SCCS

Scottish Carbon Capture & Storage

Recommendations and Conference 2014 Report

A CCS future for Europe: catalysing North Sea action

Credits and disclaimers

This report presents outputs from the SCCS Annual Conference 2014 held in Edinburgh on 29 October to discuss the strategic delivery of a Carbon Capture and Storage industry for Europe, with a particular focus on the role of the North Sea. The event brought together industry players, politicians, researchers, NGO representatives and other key stakeholders from across Europe, and beyond, to discuss the necessary inclusion of CCS in Europe's future climate and energy policy.

The report's recommendations and conclusions have been developed by SCCS based on discussions in conference focus groups held under the Chatham House Rule. These recommendations are the sole responsibility of SCCS and should not be attributed to individual speakers or participants. We are grateful to our speakers and delegates for sharing their extensive knowledge and expertise throughout the day. We would also like to thank our guest authors for their contributions, and for their support and advice prior to the conference.

More conference details can be found at **www.sccs.org.uk/conference2014**

About SCCS and our partners

Scottish Carbon Capture & Storage (SCCS) is an independent research partnership of British Geological Survey (BGS), Heriot-Watt University, the University of Aberdeen, the University of Edinburgh and the University of Strathclyde. It is the largest CCS research group in the UK and provides a single point of coordination for all aspects of CCS research, from capture engineering and geoscience to public engagement, policy and economics. SCCS is funded predominantly by the Scottish Funding Council with contributions from the European Regional Development Fund, the Natural Environment Research Council (BGS), Heriot-Watt University and the University of Edinburgh. **www.sccs.org.uk**

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Introduction

THERE is an encouraging mood of renewed optimism for Carbon Capture and Storage (CCS). The operation of the Boundary Dam CCS Project in Saskatchewan has moved the technology from being "speculative" to "proven". The Intergovernmental Panel on Climate Change (IPCC) has bluntly stated the global importance of CCS. Also, the USA-China bilateral agreement has, for the first time, committed to carbon emissions reduction. The European Union's 2030 climate and energy package specifically identifies CCS for continued funding for technology development. This is positive, but it is clear that additional policy efforts will be required to overcome remaining commercial barriers to deployment.

It is notable that some of the most carbon-intensive economies in Europe lie around the North Sea, or within striking distance. For the UK, the Netherlands, Belgium, Germany and Poland, CCS remains attractive for three reasons. Firstly, the North Sea offers immense and secure carbon dioxide (CO_2) storage for industrial and power generation emissions during the next 100 years; secondly, there is real-world experience of CO_2 transport by pipeline and shipping together with the injection of CO_2 into the deep sub-surface and its reliable monitoring; and thirdly, assessments of national energy systems by the Energy Technologies Institute, the International Energy Agency and the IPCC predict that a failure to incorporate CCS as part of the transition to a low-carbon economy will result in a doubling of associated costs.

In 2013, the SCCS conference explored storage pathways and policy options to effect this transition. We identified key actions for policy makers, and are pleased that some have already been secured. But we must all do more. This year, we brought together politicians, civil servants, developers and researchers to explore solutions that will make CCS investable, develop faster, and become more politically and commercially desirable. The importance of CCS for Europe's large industries has emerged, as has the ability of some industries to supply pure CO_2 immediately and help develop storage without delay. A second proposition is also clear, that CO_2-Enhanced Oil Recovery (CO_2-EOR) can provide the largest business opportunity for CO_2 utilisation and can pull through cost reductions in CO_2 capture. Acting on this could help to secure the construction of CO_2 infrastructure at scale decades sooner than public funding alone would allow.

There are still policy blockages and funding gaps. If Europe wishes to be amongst the leaders in climate clean-up – and wants to maximise the contribution of its science and business expertise to catalysing international action – then further domestic policy efforts are required before 2020. The primary challenge for CCS in Europe is not the technology but the need to get the commercial incentives and policy frameworks right. CCS is a large-scale climate change mitigation tool, and needs to be treated as such.

Professor Stuart Haszeldine
University of Edinburgh, SCCS Director

Executive summary

IT is unequivocal that the continued unabated use of fossil fuels is no longer an option if the world is to avoid "severe, pervasive and irreversible"[1] damage from the impacts of climate change. Carbon Capture and Storage (CCS) has a critical role to play in achieving energy system and industrial decarbonisation to successfully mitigate the changing climate.

Europe has led the world on action to address climate change, introducing leading decarbonisation targets and the world's largest carbon emissions trading scheme. It has also supported the development and deployment of low-carbon renewable energy technologies. However, despite leading early calls for the delivery of CCS technology needed to complement and secure a low-carbon future, Europe has now fallen behind. This threatens its domestic ability to successfully decarbonise as well as its international leadership in delivering climate change mitigation action.

In 2007 the European Council of European Union Member States called for "up to 12 CCS demonstration projects to be delivered by 2015". Seven years and numerous project proposals later, no CCS projects have started construction, and the majority have been cancelled or mothballed. This is in stark contrast to growing CCS momentum elsewhere, such as in North America and China (see panel *Global progress on CCS*). The remaining handful of Europe's CCS demonstration projects are negotiating much-needed financial support from the EU and national governments. Located around the North Sea – Europe's largest, best understood and most bankable CO_2 storage asset – these projects must be an immediate priority in the EU's climate objectives. However, even these will be insufficient to successfully deliver the full potential of CCS. It is essential that follow-on projects are quickly brought forward and properly supported to create a CCS industry capable of delivering significant decarbonisation along with energy, security, job retention and economic value.

GLOBAL PROGRESS ON CCS

The projects listed below are among 22 large-scale CCS projects in operation or construction around the world[2]. They are being realised through active financial support by government, revenue from CO_2-EOR and strong government commitment that high-emissions sources, including coal power plants, have no future without the installation of CCS.

