Coal Electricity.

RECS is tuition-free and the program covers all housing and meal costs. In addition, a travel allowance that should cover all or most travel may be provided.

Cambridge Carbon Capture and Petroc win Shell awards

www.shellspringboard.org.uk

Cambridge Carbon Capture won £40,000 from the Shell Springboard programme, designed to promote the growth of green businesses in the UK.

The award was for its electrochemical mineral carbonation process which generates electrical power from hydrocarbon fuels whilst permanently capturing the carbon dioxide produced as a useful solid product.

Petroc Technologies from Edinburgh also received an award of £40,000 to help develop its technology that prevents leakages from underground reservoirs used in Carbon Capture and Storage (CCS) by providing a self sealing method for the stored CO2.

The Shell Springboard programme has awarded over £1.6 million to 43 UK small businesses since it launched in 2005. The programme helps small businesses make an impact in the fight against climate change by providing a no-strings-attached financial boost to companies with innovative products and services that could help reduce greenhouse gas emissions.

Dr Robin Francis, Founder and CEO of Cambridge Carbon Capture said: "We really believe our technology can make carbon capture and storage into a profitable solution for tackling CO2 emissions and it's incredibly rewarding that such a well established programme as Shell Springboard has also recognised its potential. The funding and recognition we received tonight will allow us to press ahead with our ambitions."

James Smith, Chairman Shell UK, said: "Low carbon innovation creates real opportunities for British industry. The UK has huge talent and creativity in this area. In the last six years Shell Springboard has awarded over 40 small businesses with a total of £1.6 million to advance their new business ideas for products and services to tackle climate change."

Emissions inventory with inorganic hybrid membrane capture and measurement

Scientists at Robert Gordon University have developed an integrated system for isolating and accurately measuring CO2 captured from exhaust gases, using a ceramic membrane and novel quantum cascade laser (QCL) gas sensing.

By Professor Edward Gobina, Centre for Process Integration and Membrane Technology, The Robert Gordon University

Growing concerns on global climate disruption require the power generation and petrochemical industries to measure and to monitor carbon dioxide and other related listed gases.

Novel quantum cascade laser (QCL) gas sensing and novel ceramic membrane gas filtration technologies have been developed and combined in one project. The system is seen as an ideal way to capture CO2 emitted with the exhaust gas. The QCL gas sensor is in use in marine environments to measure SOx and NOx in ship exhaust stacks. Compared with currently available technologies (e.g. Fourier transform infrared (FTIR) spectroscopy testing and chemiluminescence), the gas sensor is more accurate, faster, more cost-effective and easier to install. The Laboratory CO2 Sensor integration trial has been managed by the Centre for Process Integration and Membrane Technology at the Robert Gordon University.

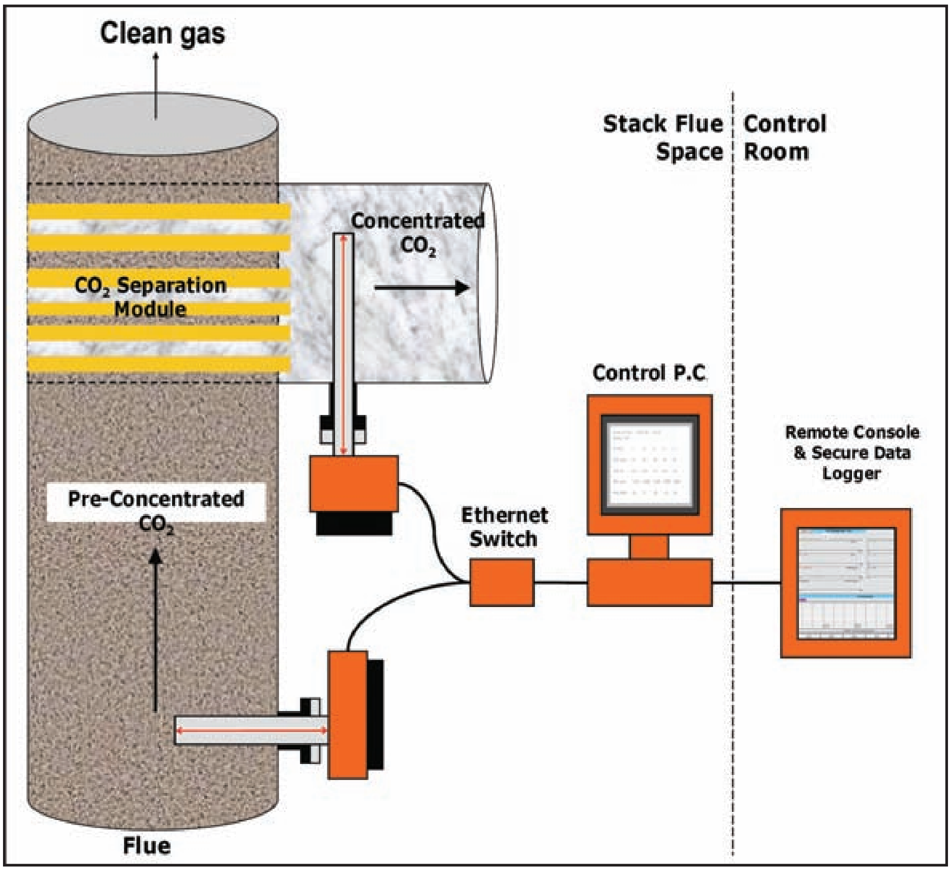


Figure 1 - schematic of the integrated cascade CO CO2 gas sensor and inorganic hybrid membrane (IHM) capture

Aim

To demonstrate the CO2 sequestration/carbon capture potential during laboratory experimentation. This has involved customizing, integrating, testing and validating of both the CO2 sensor and membrane technologies.

Objectives

The main objectives of this project are to demonstrate isolation and CO2 capture and subsequent measurement in real-time the resultant concentrated gas from the simulated exhaust flue(s) of a power station as a means of fortifying emissions inventory.

Need for measurement of CO2 concentration

With energy demand predicted to double over the next two decades and fossil fuels set to supply more than half of the world's energy needs through to 2030, Carbon Capture and Storage is seen as a major contributor to reducing man-made carbon dioxide emissions as part of a secure and sustainable global energy supply.

The goal of CO2 capture is to isolate carbon from the energy carrier in a form suitable for transport and storage. It is generally believed that a relatively pure stream of carbon dioxide must be produced. This improves the economics for compression, transport and storage [2]. It is essential that all captured CO2 be accurately measured across each stage of the CCS chain. This is necessary for environmental purposes to detect CO2 leakage and for verification of the CO2 quantity accounted under offsetting within emissions trading schemes.

However, the majority of CCS research so far has focused primarily on the 'techniques involved in the capture and separation processes and in the 'geological surveying and monitoring of storage sites'. As yet, there has been no significant research that looks into the flow measurement issues and challenges arising from the unique behavior of CO2 under different property states and CSS conditions.

In order to advance current understanding of CCS measurement needs and metering capabilities, it is necessary to further investigate various aspects of the CCS measurement chain and bring data and best practice advice to the public domain. This is vital to provide advice to legislators and regulators on what uncertainty levels are actually achievable from available metering technologies.

It is also critical to have this underpinning knowledge available to UK providers of the design, build and operation of CCS schemes to better position the UK as a leader in the provision of the technology. The ultimate goal is to incorporate the IHM in the flue gas line for a conventional pulverized coal combustion power plant as shown in Figure 1.

Laboratory experimentation

The integrated Cascade CO2 gas sensor and the ceramic membrane CO2 capture system is shown pictorially in Figure 2. The membrane consists of a thin CO2 separation layer deposited on a 15 nanometer pore TiO2/Al2O3 as the support using a dipcoating technique [1].

The thin layer provides a pathway for CO2 allowing permeation of carbon dioxide through the hybrid membrane. The TiO3 also offers physical affinity for the CO2, ensuring good mechanical stability of the hybrid membrane. The research is aimed at understanding and optimizing the synthesis and properties of the new carbon dioxide semipermeable inorganic membrane for effective separation of carbon dioxide from various gas streams especially flue gases from coal power generation plants. The process is heavily reliant on the gas sensor to monitor the inlet and exit concentrations in order to control the process.

Results of the laboratory trials

The effect of the parallel flow design on the CO2 enrichment in permeate is presented in Table 1 and 2 respectively. Contrary to the more popular opinion the results clearly show that operating the reactor with co-current flow improves the gas separation capability of the membrane by increasing its CO2 recovery capability.

This increase of the gas separation efficiency in co-current is translated by the lower driving force during co-current operation resulting in less N2 diluting the permeate. During countercurrent operation, the higher driving force results also in more nitrogen transfer across the membrane which then dilutes the permeate stream.