- **Boundary Dam, Canada**: world's first full-scale CCS project on coal power capturing 1 million tonnes per year. Began operating October 2014
- **Kemper County, USA**: Integrated gasification combined cycle (IGCC) power project that will capture 3 million tonnes per year. Nearing completion and due to start up in 2016
- **Petra Nova Carbon Capture Project, USA**: full-scale CCS on coal power, with capture capacity of 1.4 Mt per year. Under construction and due to start up in 2016

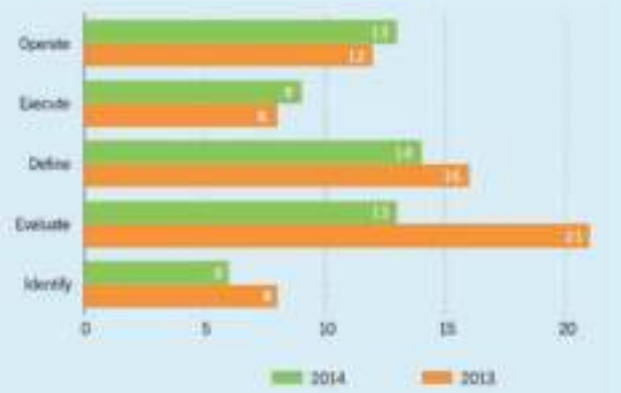


Figure 1: *Identified global large-scale CCS projects, showing figures from 2013–14. Source: The Global Status of CCS 2014 (Execute = under construction; Define = advanced development; Evaluate and Identify = early development)*

- **Abu Dhabi CCS Project, United Arab Emirates**: construction under way on world's first large-scale CCS project in iron and steel sector, which will capture 0.8 Mt per year

[1] *IPCC Synthesis Report*, Fifth Assessment Report, IPCC, 2014
[2] *The Global Status of CCS 2014*, Global CCS Institute, 2014

The 2014 SCCS Annual Conference, *A CCS future for Europe*, brought together international CCS experts from industry, government, research, non-governmental organisations (NGOs) and finance to explore how Europe can regain momentum and deliver CCS. Plenary speakers gave perspectives on the problems and opportunities for CCS in Europe, and the measures needed to secure its future (see page 10). These were set within the context of the European Council's energy and climate policy objectives for 2030. Delegates welcomed the agreement of a 40% emissions reduction target, the proposals to strengthen the EU Emissions Trading Scheme, the recognition of the need for Member States to make appropriate decarbonisation pathway and technology choices, continuation of Projects of Common Interest (PCIs), and the renewal of the New Entrants' Reserve funding mechanism (NER400) to support the demonstration of low-carbon technologies, including CCS.

Following the plenary, detailed discussions were held in three priority areas: creating the right incentives for CCS, facilitating the development of CCS infrastructures through the "cluster" approach, and catalysing research and development (R&D) activities to support CCS deployment. These discussions fed into the development of a set of recommendations (set out on page 8 and 9, *Europe's pathway to achieving CCS*) aimed at guiding European policy makers. These are summarised here: the first section describes the broader approach for the European energy and climate policy community; the second describes more detailed actions for the European Commission, Member State governments, industry and R&D actors.

CCS will deliver a climate-secure future

- CCS should be recognised as a high-leverage climate change mitigation technology and valued as such. It is unique in enabling the decarbonisation of emissions from thermal power generation and essential industrial/manufacturing processes. It also has the potential for negative emissions, through bio-energy with CCS, whereby CO_2 can be removed from the atmosphere. The timely deployment of CCS is essential for a climate-secure future.
- For CCS to deliver, it needs to be undertaken at large scale with clusters of carbon emitters sharing CO_2 transport and storage infrastructure. Initial projects may use shipping for flexibility and lower cost. Cross-border CO_2 transport will become inevitable within years and the EU should issue legal guidance on this. Governments should make it a priority to support the development of clusters, building on the first demonstration projects. The North Sea region – with its ample and proven geology, including storage sites already licensed, existing oil and gas infrastruture, supportive governments, industry and public, and a number of actionable CCS projects – is a clear candidate for the creation of Europe's first CCS clusters through the 2020s, which can be then replicated in central, eastern and southern Europe.
- CCS is not just a huge opportunity to multiple sectors and constituencies; it is essential for their existence. The creation of a CCS industry can: secure industrial output and jobs; enhance energy security by enabling a transition from the use of domestic resources; ensure a secure power supply for Europe by providing flexible low-cost and low-carbon back-up to intermittent renewable generation; and secure the future of high-value petrochemicals.
- If managed carefully, the benefits of CO_2-EOR outweigh the perceived negatives. It offers a route to break free from the funding and infrastructure blockages for CCS, and can incentivise CO_2 capture from diverse sources. It can increase energy security by prolonging domestic oil production, but regulation must ensure carbon reduction benefits. The initiation of CO_2-EOR in the North Sea requires both focused policy support and the creation of CO_2 capture clusters to deliver a stable supply of many millions of tonnes of CO_2 per year.
- Realising CCS requires clear policies that deliver appropriate finance and progressively enforce its application. This requires sector-specific measures to complement carbon pricing, and which recognise the value and required timetable of CCS deployment. The creation of the right policy and support framework will secure considerable external investment in a low-carbon industry of immense value to Europe's continued economic competitiveness.