Potential benefits

The potential benefits of the system include:

- Real-time, accurate and fast measurement of CO2 in the exhaust gas
- No need for calibration
- Simple to use and install (a ‘plug-and-play’ device is envisaged in the longer term)
- Low maintenance equipment
- Scalable ceramic membranes CO2 capture system that could be used in most coal-fired power stations.
- The ceramic membrane for separating and concentrating CO2 from the exhaust gas has the potential to exceed the per-

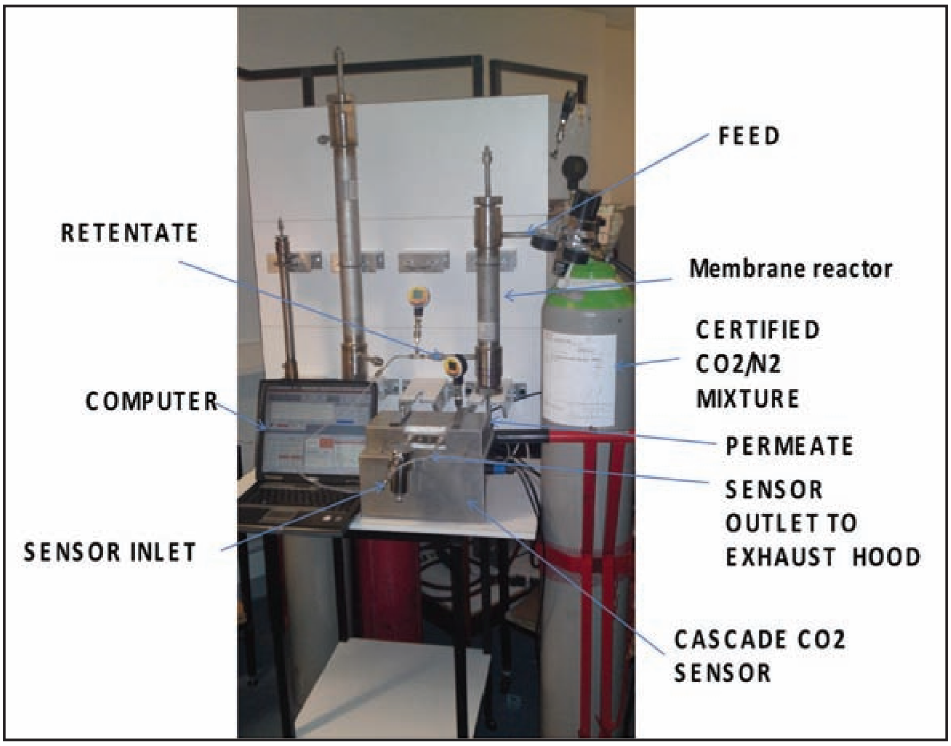


Figure 2 - picture of lab-scale CO2 sensor integration with membrane

Table 1

CO-CURRENT REACTOR OPERATION (FEED 15% CO_2-balance N_2)

RETENTATE BLEED FLOWRATE (cm^3/min)	SHELL-SIDE PRESSURE (atm gauge)	PERMEATE FLOWRATE (cm^3/min)	PERMEATE PRESSURE (atm gauge)	CO_2 SENSOR READING (%CO_2)
0.0	5.34	12.4	0.00	34.95
12.8	5.34	11.8	0.00	30.22
44.2	5.34	11.8	0.00	30.77
147.0	5.33	11.4	0.00	31.19
230.0	5.33	11.7	0.00	31.61
343.0	5.33	11.8	0.00	32.06
654.0	5.33	11.8	0.00	32.47
994.0	5.33	11.6	0.00	32.78

Table 2

COUNTERCURRENT REACTOR OPERATION (FEED 15% CO_2-balance N_2)

RETENTATE BLEED FLOWRATE (cm^3/min)	SHELL-SIDE PRESSURE (atm gauge)	PERMEATE FLOWRATE (cm^3/min)	PERMEATE PRESSURE (atm gauge)	PERMEATE CO_2 SENSOR READING (%CO_2)
0.0	5.34	12.9	0.00	28.02
12.9	5.34	10.9	0.00	28.19
55.7	5.34	10.9	0.00	28.34
142.0	5.34	10.9	0.00	28.40
238.0	5.34	11.0	0.00	28.49
358.0	5.33	11.2	0.00	28.59
668.0	5.31	11.4	0.00	28.61
925.0	5.30	11.8	0.00	28.64

formance of amine and polymer-based membrane systems; it should be mechanically stronger, more compact and be able to deal with variable flow rates at higher temperatures and pressures.

Conclusions

The system is seen as an ideal way to capture CO2 emitted with the exhaust gas and assist in the establishment of a carbon emissions inventory. The first step in developing a carbon emissions inventory is to establish the ultimate purpose of such an inventory.

The basic and foremost purpose of a carbon capture emissions inventory is to document a facility's compliance with its regulatory requirements. The carbon emissions inventory should also provide the facility with marketable resources so as to assist such compliance.

As a result, the carbon emissions inventory must be suitable for submittal to an emission registry and for trading on the carbon exchange. Ultimately, however, the carbon emissions inventory should serve as one of the basic building blocks of a corporate sustainability program that will reduce the corporation's environmental and social footprint while simultaneously enhancing its value to its employees and shareholders.

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More information

Edward Gobina is a full U.K. Professor of Chemical and Processing Engineering and has over 25 years research and teaching experience in catalysis, environmental engineering, petrochemical reaction engineering, and membrane reactor technology. He has been published extensively, with over 100 relevant publications in international scientific journals. In addition, he has over 12 years combined Market Research and in-depth Industry Analysis and authored over 20 BCC Research reports covering the entire energy infrastructure chain from LNG, gas sensors, hydrogen, and industrial gases to oil and natural gas exploitation and production. He is also the author of 12 granted patents on membrane-related technologies relating to chemical energy, sensor/monitoring instruments and oil and gas industries. Professor Gobina is a member of the European Membrane Society (EMS), the North American Membrane Society (NAMS) and the New York Academy of Sciences (NYAS). He is the current director of the Robert Gordon University's Centre of Excellence for Process Integration and Membrane Technology within the School of Engineering at the Robert Gordon University in the U.K.

Capture news

NETL CO2 capture process wins award

fossil.energy.gov

A process developed by researchers at the Office of Fossil Energy's National Energy Technology Laboratory (NETL) that improves the capture of CO2 emissions from power plants while reducing the cost has been selected to receive a 2011 Award for Excellence in Technology Transfer.

The Basic Immobilized Amine Sorbent (BIAS) Process separates CO2 from the flue or stack gas of power plants, preventing its release into the air. The captured CO2 can then be permanently stored in a carbon sequestration scenario. Application of this technology reduces the costs and energy associated with more conventional scrubbing processes to capture CO2 in large-scale power generation facilities; consequently, its transfer from the laboratory to the marketplace is another important step in moving forward the commercialization and deployment of innovations that help decrease atmospheric emissions of greenhouse gases.

This national award is presented annually by the Federal Laboratory Consortium for Technology Transfer (FLC) in recognition of outstanding work by researchers in the transfer of technology from federal laboratory to the commercial marketplace. NETL's McMahan Gray and Henry Pennline received the award for their effort on this project.

The BIAS Process will use low-cost, regenerable, solid CO2 sorbents in large-scale fossil fuel-burning power plants. An amine compound, composed of nitrogen and hydrogen atoms, is treated to make it more selective and reactive towards CO2. Combined with a porous solid support, the amine becomes a sorbent, which selectively reacts with CO2 to extract it from the flue gas. The sorbent is then heated to release the CO2 for storage, thereby refreshing the sorbent for reuse.

As a result of NETL's technology transfer efforts, a company is now ready to invest in BIAS Process technology for capturing CO2 from power plants and is developing commercial applications. Additional organizations are interested in using the sorbent for applications other than power plants.

The FLC is a nationwide network of federal laboratories that promotes the rapid transfer of laboratory research results and technologies into the marketplace. Its national and regional awards programs recognize laboratory employees who have done an outstanding work in technology transfer over the past year. NETL is one of more than 250 federal laboratories and centers, and their parent departments and agencies,that are members of the FLC.

The award will be presented at a ceremony held on Thursday, May 5, 2011 at the FLC National Meeting in Nashville, Tennessee. A panel of technology transfer experts from industry, state and local government, academia, and the federal laboratory system reviewed applications from multiple national laboratories for this prestigious award.

DNV develops CO2 reuse process

www.dnv.com

DNV has developed a process to convert carbon dioxide into useful products. Results suggest that its electrochemical conversion process could be a commercially viable technology in the future.

DNV has been working on the challenge of carbon dioxide utilisation for over three years under the premise that CO2 can be a "resource rather than a liability" according to DNV Research & Innovation Director Narasi Sridhar,

"We have invested in resources and tools to analyse the CO2 value chain using electrochemical conversion as a case study. Our research demonstrates the conversion of CO2 into formic acid. This requires less energy per ton of CO2 than most other electrochemical conversion pathways. Also, formic acid is in demand and can also be used as chemical feedstock, steel pickling, antibacterial agents, energy storage medium, and deicing solutions," explained Dr. Sridhar.

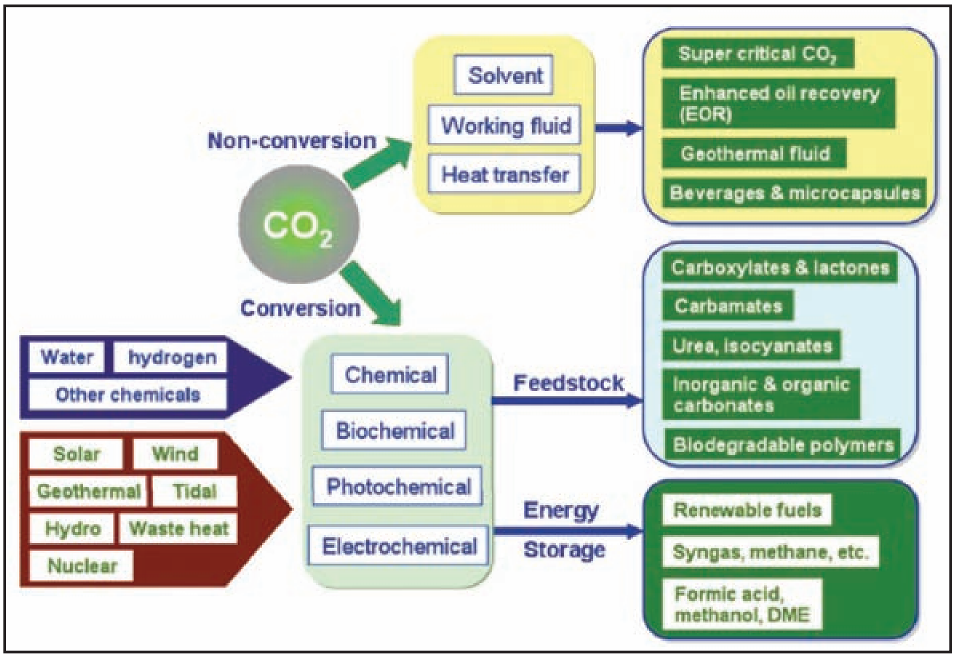
"This is part of DNV's ongoing commitment to research & innovation and its vision to make a global impact for a sustainable future," said DNV's COO Bjorn K. Haugland at the World Future Energy Summit in Abu Dhabi. "Global regulation of CO2 emissions is a looming concern for industries that depend on fossil energy sources. Solutions to reduce dependence on fossil fuels are available today, but each is only part of the solution. CO2 is at the root of the problem."

As part of its research, DNV has assembled a demonstration reactor in a solar-powered trailer. In the process, formic acid is produced from CO2 renewably, which not only utilizes CO2 but avoids CO2 emissions compared to the conventional process, while providing value added product streams. While this process generates formic acid, the process can be tuned to generate carbon monoxide, another valuable chemical feedstock according to Dr Sridhar.

"We have improved catalysts, reduced cell voltages, constructed a CO2 value chain model, examined energy and CO2 balances, modeled a scale process, and performed financial and profitability analyses for the process," pointed out Dr. Sridhar and added, "Our research is broader than just electrochemical processes. Any CO2 utilisation process will require energy and consumables, and DNV is paving the way for technological services that assure a useful future for CO2."

Dr. Sridhar firmly believes that CO2 utilisation will make a "positive impact in the future for refineries, steel mills, cement and asphalt production, manufacturing, and even shipping …we are therefore seeking progressive partners to bring CO2 utilisation to maturity."

"It is part of our continuing legacy of technical research and a key component of our focus on safeguarding life, property and the environment," said Mr Haugland and concluded, "This research demonstrates just one of the many ways that DNV remains committed to managing risks today, tomorrow, and well into the future."



DNV CO2 reuse - different pathways for using CO2 (Source: Carbon Dioxide Utilization - Electrochemical Conversion of CO2 – Opportunities and Challenges ©DNV)

Eunomia report on CO2 storage potential in East Irish Sea

Decades of industrial carbon emissions from the UK and Ireland could be stored in depleted gas fields deep beneath the East Irish Sea (EIS) according to a new study by consultancy Eunomia.

The study was sponsored by Hydrocarbon Resources Ltd and Peel Energy Ltd, leader in a consortium to establish a CCS demonstration at a proposed coal-fired plant at Hunterston, North Ayrshire in Scotland.

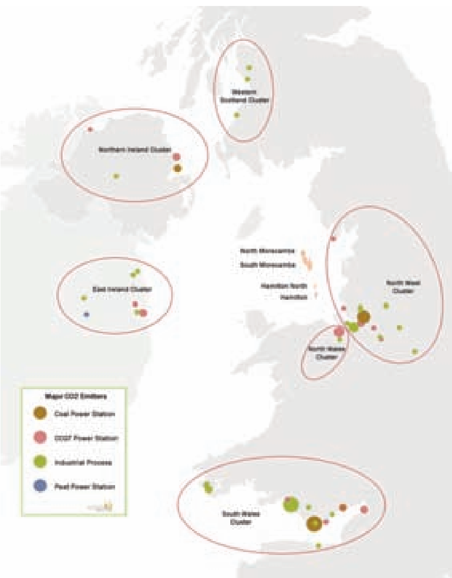
It shows that whilst the North Sea provides possible storage sites for the eastern seaboard, the EIS has the capacity to provide carbon dioxide storage sites to enable decarbonisation of the remaining fossil-fuel powered industry in the UK.

The report identifies the Ayrshire plant as the potential 'catalyst' for an EIS Cluster. With Doosan Power Systems, Fluor Ltd and offshore infrastructure and storage operator CO2DeepeStore, Peel has recently submitted a bid to the European Commission for funding through the New Entrant Reserve (NER) 300 Competition. In due course, an application will also be made to the next round of CCS Demonstration funding through UK Government, said Peel.

The study also includes commentary on technical issues relating to cluster development and considers the possible commercial structures required to deliver CCS, as well as identifying the next steps required.

Storage capacity

The potential CO2 storage capacities of both hydrocarbon fields and saline aquifers in the EIS have been assessed at a high-level by the British Geological Society (BGS). More detailed research has also been undertaken on behalf of Ayrshire Power Ltd (APL).



Existing CO2 emitters and potential storage fields

The best potential storage sites identified in both BGS and APL studies (judged according to containment, capacity and injectivity criteria) were the Liverpool Bay and Morecambe Bay natural gas fields.

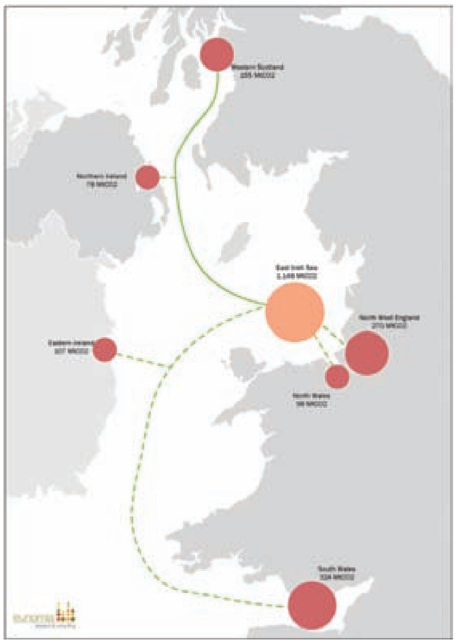
The South Morecambe field represents the most valuable asset for the long-term storage of CO2 in the EIS, and due to its massive scale, is identified by DECC as the UK's second largest natural gas field which might be 'realistically' converted into a CO2 storage site. The proximity of the two groups of fields will also provide efficiencies in terms of the relatively small distances required to connect pipelines between CO2 storage sites as part of any future 'hub' solution.

Some of the hydrocarbon fields within the EIS are now at what might be described as a 'mature' extraction phase. The Liverpool Bay Fields could become available for transfer into use for CO2 storage as early as 2014, with the Morecambe Bay Fields available from 2020.

Emitters

The EIS Cluster, set out conceptually in the report, differs from other emerging UK CCS clusters, for example those proposed in Yorkshire and Humber or Eastern Scotland, in that it is not formed around a sole pre-defined onshore region, rather it is an offshore 'storage resource' driven cluster which will potentially accept CO2 from a range of onshore areas across the UK and Ireland.

The EIS is surrounded by a range of large-scale CO2 emitters in North West England, Northern Ireland and on the east coast of Ireland. All such 'mini-clusters' could feasibly be linked to the CO2 storage sites in the EIS by either pipeline or ship. Furthermore, two further mini-clusters located on the west coast of Scotland and on the south coast of Wales have no alternative than to rely upon the EIS for CO2 storage, should CCS retrofit be required.



CO2 sources with total emissions to 2050 and the available storage capacity in the East Irish Sea

Shared pipelines

It is likely that the proposed EIS CO2 pipeline network would include a series of 'trunk' pipelines running from each mini-cluster to the storage sites. The first of these could come from the proposed power station at Hunterston in Scotland, which represents the potential 'catalyst' project for the wider EIS cluster.

It may also be possible to reuse existing oil and gas pipelines to take CO2 out to the offshore hydrocarbon fields from which the pipelines previously brought hydrocarbons ashore.

Promoting clusters

The report reccommends that additional weight should be given in the scoring process of funding opportunities such as the NER300 and DECC 'Demos 2-4' Competitions to projects which have the potential to catalyse clusters.

The report can be downloaded at: www.eunomia.co.uk

Transport and storage news

Progressing Scotland's CO2 storage opportunities

www.sccs.org.uk

A consortium of Scottish Government, industry and researchers has shown that rocks deep beneath the Moray Firth are capable of storing decades of CO2 output from Scotland's power stations.

These are key findings of the report, 'Progressing Scotland's CO2 storage opportunities'.

Detailed research calculates that rock, known as the Captain Sandstone, buried more than half a mile beneath the Moray Firth could store at least 15 years, and potentially a century's worth of CO2 output from Scotland's power industry.

The SCCS research, funded by Scottish Government and a group of businesses within the energy sector, also showed that carbon capture and storage could create 13,000 jobs in Scotland by 2020, and another 14,000 elsewhere in the UK, spread across a wide range of skills. This would increase in subsequent years. Properly developed, the UK's share of worldwide carbon capture and storage business could be worth more than £10 billion a year by around 2025.

Scotland's potentially massive offshore CO2 storage capacity is of European significance. The European Union has specified that three of the eight CCS demonstrator plants that it will fund under its multi-billion euro demonstrator programme must inject into saline aquifers. The results from this study place Scotland in a strong position to secure future EU support for more detailed assessment of CO2 storage in saline aquifers.

The study was funded by the Scottish Government and commercial organisations with operational interests in Scotland, including: Ayrshire Power Ltd (a Peel Energy company); Doosan Babcock; National Grid; RWE npower; Schlumberger; Scottish and Southern Energy; ScottishPower; Senergy; Scottish Enterprise; Shell U.K Limited; The Crown Estate; and Wood Mackenzie.

Area of study for the report 'Progressing Scotland's CO2 storage opportunities'

DOE study looks at CO2 pipeline regulation

www.sseb.org/downloads/pipeline.pdf

A private sector model with a state rather than Federal-based regulatory framework is the approach that will most likely result in a robust CO2 pipeline system in the United States, according to a new report developed with funding from the U.S. Department of Energy's National Energy Technology Laboratory (DOE/NETL).

However, a Federal role that "includes incentives to encourage the private construction of CO2 pipelines" would be an important factor in moving the concept forward, the study says.

The report, A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide, analyzes a potential pipeline infrastructure that would transport CO2 from large point sources, such as power plants, to designated underground storage locations.

The Southeast Regional Carbon Sequestration Partnership (SECARB) contracted with the Interstate Oil and Gas Compact Commission (IOGCC) to develop the report, which was undertaken by the DOE-funded Pipeline Transportation Task Force (PTTF).

The information will significantly bolster commercialization efforts by analyzing current CO2 storage situations and identifying what will be necessary to transport CO2 to storage areas.