Shaping a supportive framework

The Commission plays a crucial role in shaping Europe's CCS agenda and creating supporting policy initiatives. As it moves forward with the implementation of the 2030 climate and energy framework, the Commission and Member State governments are called upon to:

- Rapidly secure final investment decisions on remaining demonstration projects to ensure their delivery and resulting learning.
- Fast-track the renewal of the NER400 Innovation Fund to support the development of follow-on CCS projects, as a progression from the initial demonstrations. It should provide appropriate capital grants and/or operational support to accelerate deployment of CCS on power generation and industrial CO_2 emissions. Member State governments need to create and clarify national support mechanisms to enable these projects to begin design and take financial investment decisions in parallel with commissioning first-phase projects.
- Support the creation of a pipeline and shipping CO_2 transport infrastructure through PCIs and complementary national measures to enable cluster development around initial capture projects, to act both before and after 2020.
- Undertake analysis and appraisal of incentive mechanisms for CCS in both power generation and industry to facilitate the development of financial and regulatory support structures.
- Facilitate the establishment of business models for CO_2 transport and storage, in parallel with CO_2 capture, that enable fair access and transparent charging mechanisms for all emitters.
- Coordinate investigation and communication of CO_2-EOR potential to stimulate commercial interest and put in place supporting policies across the North Sea region.

Alongside the above actions, industry and the R&D community are encouraged to further their collaboration to ensure the appropriate and timely delivery of research outputs. Here, there is a need to develop formal detailed communication between commercial project development and wider research to allow emerging issues to be understood and addressed in good time. There is a clear role for supporting CCS bodies to help deliver effective mechanisms for information exchange and research prioritisation.

The creation of the right policy and support framework will secure considerable external investment in a growing, long-term low-carbon industry of immense value to Europe's continued economic competitiveness.

Europe's pathway to achieving CCS

A number of important milestones have already been attained by CCS project developers and European policy makers. To build on recently regained momentum and ensure that CCS secures its place in the EU's future climate and energy policies, SCCS proposes these recommendations, which will feed into and influence Europe's current trajectory towards a low-carbon future (see *The building blocks of a North Sea network* from page 20 for detailed descriptions of these recommendations and the supporting rationale).

INCENTIVISING CCS TO 2030+

Recommendation 1: Ensure rapid delivery of renewed NER400 programme

Recommendation 2: Support creation of CO_2 transport and storage infrastructure through PCIs

Recommendation 3: Undertake analysis of different incentive mechanisms for CCS

DESTINATION NORTH SEA

Recommendation 4: Devise a clear pricing mechanism for CO_2 transport and storage

Recommendation 5: Develop a CO_2-EOR plan for the North Sea

Recommendation 6: Create a CCS cluster plan for Europe

Recommendation 7: Provide specific funding support for developing local carbon capture clusters

R&D CATALYSTS

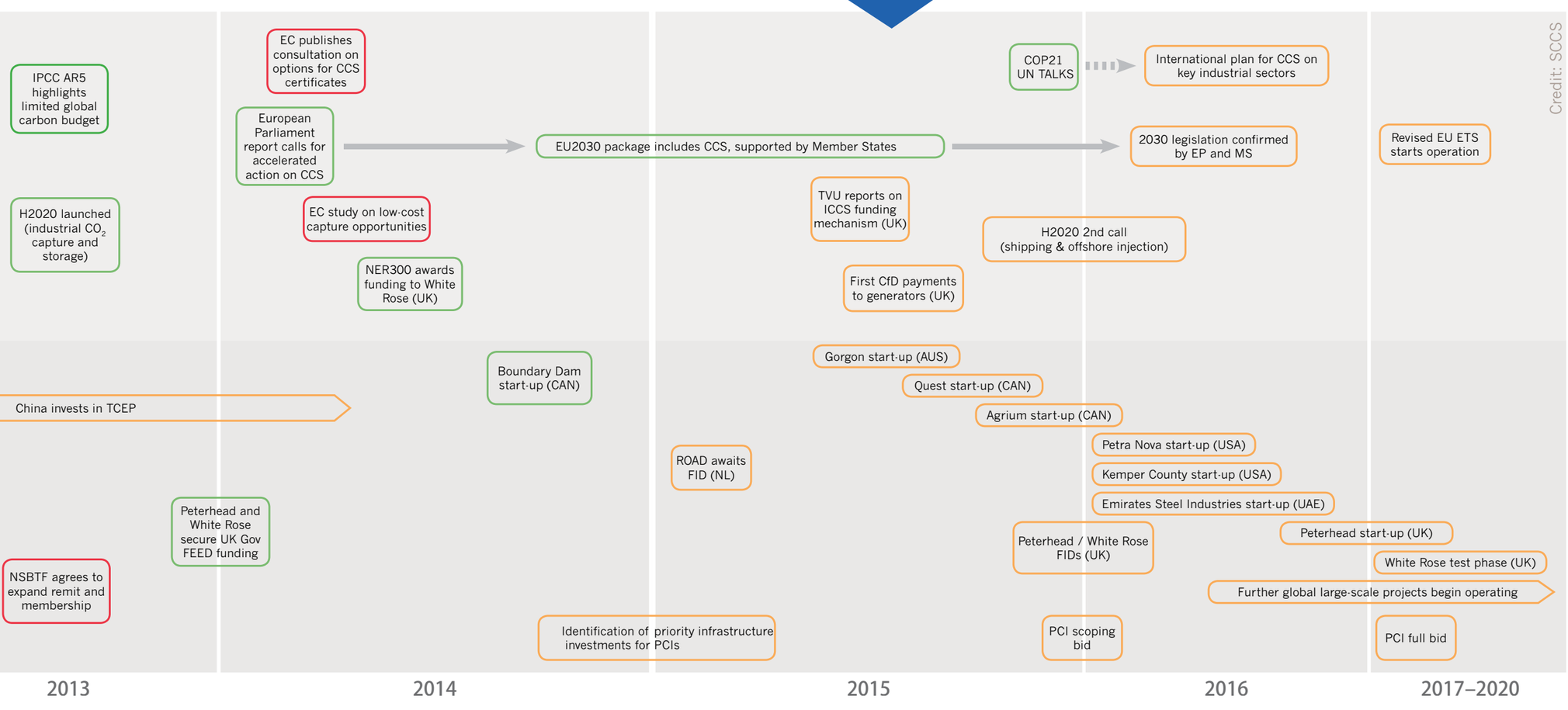
Recommendation 8: Research community to take lead on defining future R&D needs with strategic industry input