Composed of regulators, policymakers, and industry representatives, and led by IOGCC and the Southern States Energy Board, the PTTF is focused on overcoming the transportation hurdles associated with CO2 underground storage. These hurdles include legal, regulatory, economic, environmental, and educational issues, all of which could be potential roadblocks as carbon sequestration projects move toward commercialization. The pipeline report addresses these topics and offers comprehensive guidance on barriers and opportunities for the wide-scale construction of a CO2 pipeline network to enhance the Nation's carbon sequestration efforts.

The IOGCC is a multi-state government agency whose mission is to promote the conservation and efficient recovery of the Nation's domestic oil and natural gas resources while protecting health, safety, and the environment.

The Southern States Energy Board is a non-profit interstate compact organization created in 1960 whose membership includes governors, state legislators, and a Federal Representative appointed by the President of the United States. The Board's mission is to enhance economic development and the quality of life in the South through innovations in energy and environmental policies, programs, and technologies.

Scottish University developing CO2 leak sealing technology

www.pet.hw.ac.uk

Academics from Scotland's Heriot-Watt University's Institute of Petroleum Engineering have developed technology that identifies and seals leaks that could occur in carbon dioxide storage sites.

The development is designed for companies looking to develop geological carbon dioxide storage sites. When implemented commercially, the technology could be worth tens of millions of pounds and be a crucial element of the fight against climate change.

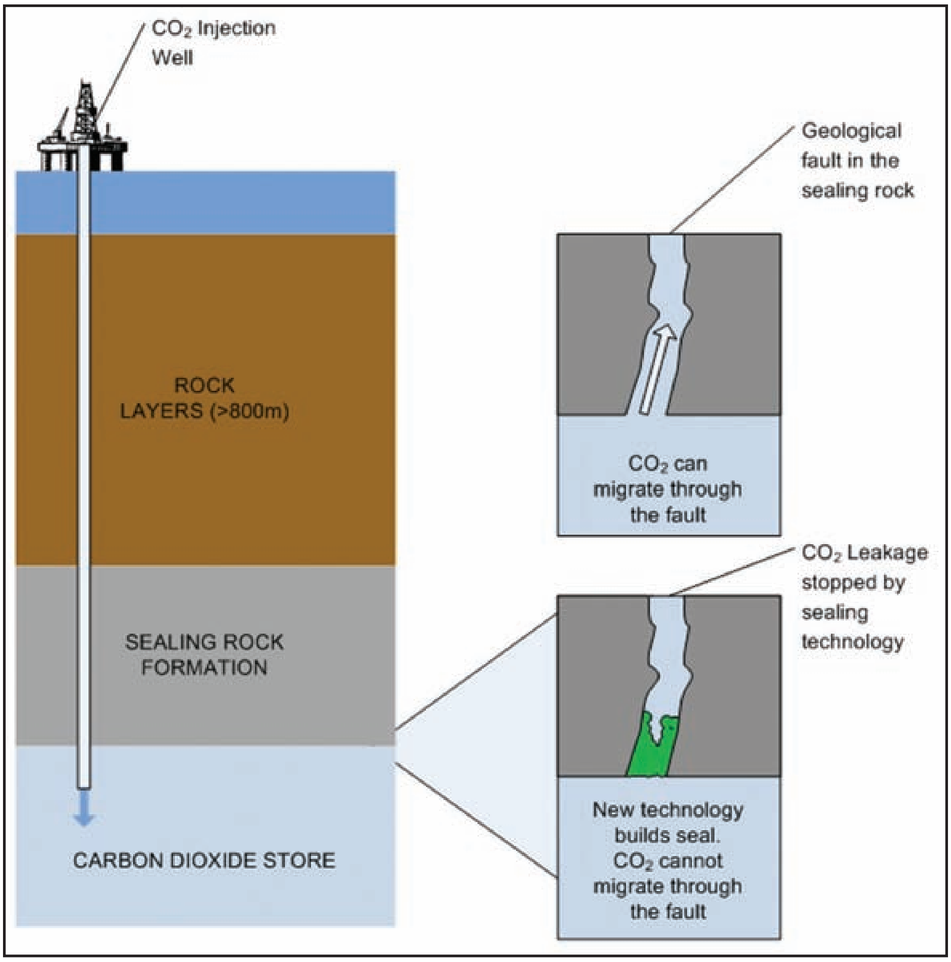
The technology, which can search out leaks even before they have been detected at the surface injection site, has already undergone rigorous lab testing in a Scottish Enterprise funded Proof of Concept programme. Funding from a number of major oil and gas and power companies has been secured and a three year Joint Industry Project {JIP}, paving the way for large scale field trials of the technology has just commenced.

Project Director Professor Mehran Sohrabi from the Institute of Petroleum and Engineering at Heriot-Watt University said the development had the potential to accelerate the adoption of carbon capture and storage across the globe. The technology answers many of the public's concerns about the ability to safely store CO2. The project at Heriot-Watt will further test the technology and show its effectiveness in a range of typical settings.

"The North Sea has the capacity to store more than 200 years of CO2 for the whole of Western Europe. We believe that we have now solved the problem of how to seal cracks or fissures in the porous rock that the carbon dioxide will be lodged in. It is a huge step forward for carbon capture and storage and one that could see Scotland established as a world leader in the field."

CO2 is produced when carbon based fuels are used to generate power and the Heriot-Watt team, led by Professor Sohrabi, believe they have now answered one of the key concerns of sub-surface storage. Heriot-Watt's project partners see this project as an important part in the development of intrinsically secure underground CO2 storage. This will help gain the public acceptance necessary for large scale CCS.

Professor Sohrabi continued, "This hugely exciting development draws on the Institute of Petroleum Engineering at Heriot-Watt University's world class understanding of the behaviour of CO2 in oil and gas reservoirs. The large scale trials that have now commenced will be a significant step forward in helping to capture and safely store millions of tonnes of CO2 every year. The environmental benefits will be massive and we are proud that the technology has been developed here in Scotland."



Heriot-Watt University's CO2 leak prevention system

DNV evaluates Rotterdam CO2 hub safety

www.dnv.com

Risk management studies carried out by DNV will be crucial to the safety and public acceptance of the CO2 logistics hub being developed through the Rotterdam Climate Initiative, says the company.

The project will involve port and offshore infrastructure development, along with a range of transportation solutions, which could eventually service many of north-western Europe's greenhouse gas reduction initiatives.

The City of Rotterdam and its industry partners are involved in a range of innovative projects and pilot studies aimed at reducing local CO2 emissions to 50 per cent of 1990 levels by 2025. Carbon capture and storage (CSS) is a key component of the strategies needed to achieve this goal.

Rotterdam hosts a significant number of CO2-producing power and process industries and has ready access to sites in the North Sea that are suitable for the geological storage of CO2.

So far CSS has only been undertaken at small scales and an end-to-end processing chain does not exist. A barrier to effective large-scale deployment is the current lack of a suitable regulatory framework, so in support of the growing demand for CSS technology worldwide, DNV initiated a number of joint industry research projects and subsequently released recommended practices for activities such as the qualification of CO2 capture technology, the selection of sites for geological storage and the design and operation of CO2 pipelines.

DNV's involvement in Rotterdam will build on this knowledge to provide targeted safety studies for the development of the infrastructure that will enable large and small producers of CO2 to become part of an integrated logistics and storage system designed to simplify management and maximise cost effectiveness. The project brings together the entire CO2 activity chain including regulators, the power industry, process and piping specialists, shipping and offshore storage providers.

"With so many stakeholders and so much new technology, the challenges, like the rewards, will be great. Rotterdam continues to demonstrate a strong commitment to the environment and the future well-being of society and this innovative project will demonstrate to the world how a new, more responsible way of handling carbon-based fuels can fit into a positive energy future. DNV is likewise committed to demonstrating world's best practice in making such paradigm shifts safely," said Johan den Biggelaar, Country Chair for DNV in the Benelux.

DNV in Rotterdam

DNV's Rotterdam office is supporting the Port of Rotterdam Authority by evaluating the feasibility of a distribution network that will involve inland and sea-going ships, barges and pipelines. They are exploring the potential risks and opportunities of different lay-out options and the location of a CO2 terminal at the port. An understanding of the synergies that could be created with neighbouring industrial facilities is being explored.

The office is also carrying out a study for the CINTRA consortium, some of the participants in the Rotterdam Climate Initiative, in their bid to offer a transport solution involving CO2 liquefaction technology. The scope of the safety study includes consequence modelling and a risk assessment of accidental CO2 releases from ships, the terminal and pipelines.

The integrated CSS network is expected to scale-up from demonstration to commercial operation by 2015, handling as much as 20 mega tonnes of CO2 annually by 2025. Future challenges include expanding public support for the project throughout the region and the development of requirements for the safe operation and subsequent decommissioning of geological storage sites.

"A full understanding of the safety issues involved will help accelerate CSS deployment and fast-track achievement of Rotterdam's greenhouse gas reduction goals," says Johan den Biggelaar, managing director DNV Rotterdam.

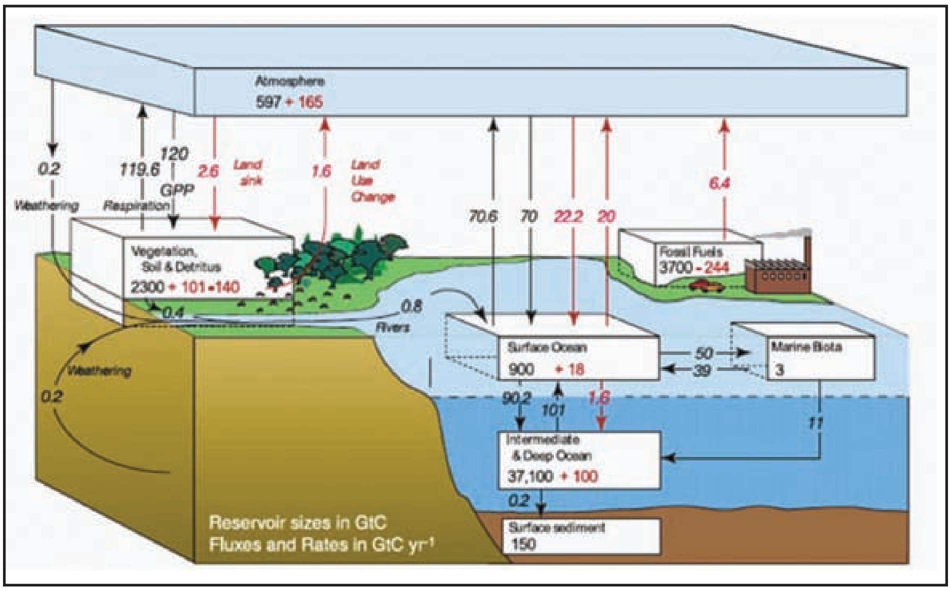


Figure 1: The Carbon Cycle. Carbon cycles constantly between land, oceans, and the atmosphere. Black arrows in this image show natural fluxes and red arrows show anthropogenic contributions. The residence time of carbon varies widely among different reservoirs. On average a carbon atom spends about 5 years in the atmosphere, 10 years in terrestrial vegetation, and 380 years in intermediate and deep ocean waters (©IPCC, 2007)

DOE manual on 'terrestrial' carbon capture

www.netl.doe.gov

The latest carbon capture and storage "best practices" manual issued by the U.S. Department of Energy looks at ways of removing CO2 from the air.

Best Practices for Terrestrial Sequestration of Carbon Dioxide details the most suitable operational approaches and techniques for terrestrial sequestration for removing CO2 already in the air. Consequently, terrestrial sequestration, which uses photosynthesis – part of the natural carbon cycle – to create organic matter that is stored in vegetation and soils, differs from CO2 mitigation technologies that focus on capturing and permanently storing human-generated emissions.

The Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL) prepared the manual with data from the seven Regional Carbon Sequestration Partnerships. Topics covered include land types and management methods that can maximize carbon storage in vegetation and soil, as well as the status of greenhouse gas trading and participating institutions. The manual also discusses the analytical techniques necessary to monitor, verify, and account for terrestrially stored carbon; such techniques are required for carbon trading. Finally, results from the partnerships' terrestrial field projects are presented to illustrate what can be done.

Among other things, terrestrial sequestration takes advantage of degraded soils (such as those resulting from overgrazing and deforestation) to restore carbon stocks to their former levels. The effort holds promise to decrease atmospheric CO2 levels and increase productivity of the land.

FutureGen Alliance selects Morgan County for CO2 storage

www.futuregenalliance.org

The FutureGen Alliance has selected Morgan County, Illinois as the preferred location for the FutureGen 2.0 carbon dioxide storage site, visitor center, research, and training facilities.

The Alliance cited the site's high quality geology and its close proximity to the Meredosia power plant, which simplifies pipeline routing and substantially reduces the project's overall cost, as the main factors in its selection.

It also received a strong show of support from community business and elected leaders, as well as significant support from directly affected landowners.

"We had an exceptional portfolio of sites from which to choose. Ultimately, the Alliance selected the site that best supported the overall mission of the project cost-effectively. Along with the CO2 storage site, a visitor center, and research and training facilities will be located in Morgan County. These facilities are critical to the project's mission to advance clean coal technology in central Illinois and worldwide. This project will put Morgan County and Illinois on the global map as a center of clean energy technology," said Kenneth K. Humphreys, chief executive officer of the FutureGen Alliance.

The CO2 storage facility will receive and store emissions from an Ameren Energy Resources power plant in Meredosia, Illinois that will be repowered with oxy-combustion technology provided by The Babcock & Wilcox Company and Air Liquide Process and Construction, Inc.

With the selection of the Morgan County site now complete, the Alliance will conduct further geologic characterization this summer. Should concerns arise around the technical, legal, or public acceptability of the preferred site, the Alliance has identified the Christian and Douglas County sites as alternative sites.

Status of CCS project database

The status of 80 large-scale integrated projects data courtesy of the Global CCS Institute

For the full list, with the latest data as it becomes available, please see the pdf version online at www.carboncapturejournal.com

Project Name	Description	Asset Stage	Country	State / District
ADM Company Illinois ICCS	The project will capture around 1 million tonnes per annum of carbon dioxide from ethanol production. The carbon dioxide will be stored approximately 2.1 km underground in the Mount Simon Sandstone, a deep saline formation.	Define	UNITED STATES	Illinois
AEP Mountaineer 235MWe CO2 Capture	AEP's Mountaineer coal-fired power station was retrofitted with Alstom's patented chilled ammonia carbon capture technology. This project has been operational at pilot scale since September 2009 and full-scale operation is expected by 2015.	Define	UNITED STATES	West Virginia
Air Liquide	Air Liquide is building a new hydrogen plant in Rotterdam. The installation of a cryogenic purification unit (CPU) at the plant, capturing up to 550,000 tonnes per annum of carbon dioxide, is under evaluation.	Define	NETHERLA NDS	Rotterdam
Air Products Project	This project proposes to capture more than 1 million tonnes per year of carbon dioxide from two steam methane reformers. The carbon dioxide will be transported via Denbury's Midwest pipeline to the Hastings and Oyster Bayou oil fields for enhanced oil recovery.	Define	UNITED STATES	Texas
Belchatow	Alstom and PGE EBSA are partnering to build an 858 MW lignite-fired power plant with CCS. Around 1.8 million tonnes per annum of carbon dioxide will be captured and stored in deep saline formations.	Define	POLAND	Lodz Voivodeshi p
Boise White Paper Mill	The Battelle Memorial Institute is partnering with Boise White Paper and Fluor Corp to demonstrate carbon capture from the combustion of black liquor at a paper mill. Around 700,000 tonnes per annum of carbon dioxide will be stored in deep flood basalt formations.	Evaluate	UNITED STATES	Washingto n
Bow City	The Bow City Power Project is a proposed super critical 1,000 MW coal-fired power plant incorporating post combustion carbon capture and storage. Around 1 million tonnes per annum of carbon dioxide will be captured at the plant.	Evaluate	CANADA	Alberta
Browse LNG	Up to 3 million tonnes per annum of carbon dioxide will be captured at this proposed liquid natural gas development located in the government precinct near James Price Point on the Dampier peninsula.	Evaluate	AUSTRALIA	Western Australia
Cash Creek	The Erora Group proposes to build a 630 MW IGCC power plant in Henderson County, Kentucky. Around 2 million tonnes per annum of carbon dioxide will be captured and used for enhanced oil recovery.	Evaluate	UNITED STATES	Kentucky
CEMEX - CO2 Plant	CEMEX proposes to demonstrate a dry sorbent carbon capture and compression technology at one of its cement plants in the United States, capturing around 1 million tonnes per annum of carbon dioxide.	Evaluate	UNITED STATES	TBD
Coffeyville Gasification Plant	Coffeyville Resources is proposing to build a carbon capture unit at an existing gasification plant in Kansas. The project would capture 585,000 tonnes per annum of carbon dioxide for urea production and enhanced oil recovery.	Define	UNITED STATES	Kansas
Compostilla Project	This project uses oxyfuel and fluidised bed technology on a 30 MW pilot plant which will scale up to 300 MW. It has received funding from the European Energy Programme for Recovery (EEPR).	Define	SPAIN	Leon
Coolimba	Aviva Corporation Ltd proposes the construction of a "CCS-ready", coal-fired base-load power station using circulating fluidized bed (CFB) technology. Suitable storage sites are being sought.	Identify	AUSTRALIA	Western Australia
Dongguan	Dongguan Taiyangzhou Power Corporation intends to construct an 800 MW IGCC plant capturing up to 1 million tonnes per annum of carbon dioxide, which would be stored in depleted oil and gas reservoirs.	Define	CHINA	Guangdon g
Emirates Steel Industry	This project proposes to capture around 800,000 tonnes per annum of carbon dioxide from a steel plant in the Industrial City of Abu Dhabi (ICAD) by 2014. The project is being developed as part of the Abu Dhabi CCS Network (Masdar).	Evaluate	UNITED ARAB EMIRATES	Mussafah (Abu Dhabi)
Enhance Energy EOR Project	Enhance Energy and Fairborne Energy Trust are jointly developing an enhanced oil recovery project at their Clive D2A and D3A fields, using carbon dioxide captured from a refinery and a fertiliser plant, and transported via the Alberta Carbon Trunk Line.	Execute	CANADA	Alberta
Enid Fertilizer	enhanced oil recovery. The pipeline and wells are operated separately by Anadarko Petroleum. This project has been in operation since 2003.	Operate	UNITED STATES	Oklahoma
Faustina Hydrogen	Faustina Hydrogen is building a solid gasification facility in Louisiana which will use petcoke to produce various industrial chemicals. The carbon dioxide captured at this plant will be used for enhanced oil recovery.	Evaluate	UNITED STATES	Louisiana
Freeport Gasification	Hunton Energy proposes to build a gasification plant that will convert syngas to synthetic natural gas (SNG) and generate 400 MW of additional electricity. The carbon dioxide captured at the plant will be used for enhanced oil recovery.	Evaluate	UNITED STATES	Texas
FutureGen 2.0	FutureGen 2.0 is an initiative to demonstrate state-of-the-art CCT by repowering an existing 200 MW unit at Amerden's coal fired power plant in Meredosia, Illinois, with advanced oxy-combustion technology.	Identify	UNITED STATES	Illinois