Recommendation 9: R&D priorities to be steered by industry needs as demonstration projects proceed

Recommendation 10: Existing CCS networks and bodies to have a key role in developing mechanisms for information exchange between industry and academia

Glossary

CfD	Contracts for Difference
EC	European Commission
FEED	Front-end engineering and design
FID	Final Investment Decision
ICCS	Industrial CCS
MS	Member State
NSBTF	North Sea Basin Task Force
PCIs	Projects of Common Interest
TCEP	Texas Clean Energy Project
TVU	Tees Valley Unlimited



1 A CCS future for Europe: framing the options

THE science is unequivocal and the conclusion clear: the continued unabated use of fossil fuels is no longer an option if the world is to avoid "severe, pervasive and irreversible"[1] damage from the impact of climate change.

Governments worldwide have woken up to the fact that the venting of billions of tonnes of carbon dioxide (CO_2) every year by the power and industry sectors is unsustainable, but they are yet to commit to the best means of tackling this. Compounding the problem is the likelihood that fossil fuels will remain part of energy systems for decades yet.

The European Union currently emits around 10% of global CO_2 emissions[2]. Its 2030 framework for climate and energy policies unveiled in autumn 2014 set a binding target of cutting carbon emissions by at least 40% by 2030 – a laudable and necessary step but one unlikely to succeed unless CCS technology is brought swiftly and efficiently into play.

With this in mind, in October 2014 SCCS gathered a wealth of international CCS expertise to help frame the actions that will establish a European CCS industry that capitalises on a unique set of assets offered by the North Sea region.

The SCCS 2014 Conference featured two sessions: a programme of plenary talks to provide background and inspiration, followed by three themed discussion groups. The following section provides an overview of the plenary session.

[1] *IPCC Synthesis Report*, Fifth Assessment Report, IPCC, 2014
[2] http://ec.europa.eu/clima/policies/g-gas/index_en.htm

Creating a North Sea resource

THE EU at one time led the way on CCS development with an ambitious programme, unveiled in 2009, to accelerate the deployment of large-scale projects. The programme has been badly hit by the economic crisis and collapse of the EU emissions trading cheme (EU ETS), and has failed to secure the envisaged investments by Member States and industry alike. North America has since taken the lead on CCS, with one full-chain power project already operating (see panel *Boundary Dam: Canada's game changer* on page 18) and others in the pipeline; China looks set to follow suit. So how can Europe regain its original momentum? Our first group of speakers laid out the options.

Prof Stuart Haszeldine, SCCS Director, described the critical role of the North Sea in realising the opportunities of CCS in Europe. He welcomed the renewal of the NER400 mechanism to support CCS in the EU's 2030 council conclusions, and highlighted the importance of PCIs[1] to developing CO_2 transport networks. These, he said, could be a "game-changer" that could facilitate the CO_2 transport networks needed to provide Member States with access to abundant North Sea storage. For North Sea nations with high-carbon industrial economies, such as the UK, Germany, the Netherlands and Poland, CCS can provide an effective route to achieving substantial emissions reduction while maintaining industrial output and high-value jobs.

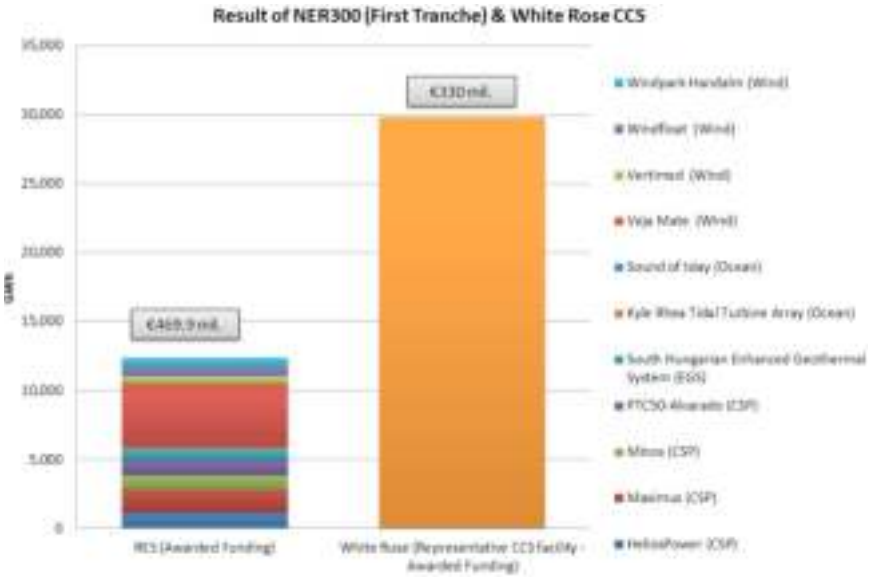


Figure 2: *Bellona analysis suggests that 11 RES projects will generate 12,000 GWh for EU investment of €479 million, while the White Rose CCS Project will deliver 35,000 GWh for €330m investment. Additional subsidies from Member States are, of course, required for both. Source: Jonas Helseth, Bellona*

The UK North Sea alone, Haszeldine said, could handle decades worth of current EU power and industry carbon emissions, with storage assets of around 60–80 billion tonnes already identified[2][3]. Likewise, Norway has identified a further 70 billion tonnes of potential storage[4]. With around 40–50 million tonnes of storage needed for each large-scale project, and with well-characterised CO_2 storage options available as a result of decades of oil sector activity, this is a huge opportunity for the first and follow-on schemes that will establish a CCS industry in the North Sea basin. Anchor projects, such as Peterhead in the north east of Scotland and White Rose in Yorkshire will be crucial for building the infrastructure and enabling access to millions of tonnes of storage for multiple users. With project financing being a significant issue, the use of CO_2 in EOR operations could offer a market-led driver for CCS. Governments should also consider fresh ideas, such as extraction obligations, whereby fossil fuel producers meet the cost of storing carbon or face a financial penalty. In order to create a properly integrated and stable energy system, Haszeldine reiterated the need for "level playing field" funding for CCS alongside renewable energies, through finance mechanisms such as the UK's pioneering Contracts for Difference (CfDs) scheme[5].

[1] http://ec.europa.eu/energy/infrastructure/pci/pci_en.htm
[2] *Opportunities for CO_2 Storage around Scotland*, SCCS/Scottish Government, 2009
[3] *A Picture of CO_2 Storage in the UK – learnings from ETI's UKSAP and derived projects*, ETI, 2013
[4] http://www.npd.no/en/Topics/Storage-and-use-of-CO_2/
[5] https://www.gov.uk/government/publications/electricity-market-reform-contracts-for-difference

Jonas Helseth of environmental NGO Bellona also welcomed the inclusion of CCS in the EU's 2030 vision and underlined the urgency of the task facing governments. By 2050 and beyond, the world will witness rising population number with attendant increases in energy consumption and CO_2 emissions. He urged policy makers not to "pick and choose" technologies but to accept the need for mixed, flexible energy systems. Interestingly, a comparison of projects supported by the NER300 programme suggests that just one CCS project may potentially deliver more than twice the combined total low-carbon electricity output of 11 renewables projects (*Figure 2*). CCS could provide concentrated contributions of low-carbon dispatchable electricity to complement the deployment of renewables.

Helseth also reiterated Bellona's support for bio-energy with CCS (BECCS) and recommended its adoption as a pathway to negative carbon emissions. Indeed, Bellona sees it as vital to meeting emissions targets. He outlined the arguments against BECCS, including the use of unsustainable biofuels and the perceptions of negative emissions as "science fiction". The introduction of appropriate sustainability criteria and incentives for negative emissions within the EU ETS would counter the environmental objections, he proposed.

"Overall, the European Commission believes that CCS is an essential part of the EU's future low carbon electricity system. It encourages Member States with high-carbon sectors to support CCS development actions."

Ilinca Balan

Against criticisms that CCS is science fiction, Helseth argued that BECCS is actually the "low-hanging fruit of CCS" with essentially pure CO_2 streams, as with the Archer Daniels Midland bioethanol plant in Illinois, USA. However, with no current support mechanisms, and no societal case for bio-CCS being made by the CCS community, there will continue to be a backlash from environmental NGOs.

While advocates have argued for greater emphasis on CCS within Europe's energy strategy, its explicit inclusion in the 2030 package is significant. It was encouraging to hear of the continued support for CCS by European Commission leaders, and Ilinca Balan of the Directorate General for Energy outlined several key priorities. Action on securing support for the ROAD and Don Valley projects – initiatives supported by the EEPR[1], which have been treading water for some time – was particularly welcomed. Despite ongoing criticism, the EU ETS remains the preferred long-term instrument to drive decarbonisation. However, further analysis is under way on intermediate support measures. Alongside this, it is considered crucial that the renewed NER scheme continues to support CCS.

International bodies, such as the IPCC, continue to call for greater strides on industrial CCS, particularly as it remains the only cost-effective way for industries to decarbonise while remaining competitive in a global marketplace. The Commission recognises this, said Balan, and believes CCS should form part of the EU's industrial strategy. There is also awareness that an adequate CO_2 transport and storage network must be developed, and that PCIs offer a way to facilitate this. The Commission is keen to work with North Sea Basin Task Force members, demonstration projects and other parties to take this further.

Echoing Jonas Helseth's earlier point, Balan also underscored the role of CCS in providing flexible and secure power while renewables continue to increase their role in the electricity system. In the coming years, any continued use of domestic coal resources will require the use of CCS if carbon targets are to be met.

Jude Kirton-Darling MEP focused on the importance of tying industrial policy to the necessary transition towards a low-carbon economy while maintaining and creating jobs in Europe. She said that her own constituency in the north

[1]European Energy Programme for Recovery, *http://ec.europa.eu/energy/eepr/*

east of England has a particularly strong interest in CCS "for three interlocking reasons: industrial, geographic and, most importantly, social interests that see CCS as part of our future". Its proximity to offshore North Sea oil and gas networks is also significant. However, Kirton-Darling warned of current differences between Member States on the role of CCS, which makes it challenging to reach consensus on an EU-wide strategy. Drawing on her background as leader of European metalworkers and at the forefront of trade union efforts on climate change, she also highlighted the need for the EU to create a business model that enables proactive investment in CCS as part of a broader industrial strategy to retain jobs and skills. One of the major weaknesses of the EU ETS, she said, was the lack of incentive to invest in CCS, with governments remaining silent on how this might be stimulated.

"When the EC set out 2030 climate and energy proposals it also made recommendations on reindustrialising Europe – with heavy emphasis on regional clusters and innovation policies. A concerted attempt to join these two objectives is a key way to build regional clusters, grassroots support and industrial-public sector cooperation for CCS."