Volume CO2	Operation Date	Facility Details	Capture Type	Transport Type	Transport Length	Storage Type	Project URL
1 Mtpa	2012	Ethanol plant	Industrial Separation	Pipeline	1.6 km	Deep Saline Formations	http://www.adm.com/
1.5 Mtpa	2015	235 MWe slipstream from 1300 MW net coal-fired power plant	Post-Combustion	Pipeline	30 km	Deep Saline Formations	http://www.aep.com/environmental/climatechange/carboncapture/
0.55 Mtpa	2012	Hydrogen production	Pre-Combustion	Ship	Not specified	Enhanced Oil Recovery	http://www.airliquide.com/
1 Mtpa	2015	Hydrogen production at oil refinery	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.airproducts.com/index.asp
1.8 Mtpa	2015	260 MW equivalent on 858 MW lignite-fired power plant	Post-Combustion	Pipeline	60-140 km	Deep Saline Formations	http://www.bot.pl/
0.72 Mtpa	2014	Pulp and paper mill	Post-Combustion	Not Specified	Not specified	Deep Basalt Formations	http://www.battelle.org/
1 Mtpa	2016	1000 MW coal-fired power plant	Post-Combustion	Pipeline	6-30 km	Enhanced Oil Recovery	www.bowcitypower.ca
3 Mtpa	2017	Liquefied natural gas (LNG) plant	Gas Processing	Pipeline	Not specified	Not Specified	http://www.woodside.com.au/
2 Mtpa	2015	630MW net coal IGCC power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.erora.com/
1 Mtpa	2015	Cement plant	Post-Combustion	Pipeline	Not specified	Not Specified	http://www.cemex.com/SustainableDevelopment/CarbonCapture.aspx
0.585 Mt-pa	2020	Fertiliser plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.cvrenergy.com/NitrogenFertilizerOperations/index.html
1.1 Mtpa	2015	300 Mwe (Phase 2) coal-fired oxyfuel combustion power plant	Oxyfuel Combustion	Pipeline	120 km	Deep Saline Formations	http://www.compostillaproject.es/
2 Mtpa	2015	2x200 MW or 3x150 MW coal-fired CFB power plant	Post-Combustion	Pipeline	20-80km	Depleted Oil and Gas Reservoirs	www.coolimbapower.com.au
1 Mtpa	2015	800 MW net coal-fired IGCC power plant	Pre-Combustion	Pipeline	100 km	Depleted Oil and Gas Reservoirs	http://www.dgpowerfuel.com/english/profile.asp
0.8 Mtpa	2014	Steel plant	Other	Pipeline	50 km	Enhanced Oil Recovery	http://www.esi-steel.com/
1.8 Mtpa	2012	Fertiliser production and hydrogen production at the oil refinery	Pre-Combustion and Gas Processing	Pipeline	240 km	Enhanced Oil Recovery	http://www.enhanceenergy.com/projects/clive.html
0.68 Mtpa	2003	Fertiliser plant	Pre-Combustion	Pipeline	192 km	Enhanced Oil Recovery	http://www.kochfertilizer.com/
1.5 Mtpa	2019	Coal to liquids plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.eastman.com/
2 Mtpa	2013	Petcoke to SNG plant (plus 400 MW electricity from excess steam)	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.huntonenergy.com/
1 Mtpa	2020	200 MW coal-fired oxy-fuel combustion plant	Oxyfuel Combustion	Pipeline	Not specified	Not Specified	http://www.futuregenalliance.org/

Status of CCS project database

Good Spring IGCC	EmberClear Corporation, in partnership with China's Thermal Power Research Institute, plans to build a 270 MW IGCC plant in Pennsylvania. Around 1 million tonnes per annum of carbon dioxide will be captured at the plant.	Identify	UNITED STATES	Pennsylva nia
Gorgon Project	This component of a larger gas production and LNG processing project will inject 3.4 to 4 million tonnes per annum of carbon dioxide into a saline formation. Construction is under way after a final investment decision was made in September 2009.	Execute	AUSTRALIA	Western Australia
GreenGen	GreenGen Co. proposes to build a coal-based energy system that includes hydrogen production, electricity generation and carbon capture. The carbon dioxide captured at the site will be used for enhanced oil recovery.	Evaluate	CHINA	Tianjin
Hatfield	Powerfuel Power Ltd is developing this project to capture nearly 5 million tonnes per annum of carbon dioxide from a 900 MW coal-fired power station. The project is part of the Yorkshire Forward initiative.	Evaluate	UNITED KINGDOM	South Yorkshire (England)
HECA	This project will use IGCC technology at a petcoke plant to produce hydrogen and carbon dioxide. The hydrogen will then be used to fuel a power station. The carbon dioxide will be transported by pipeline to nearby oil fields for enhanced oil recovery.	Define	UNITED STATES	California
HPAD	This project will convert natural gas into hydrogen and carbon dioxide. The 400 MW hydrogen power plant will generate more than 5 per cent of all Abu Dhabi's current power generation capacity. The carbon dioxide captured at the plant will be used for enhanced oil recovery.	Define	UNITED ARAB EMIRATES	Western Region
Hunterston	ull scale.	Evaluate	UNITED KINGDOM	North Ayrshire (Scotland)
Immingham CCS	This project proposes to use IGCC and pre-combustion carbon capture technology at an oil refinery. The carbon dioxide captured at the plant will we transported offshore to the Southern North Sea for geological sequestration.	Identify	UNITED KINGDOM	Lincolnshir e (England)
In Salah	In Salah is a fully operational onshore gas field in Algeria. Since 2004, 1 million tonnes per annum of carbon dioxide are separated from produced gas and reinjected into the producing hydrocarbon reservoir zones for storage in a deeper saline formation.	Operate	ALGERIA	Ouargla Wilaya
Indiana Gasification	This coal-gasification plant project will include a methanation process to produce pipeline quality synthetic natural gas (SNG). The carbon dioxide captured at the plant will be used for enhanced oil recovery.	Evaluate	UNITED STATES	Indiana
Jänschwalde	Vattenfall's Jänschwalde project will capture 1.7 million tonnes per annum of carbon dioxide using oxyfuel and post-combustion capture at a 3000 MW lignite-fired power plant. Storage options in the area are under investigation.	Define	GERMANY	Brandenbu rg
KOR-CCS1	This project proposes to capture up to 1.5 million tonnes per annum of carbon dioxide from an integrated Circulating Fluidized Bed Combustion (CFBC) power plant. The carbon dioxide captured at the plant would be stored in deep saline formations.	Evaluate	REPUBLIC OF KOREA	Not Specified
KOR-CCS2	This project proposes to capture 1.5 to 2.5 million tonnes per annum of carbon dioxide from an oxyfuel or IGCC power plant. The carbon dioxide captured at the plant would be shipped for injection into a deep saline formation.	Identify	REPUBLIC OF KOREA	TBD
Lake Charles Gasification	Leucadia and Lake Charles Cogeneration plan to build a gasification plant to produce synthetic natural gas from petcoke. Around 4 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.	Define	UNITED STATES	Louisiana
Leucadia Mississippi	Leucadia Energy LLC and Mississippi Gasification LLC propose to capture around 4 million tonnes per annum of carbon dioxide from a petcoke gasification plant in Moss Point, Mississippi. The carbon dioxide will be used for enhanced oil recovery.	Evaluate	UNITED STATES	Mississippi
Lianyungang	This project will construct a 1200 MW IGCC capturing up to 1 million tonnes per annum of carbon dioxide. Synthetic natural gas (SNG) and chemicals will be co-produced at this plant.	Define	CHINA	Jiangsu
Longannet	This project led by Scottish Power will retrofit two 600 MW turbines with amine-based carbon capture units. Up to 2 million tonnes per annum of carbon dioxide will be transported by pipeline to oil and gas fields in the Central North Sea for storage.	Define	UNITED KINGDOM	Fife (Scotland)
Lost Cabin	This project will retrofit the Lost Cabin natural gas processing plant in Wyoming with CCS facilities, capturing around 1 million tonnes per annum of carbon dioxide to be used for enhanced oil recovery.	Define	UNITED STATES	Wyoming

1 Mtpa	2015	270 MW coal-fired IGCC power plant	Pre-Combustion	Pipeline	Not specified	Deep Saline Formations and EOR	http://www.emberclear.com/
3.4 Mtpa	2014	Liquefied natural gas (LNG) processing plant	Gas Processing	Pipeline	10 km	Deep Saline Formations	http://www.chevronaustralia.com/ourbusinesses/gorgon.aspx
2 Mtpa	2016	1x400 MW (phase III) coal-fired IGCC power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.greengen.com.cn/en/index.asp
4.75 Mtpa	2015	2x450 MW gross coal-fired IGCC power plant	Pre-Combustion	Pipeline	175 km	Depleted Oil and Gas Reservoirs and Deep Saline Formations	http://powerassetmodelling.co.uk/html/hatfield_igcc_.html
2 Mtpa	2016	250 MW net multi-fuel-fired IGCC power plant	Pre-Combustion	Pipeline	6.4 km	Enhanced Oil Recovery	http://www.hydrogenenergycalifornia.com/
1.7 Mtpa	2015	400 MW net hydrogen power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.hydrogenenergy.com/abudhabi.aspx
2 Mtpa	2017	2x926 MW multi-fuel (coal/biomass)-fired power plant	Post-Combustion	Pipeline	Not specified	Depleted Oil and Gas Reservoirs	www.ayrshirepower.co.uk
4 Mtpa	2020	800-1200 MW multi-fuel IGCC power plant at oil refinery	Pre-Combustion	Pipeline	300 km	Not Specified	http://www.conocophillips.com/EN/susdev/environment/climatechange/carboncapture/Pages/index.aspx
1 Mtpa	2004	Natural gas processing plant	Gas Processing	Pipeline	14 km	Deep Saline Formations	http://www.insalahco2.com/
1 Mtpa	2020	Coal to SNG plant	Pre-Combustion	Pipeline	7.2 km	Enhanced Oil Recovery	http://www.leucadia.com/
1.7 Mtpa	2015	300 MW equivalent (250 MW oxyfuel and 50 MW PCC) on a 3000 MW lignite-fired power plant	Oxyfuel combustion and Post-Combustion	Pipeline	150 km	Deep Saline Formations	http://www.vattenfall.com/www/co2_en/co2_en/879177tbd/879231demon/879320demon/index.jsp
1.5 Mtpa	2017	300 MW coal-fired power plant	Post-Combustion	TBD	250 km	Deep Saline Formations	http://www.kepco.co.kr/eng/
1.5 Mtpa	2019	300 MW coal-fired oxy-fuel or IGCC power plant	TBD	Ship	800 km	Deep Saline Formations	http://www.kepco.co.kr/eng/
4 Mtpa	2014	Petcoke to SNG plant	Pre-Combustion	Pipeline	19 km	Enhanced Oil Recovery	http://www.leucadia.com/
4 Mtpa	2014	Petcoke to SNG plant	Pre-Combustion	Pipeline	176 km	Enhanced Oil Recovery	http://www.denbury.com/
1 Mtpa	2015	1200 MW IGCC and 2x1300 MW ultra supercritical PC plants coproduction power/chemical	Pre-Combustion and Post-Combustion	Pipeline	100 km	Deep Saline Formations	http://english.cas.cn/
2 Mtpa	2014	2x600 MW units at a 2400 MW coal-fired power plant with co-firing capability	Post-Combustion	Pipeline	Not specified	Depleted Oil and Gas Reservoirs	http://www.scottishpower.com/carbon_capture_storage/
1 Mtpa	2014	Natural gas processing plant	Gas Processing	Pipeline	370 km	Enhanced Oil Recovery	http://www.conocophillips.com/EN/tech/Pages/carbon-article.aspx