Jude Kirton-Darling MEP

The current review of the EU's CCS Directive is an opportunity to identify options for supporting industrial CCS, such as rewards for industries that take the next big step towards clean production, said Kirton-Darling. With the North Sea as an obvious centre of activity and cooperation there must also be support for similar regional initiatives across the EU. She urged engagement across sectors and between regions to rebuild political support for CCS, so that it is properly integrated into the EU's 2030 framework "as part of a resource-efficient and high-employment economy".

With CCS policy under such scrutiny in Europe, could any light be shed by North America's experience? Kurt Waltzer, from the Clean Air Task Force, explored the role of regulations alongside market conditions in creating a "virtuous" rather than "vicious" circle for CCS. He began by pointing to the need for CCS to work for China, India and other countries as well as Europe and North America. A useful historic parallel, he said, was the regulation of sulphur dioxide emissions in the USA, which required the widespread deployment of scrubbing technologies and resulted in costs being halved.

"CCS offers a once-in-a-lifetime opportunity to future-proof clean thermal baseload capacity, to increase our security of supply, and to reduce emissions ... [and] to create an entirely new strand of our energy sector in Scotland and use the marvellous engineering and academic expertise we have in this field."

Fergus Ewing MSP

Under the Clean Air Act, the US Environmental Protection Agency is now proposing CO_2 emissions performance standards (EPS) for both new and existing stationary pollution sources, which is already helping drive progress on CCS. The regulations will require coal power to meet the same emission levels as natural gas, which effectively means CCS is required – crucially, said Waltzer, this rule was based on the fact that the technology was already considered feasible due to four decades of CO_2-EOR operations and 4000 miles of CO_2 pipelines. With seven-year review periods, the use of the Act will help to keep moving CCS deployment forward. The regulations also provide the foundation for challenging permits for power plants that might fail to meet the EPS. Referring to the role of CO_2-EOR in storing carbon, Waltzer concluded that it was an "opportunity missed" for oil to be produced by methods that did not make use of and store anthropogenic CO_2.

THE LONG PLAY: CLUSTERED CCS PROJECTS

Eric Redman of Summit Power believes an integrated system of clustered CO_2 capture projects, which share CO_2 pipeline and offshore infrastructure en route to ample North Sea storage, will provide a cost-effective route to low-carbon power for the UK, with strong economic and employment benefits. Furthermore, a North Sea CO_2-EOR sector would boost the net storage of CO_2 captured at onshore CCS clusters.

Summit's proposals for Grangemouth in Scotland, part of the "long play" to realise the potential of CCS, include the development of a 570 MW IGCC power plant at Grangemouth, coordinating with the Peterhead CCS Project and sharing the Goldeneye storage site. An existing onshore gas pipeline, Feeder 10, could carry the CO_2 captured at this plant. A second phase, including a second IGCC power plant alongside the development of industrial CCS, is also being proposed. This phase could also be served by Feeder 10, with some additional boosting, allowing up to 10 Mt per year[1] of CO_2 captured from power and industry projects in Scotland's Central Belt[2] to be transported to North Sea storage.

Crucially, these proposals will rely on financial support via the UK electricity market's CfD scheme, investment in oilfields suitable for CO_2-EOR and the negotiation of tax provisions, similar to those in the USA, that support such operations.

Summit Power is the developer of the Texas Clean Energy Project in the USA and the Caledonia Clean Energy Project at Grangemouth in Scotland[3].

[1] *Scotland and the Central North Sea: CCS Hub Study*, Element Energy, Amec, Dundas Consultants and SCCS, 2014
[2] According to SCCS analysis, 14 of Scotland's top 20 emitters are located within 40km of the Feeder 10 pipeline, providing a route to offshore North Sea storage sites: http://www.sccs.org.uk/events/all-energy-2014
[3] http://www.summitpower.com/projects/carbon-capture

From opportunity to delivery: policy options to support CCS

THERE is little doubt that the building blocks of a CCS industry for Europe exist, so how can Member State governments and EU policy makers create a supportive framework that will lock these firmly in place?

Energy Minister, Fergus Ewing MSP, reaffirmed the Scottish Government's wholehearted support for CCS and its importance in reducing emissions while driving sustainable economic growth. He also stressed its role in helping industry's efforts to decarbonise while they seek to remain competitive in a challenging global market. Hydrocarbons would remain a central element of the energy mix for many years but the "enormous and practical benefit of CCS", Ewing said, was how it could complement renewables, balancing out the intermittency of wind power by enabling coal and gas power plants to operate with low emissions.

Ewing welcomed the start-up of the Boundary Dam CCS Project in Canada as a stepping stone bringing "new momentum and vigour" on CCS progress. Highlighting the UK Department of Energy and Climate Change's support for the Peterhead and White Rose CCS demonstration projects, he urged further backing for follow-on projects, such as Summit Power's proposals at Grangemouth, which are ready to proceed if support from the CfD scheme is secured and an investment deal offered by China is agreed. Two projects alone, he said, could not build a CCS industry in the UK.

Ewing welcomed moves by both industry and academia to explore the potential for CO_2-EOR in the North Sea but warned that a steady, guaranteed supply of EOR opportunities would be needed to unlock investment alongside an efficient CO_2 transport network. One potential champion could be the new Oil and Gas Authority, proposed by the Wood Review, which will require operators to harness innovation through collaboration to maximise oil and gas recovery from the UK Continental Shelf.

Dr Harsh Pershad of Element Energy focused on findings from the recent Central North Sea joint study commissioned by Scottish Enterprise[1]. These make a strong economic case for Scotland leading CCS development in Europe given its offshore geography, infrastructure and the potential for CO_2-EOR. Even without changes to the tax regime, the report found CO_2-EOR could provide revenue for the UK Treasury to offset the costs of CO_2 emission reductions while also benefiting oil companies and supply chains. Yet despite such clear benefits, progress on CO_2-EOR in the UK has been limited. The study considered scenarios for efficient CO_2-EOR infrastructure, specifically the role

Figure 3: *A preliminary assessment of strengths and weaknesses of bundles of measures for CO_2 transport and storage options, undertaken as part of the 2014 CCS Hub Study. Source: Element Energy 2014*

[1] *Scotland and the Central North Sea: CCS Hub Study*, Element Energy, Amec, Dundas Consultants and SCCS, 2014

of hubs that would allow the swift reuse of existing infrastructure – such as the Feeder 10 pipeline and various offshore structures – and reduce the risk of "stranded assets". While CO_2-EOR projects will bring challenges, Pershad pointed out that this is true for all major oil and gas projects. However, as with other investment options, he asked, how might operators be tempted to consider CO_2-EOR?

Currently, CO_2-EOR is excluded from tax allowances because of concerns over electricity consumers subsidising oil companies, so other incentivising methods need to be considered. By pursuing the "aggressive" CO_2-EOR scenarios outlined in the study, Pershad said, this could unlock hundreds of millions of pounds in pre-tax economics between 2025 and 2050 with relatively low numbers of new wells and pipelines required compared to current activity. He then presented a number of "packages" for developing CO_2 transport and storage infrastructure, with the study's conclusion that regional monopolies, either regulated private or public–private joint ventures, were the preferred options (*Figure 3*).

POLICY AND PRACTICE: IMPROVING OIL RECOVERY AND ENABLING CCS

As seen in North America, carbon capture utilisation and storage (CCUS) has provided a financial case for CCS, with the potential to accelerate large capture projects and establish CO_2 transport networks. Dr Andrew Cavanagh of Statoil drew attention to the considerable amount of natural gas recycling (*Figure 4*) that has taken place in North Sea fields over many years: in fact, more than the amount of CO_2 injected in the USA for CO_2-EOR. The oil industry could potentially switch from reinjecting natural gas to using anthropogenic CO_2 if a reliable source was available. But is this affordable and could the same formula work for Europe?

In Europe, the cost of polluting is currently low compared to the cost of deploying CCS and, while the carbon price as a potential driver might be expected to increase, it may take decades to arrive at the right incentive based on carbon price alone. However, Cavanagh challenged the perception that carbon price is a function of time. It is, he said, rather a product of market maturity and regional factors, such as energy security.

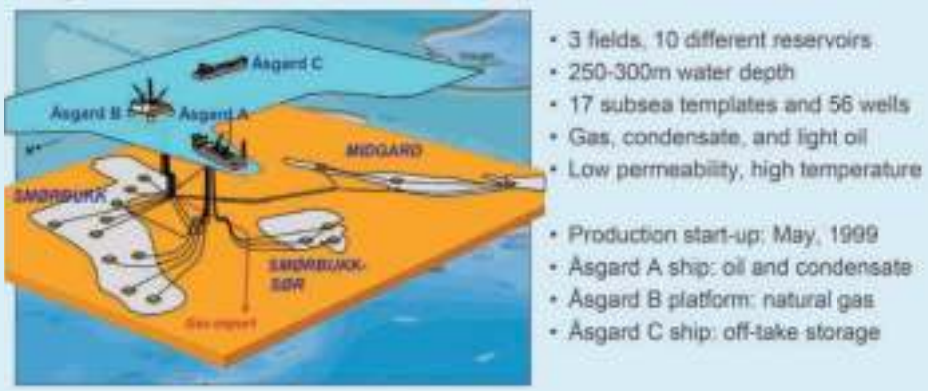


Figure 4: *The volume of natural gas injection in the North Sea currently exceeds CO_2 for EOR in North America. For example, a decade of natural gas injection at the Norwegian Åsgard development would be equivalent to around 80Mt of CO_2, recovering an additional 430 million barrels of oil equivalent (mmboe). This is comparable to the Weyburn field in Canada, which has recovered 120 mmboe for 22Mt of CO_2 over a decade. Source: Statoil*

Using the Weyburn EOR project as an example and hypothesising the conversion of the Åsgard field to CO_2-EOR, Cavanagh showed that as much as US$5 of revenue could be returned for every US$1 spent on CO_2, with the additional bonus of lower carbon oil (CO_2 emissions halved)[1]. The North Sea has a number of potential CO_2-EOR opportunities but capital expenditure remains high. With the right policy drivers and regulations to support CO_2-EOR, Cavanagh concluded, the development of CO_2 capture clusters and storage hubs in Europe would almost certainly be accelerated.

[1] These calculations assume an oil price of US$70/barrel, a CO_2 price of US$70/tonne, a carbon price of US$35/tonne and 350kg of CO_2/barrel of oil.

A critical part of the CCS equation has always been the pursuit of adequate investment to build an industry of sufficient impact. Allan Baker, of Société Générale[1], tackled this thorny issue head-on by asking: can European CCS ever be investable, and is it now or never? He believes the commercial challenges for CCS are currently more significant that the technical challenges. Most of the European demonstration projects that remain in preparation have relied on public subsidy. The challenge, Baker said, is to find ways to make these projects commercially viable and, on that score, prospects have improved in the last three years. However, in keeping with a palpable sense of urgency at the conference, he agreed that CCS must soon show itself to be a worthy recipient of investment.