Status of CCS project database

Mongstad	StatoilHydro and the Norwegian government entered into an implementation agreement to develop carbon capture solutions at the Mongstad natural gas energy plant, with a view to capture and store up to 1 million tonnes per annum of carbon dioxide.	Evaluate	NORWAY	Hordaland
Nelson 6	This project developed by Tenaska and Entergy will capture up to 4 million tonnes per annum of carbon dioxide from an existing coal-fired power station when operating at full scale. The carbon dioxide will be used for enhanced oil recovery.	Define	UNITED STATES	Louisiana
North East CCS Cluster	This regional initiative led by One North East includes a new CCS power plant at Eston Grange and a part-conversion of the Rio Tinto Alcan power plant at Lynemouth, which together will capture up to 7.5 million tonnes per annum of carbon dioxide.	Identify	UNITED KINGDOM	England
Nuon Magnum	Nuon Magnum is envisaged as a multi-fuel 1200 MW IGCC power plant. Up to 1.3 million tonnes per annum of carbon dioxide will be captured at the plant and stored in depleted oil and gas reservoirs.	Define	NETHERLANDS	Groningen
Occidental Gas Processing Plant	Occidental Petroleum, in partnership with Sandridge Energy, is currently constructing a natural gas processing plant in West Texas. The plant will capture up to 9 million tonnes per annum of carbon dioxide for use in enhanced oil recovery.	Execute	UNITED STATES	Texas
Peterhead	Around 1 million tonnes per annum of carbon dioxide will be captured at GCTT Peterhead, the largest power station in Scotland. The carbon dioxide captured at the plant will be used for enhanced oil recovery at the Miller Field in the North Sea.	Evaluate	UNITED KINGDOM	Aberdeenshire (Scotland)
Plant Ratcliffe	Mississippi Power (Southern Company) plans to build an air-blown 582 MW IGCC plant using a coal-based transport gasifier. Up to 2.5 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.	Execute	UNITED STATES	Mississippi
Porto Tolle	This project will capture around 1 million tonnes per annum of carbon dioxide from 660 MW coal power station units using post-combustion capture technology. The carbon dioxide will be injected into a deep saline aquifer in the northern Adriatic Sea.	Define	ITALY	Rovigo
Project Kedzierzyn	The Kedzierzyn Polygeneration Power Plant will produce energy and heat as well as chemical products. A full-scale pre-combustion carbon capture unit will separate up to 2.5 million tonnes per annum of carbon dioxide to be injected into a saline formation.	Identify	POLAND	Opolskie
Project Pioneer	This project will capture 1 million tonnes per annum of carbon dioxide from one of TransAlta's three local coal-fired power plants, using Alstom's chilled-ammonia process. The carbon dioxide will be used for enhanced oil recovery or sequestered locally.	Define	CANADA	Alberta
Project Viking	This project proposes to convert refinery pitch to MSAR® synthetic fuel oil, which will in turn be used to produce power, steam and carbon dioxide through an oxycombustion process. The carbon dioxide will be used for enhanced oil recovery.	Identify	UNITED STATES	New Mexico
PurGen One	SCS Energy LLC is proposing to build a 500 MW IGCC power plant with CCS in New Jersey. Around 2.6 million tonnes per annum of carbon dioxide would be transported by pipeline to deep saline formations about 110 km offshore.	Evaluate	UNITED STATES	New Jersey
Quest CCS Project	The Quest Project proposes to capture more than 1.2 million tonnes per annum of carbon dioxide from an oil sands upgrader. The carbon dioxide will be transported in a 80 kilometre pipeline to a deep saline formation, with possible sales to third parties.	Define	CANADA	Alberta
Rangely Weber	ChevronTexaco, the current owner and operator of the Rangely Weber Sand Unit, sources around 1 million tonnes per annum of carbon dioxide from a gas processing plant that is used for enhanced oil recovery. This project has been in operation since 1986.	Operate	UNITED STATES	Colorado
ROAD	Electrabel and E.ON are developing this project in partnership with the Rotterdam Climate Initiative (RCI). A 250 MW capture plant is being built at E.ON's Maasvlakte power plant and operation is expected to start in 2015.	Define	NETHERLANDS	Zuid-Holland
Romanian CCS Demo (Getica)	This project will capture around 1.5 million tonnes per annum of carbon dioxide from a lignite-fired power plant. The carbon dioxide captured at the plant will be stored in onshore deep saline formations.	Evaluate	ROMANIA	Gorj County
Rotterdam CCS Network	This project aims to develop a business case for a large-scale carbon transport hub based in Rotterdam. Nine capture facilities have been validated, as well as the transport infrastructure. The independent storage assessment is under way.	Evaluate	NETHERLANDS	Rotterdam
RWE Eemshaven	RWE and Gasunie aim to capture and store around 1.1 million tonnes per annum of carbon dioxide in this project, which is scheduled to become operational in 2015.	Define	NETHERLANDS	Groningen
Salt Creek EOR	Carbon dioxide recovered from the Shute Creek gas processing plant in southwest Wyoming is transported by pipeline to Anadarko's enhanced oil recovery project at the Salt Creek field. This project has been operational since 2004.	Operate	UNITED STATES	Wyoming

1 Mtpa	2020	Natural gas-fired power plant (280 MW electric, 350 MW heat)	Post-Combustion	Pipeline	Not specified	Deep Saline Formations	http://www.statoil.com/en/OurOperations/TerminalsRefining/ProdFacilitiesMongstad/Pages/EnergiverkMongstad.aspx
4 Mtpa	2015	585 MW coal-fired power plant	Post-Combustion	Pipeline	< 160 km	Enhanced Oil Recovery	http://www.entergy.com/
7.5 Mtpa	2015	850 MW coal-fired IGCC and 420 MW coal and biomass-fired power plants	Pre-Combustion	Pipeline	225 km	Deep Saline Formations	http://www.progressive-energy.com/
1.3 Mtpa	2015	1200 MW multi-fuel-fired IGCC power plant	Pre-Combustion	Pipeline	Not specified	Depleted Oil and Gas Reservoirs	http://www.nuon.com/company/Innovative-projects/magnum.jsp
9 Mtpa	2011	Natural gas processing plant	Gas Processing	Pipeline	256 km	Enhanced Oil Recovery	http://www.oxy.com/
1 Mtpa	By 2020	400MW gas-fired power plant	Post-Combustion	Pipeline	320 km	Not Specified	http://www.sse.com/
2.5 Mtpa	2014	582 MW net coal-fired IGCC power plant	Pre-Combustion	Pipeline	98 km	Enhanced Oil Recovery	http://www.mississippipower.com/kemper/
1 Mtpa	2015	3x660 MW ultra supercritical PC power unit	Post-Combustion	Pipeline	100 km	Deep Saline Formations	http://www.zeportotolle.com/
2.47 Mtpa	2015	300 MW gross polygeneration power plant	Pre-Combustion	Pipeline	Not specified	Deep Saline Formations	http://www.pke.pl/en
1 Mtpa	2015	450 MW gross coal-fired power plant	Post-Combustion	Pipeline	50 km	EOR or Geological	http://www.projectpioneer.ca/
1.2 Mtpa	2014	150 MWe oxyfuel combustion using synthetic fuel oil	Oxyfuel Combustion	Pipeline	48 km	Enhanced Oil Recovery	http://www.co2.no/
2.6 Mtpa	2016	500 MW coal-fired IGCC power plant	Pre-Combustion	Pipeline	160 km	Deep Saline Formations	http://www.purgenone.com/
1.2 Mtpa	2015	Hydrogen production at oil sands upgrader	Pre-Combustion	Pipeline	80 km	Deep Saline Formations	http://www.shell.ca/
1 Mtpa	1986	Natural gas processing plant	Gas Processing	Pipeline	285 km	Enhanced Oil Recovery	http://www.chevron.com/
1.1 Mtpa	2015	250 MW on 1070 MW coal and biomass-fired power plant	Post-Combustion	Pipeline	25 km	Depleted Oil and Gas Reservoirs	http://www.eon-benelux.com/
1.5 Mtpa	2015	330 MW lignite-fired power plant	Post-Combustion	Pipeline	20-50 km	Deep Saline Formations	http://www.ispe.ro/en/
3.35 Mtpa	2015	Various capture facilities	Various	Combination	25 km	Depleted Oil and Gas Reservoirs	http://www.rotterdamclimateinitiative.nl/en/
1.1 Mtpa	2015	780 MW net coal-fired power plant (biomass in future)	Post-Combustion	Not Specified	80 km	Depleted Oil and Gas Reservoirs	http://www.rwe.com/
2.4 Mtpa	2004	Natural gas processing plant	Gas Processing	Pipeline	201 km	Enhanced Oil Recovery	http://www.anadarko.com/Operations/Pages/EnhancedOilRecovery.aspx

Status of CCS project database

SaskPower Boundary Dam 3	SaskPower proposes to rebuild a coal-fired power generator with carbon capture technology near Estevan, in the Saskatchewan province. When fully operational in 2015, this project will capture around 1 million tonnes per annum of carbon dioxide.	Define	CANADA	Saskatche wan
Sharon Ridge	This enhanced oil recovery project uses carbon dioxide sourced from the Mitchell, Gray Ranch, Puckett and Turrell gas processing plants and transported via the Val Verde and CRC pipelines. This project has been in operation since 1999.	Operate	UNITED STATES	Texas
Shell CO2	This project intends to capture, condition, and transport by pipeline approximately 1 million tonnes per annum of by-product and off-gas carbon dioxide streams from various facilities. The carbon dioxide will be sequestered in saline formations.	Evaluate	UNITED STATES	Louisiana
Shenhua Ph 2	This project intends to capture around 1 million tonnes per annum of carbon dioxide from a coal- to-liquids facility by 2020. It is the second phase of the pilot-scale Ordos Shenhua DCL plant CCS Project.	Identify	CHINA	Inner Mongolia
Sleipner	Sleipner is a fully operational offshore gas field with carbon dioxide injection. The carbon dioxide is separated from produced gas and reinjected into a saline aquifer above the hydrocarbon reservoir zones. This project has been in operation since 1996.	Operate	NORWAY	North Sea
Snøhvit	The Snøhvit offshore gas field and related CCS activities have been in operation since 2007. Carbon dioxide separated from the gas produced at an onshore liquid natural gas plant is reinjected into an offshore saline aquifer below the reservoir zones.	Operate	NORWAY	Barents Sea
South Heart	Great Northern Power Development and Allied Syngas are planning a 175MW IGCC plant capturing about 90 per cent of its carbon emissions. The plant will produce 2.1 million tonnes per annum of carbon dioxide for enhanced oil recovery.	Evaluate	UNITED STATES	North Dakota
Southland CTF Project	Solid Energy and Ravensdown have partnered to investigate a coal to fertiliser plant (1.2 million tonnes per annum of fertiliser) with carbon capture and sequestration in a deep saline formation. The plant is projected to begin operations in 2016.	Evaluate	NEW ZEALAND	Southland
Spectra Fort Nelson	Carbon dioxide sourced at the Fort Nelson natural gas-processing plant will be injected into a nearby saline formation at a depth of approximately 2200 metres. Injection rates will ramp up to 1.2 to 2 million tonnes per annum of carbon dioxide.	Evaluate	CANADA	British Columbia
Swan Hills	This project intends to build a 300 MW combined cycle power plant, using syngas produced at an adjacent coal gasification unit. Around 1.4 million tonnes per annum of carbon dioxide will be captured and sold to local enhanced oil recovery operators.	Evaluate	CANADA	Alberta
Sweeny Gasification	This project proposes to build an IGCC plant in Southeast Texas using petroleum coke and ConocoPhillips's proprietary E-Gas gasification technology. The plant with capture around 3 million tonnes per annum of carbon dioxide for enhanced oil recovery.	Evaluate	UNITED STATES	Texas
Taweelah Asia Power Co / Emirates Aluminium	This project proposes to capture up to 4.2 million tonnes per annum of carbon dioxide from an amine-based natural gas fired power plant by 2017. The project is being developed as part of the Abu Dhabi CCS Network (Masdar).	Identify	UNITED ARAB EMIRATES	Taweelah (Abu Dhabi)
Taylorville IGCC	The Taylorville Energy Center is a proposed 716 MW (gross) IGCC power plant located in Illinois. Around 1.9 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.	Evaluate	UNITED STATES	Illinois
Texas Clean Energy (NowGen)	Summit Power Group, Inc. is developing a 400 MW IGCC power plant capturing 2.7 million of tonnes per annum of carbon dioxide to be used for enhanced oil recovery in the Permian Basin in West Texas.	Define	UNITED STATES	Texas
The Collie Hub	This project proposes to develop a transport and storage hub collecting carbon dioxide captured from various facilities in Western Australia. The project aims to store between 2.5 and 7.5 million tonnes per annum of carbon dioxide in saline formations.	Evaluate	AUSTRALIA	Western Australia
Trailblazer	Tenaska, Inc. is developing a site near Sweetwater, Texas, upon which to construct a supercritical pulverized coal-fueled electric generating plant designed to capture up to 85-90 per cent of the carbon dioxide that would otherwise enter the atmosphere.	Define	UNITED STATES	Texas
ULCOS Florange	The Ultra-Low-CO2-Steel (ULCOS) consortium proposes to build a prototype blast furnace that will be able to efficiently capture around 500,000 tonnes per annum of carbon dioxide from a steel plant. The carbon dioxide will be stored in a deep saline formation.	Define	FRANCE	Moselle (Lorraine)
Victorian CarbonNet	The Victorian Government is developing this carbon transport and storage hub project in the state of Victoria. The project aims to collect between 3 and 5 million tonnes per annum of carbon dioxide from various capture facilities.	Evaluate	AUSTRALIA	Victoria
Wandoan Power	This project based on General Electric's IGCC and capture technologies will capture up to 2.5 million tonnes per annum of carbon dioxide from a 400 MW power plant. The carbon transport and storage components are pursued in alliance with Xstrata Coal.	Evaluate	AUSTRALIA	Queenslan d
Weyburn EOR	This project captures about 3 million tonnes per annum of carbon dioxide from a synfuels plant. The carbon dioxide is transported by pipeline across the Canadian border for enhanced oil recovery. The project has been in operation since 2000.	Operate	CANADA	Saskatche wan
Yulin	This project developed by Dow Chemical proposes to build a coal to liquids plant. Various storage options are under evaluation.	Identify	CHINA	Shanxi Province

1 Mtpa	2013	115 Mwe coal-fired power plant	Post-Combustion	Pipeline	100 km	Enhanced Oil Recovery	http://www.saskpower.com/sustainable_growth/projects/carbon_capture_storage.shtml?linkid=home_right2_carbon_capture_and_storage_demo
1.3 Mtpa	1999	Natural gas processing plants	Gas Processing	Pipeline	Not specified	Enhanced Oil Recovery	http://www.exxonmobil.com/
1 Mtpa	2015	Various CO2 capture facilities	Various	Pipeline	Not specified	Deep Saline Formations	http://www.shell.com/home/content/innovation/managing_emissions/ccs/
1 Mtpa	By 2020	Coal to liquids plant	Pre-Combustion	Not Specified	30-100 km	Deep Saline Formations	http://www.shenhuagroup.com.cn/english/
1 Mtpa	1996	Natural gas processing platform	Gas Processing	On Site	Minimal (capture same as storage location)	Deep Saline Formations	http://www.statoil.com/en/TechnologyInnovation/ProtectingTheEnvironment/CarboncaptureAndStorage/Pages/CarbonDioxideInjectionSleipnerVest.aspx
0.7 Mtpa	2007	Natural gas processing platform	Gas Processing	Pipeline	160 km	Deep Saline Formations	http://www.statoil.com/en/technologyinnovation/newenergy/co2management/pages/snohvit.aspx
2.1 Mtpa	2017	175 MW net lignite-fired IGCC plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.greatnorthernpower.com/
1.2 Mtpa	2016	Coal to fertiliser plant	Pre-Combustion	Pipeline	100 km	Deep Saline Formations	http://www.coalnz.com/
1.2 Mtpa	2014	Natural gas processing plant	Gas Processing	Pipeline	15 km	Deep Saline Formations	http://www.spectraenergy.com/our_responsibility/climate/carbon_capture/
1.4 Mtpa	2015	In-situ coal gasification (syngas) with 300 MW net combined cycle power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.swanhills-synfuels.com/
3 Mtpa	2015	680 MW petcoke IGCC power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	www.sweenygasification.com
4.2 Mtpa	2017	Amine-based natural gas-fired power plant	Post-Combustion	Pipeline	450 km	Enhanced Oil Recovery	http://www.tapco.ae/
1.9 Mtpa	2015	716 MW gross hybrid IGCC coal power plant	Pre-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.cleancoalillinois.com/tec.html
2.7 Mtpa	2014	400 MW coal-fired IGCC power/ poly-generation plant	Pre-Combustion	Pipeline	132 km	Enhanced Oil Recovery	http://texascleanenergyproject.com/
2.5 Mtpa	2015	Various CO2 capture facilities	Pre-Combustion and Post-Combustion	Pipeline	80 km	Deep Saline Formations	http://www.dmp.wa.gov.au/9525.aspx
5.75 Mtpa	2016	600 MW net supercritical PC power plant	Post-Combustion	Pipeline	Not specified	Enhanced Oil Recovery	http://www.tenaskatrailblazer.com/
0.5 Mtpa	2015	Steel plant	Post-Combustion	Pipeline	100 km	Deep Saline Formations	http://www.ulcos.org/en/
3.3 Mtpa	2018	Various CO2 capture facilities	Pre-Combustion and Post-Combustion	Pipeline	150 km	Deep Saline Formations	http://www.invest.vic.gov.au/
2.5 Mtpa	2015	400 MW net coal-fired IGCC power plant	Pre-Combustion	Pipeline	200 km	To Be Determined	http://www.wandoanpower.com.au
3 Mtpa	2000	Synfuels plant including SNG	Pre-Combustion	Pipeline	330 km	Enhanced Oil Recovery	http://www.cenovus.com/operations/oil/weyburn.html
5 Mtpa	2019	Coal to liquids plant	Pre-Combustion	Pipeline	Not specified	Various Options	http://www.dow.com/

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