Developing a new sector is always a risk for financial institutions and other investors, and there are challenges for the banking system in financing CCS. These include a lack of precedent for CCS in order to inform the risk allocation ("banks don't like first of a kind, even if CCS technology already exists"), a perceived lack of confidence created by project cancellations, and uncertainties over policy support and technology. The view is also decidedly different in North America, where CO_2 is viewed as a commodity rather than a liability.

Baker drew a useful comparison with the offshore wind industry, where there has been good support, subsidies and targets from governments. At first, the offshore wind industry struggled on for ten years with very little support. It then took a further five years to realise the first financed project. With real CCS projects starting up – such as Boundary Dam, Kemper County and others – CCS finance has now moved from "difficult" to "potentially interesting".

Building clusters to catalyse CCS deployment

GEOGRAPHIC groupings of CO_2 emitters, including power generation and industrial facilities, provide an opportunity to share planning and infrastructure and therefore reduce the cost of delivering projects. This common-sense approach is evident in the Netherlands, with the Rotterdam CCUS Network and ROAD CCS Project, and Tees Valley Unlimited's proposals for an industrial CCS network in the north east of England. Both projects illustrate not just the challenges involved in realising such initiatives but also the opportunities for tapping into shared transport infrastructure and North Sea storage.

Rotterdam, the Netherlands

Filip Neele of TNO outlined North Sea synergies for Rotterdam, where the authorities are keen to create a "greener" industrial port with a significantly lower carbon footprint. There are a large number of offshore gas fields, including depleted fields, available for CO_2 storage within 400 kilmetres of the port, and there is an existing onshore pipeline infrastructure enabling the reuse of 0.4 Mt per year of CO_2 in greenhouses since 2006.

Various studies have been undertaken to define North Sea storage options and analyse different scenarios. For example, 80Mt of offshore storage has been identified close to Rotterdam, with a further 200Mt potentially available 110km away. One such study[2] has demonstrated a very good case for sharing infrastructure, with costs reducing as the amount of CO_2 transported and stored increases (*Figure 5*).

"There is a good case for collaboration between industries to build clusters. Results [from 2012 analysis] show a decrease in storage and transport tariffs as more projects cooperate, and more and more CO_2 is captured and transported."

Filip Neele

[1]Société Générale is currently advising the UK's White Rose CCS Project and the Teesside Industrial CCS Project
[2]http://decarboni.se/sites/default/files/publications/101121/transport-storage-economics-ccs-networks-netherlands.pdf

Neele agreed that early-phase CCS would benefit from CO_2-EOR, combining captured CO_2 from early clusters and using operations to build significant and dependable storage of around 5 Mt per year. As well as pipeline infrastructure, shipping could be used to gather and carry CO_2 from capture sources to offshore storage sites and for use in EOR operations. With limited incentives at present for industry to engage in CCS, the project developers will be looking at CO_2 utilisation as a driver, including sectors such as carbonate mineralisation, polymer processing, water treatment and urea fertiliser production.

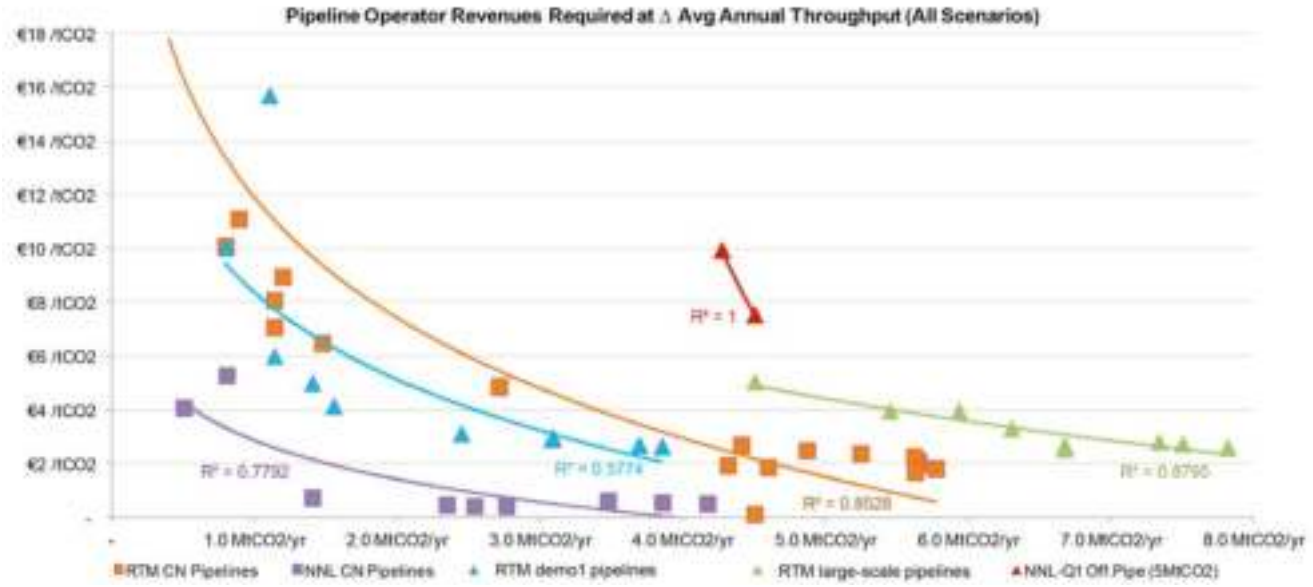


Figure 5: *A study of the transport and storage economics of CCS in the Netherlands shows transport tariffs reducing as the amount of CO_2 being transported increases. Source: Transport and storage economics of CCS networks in the Netherlands: analysis of CCS business cases in the Netherlands (Phase 1), CATO report CATO2-WP2.4-D05, Loeve D, Neele F, Hendriks C and Koornneef J, 2013*

BOUNDARY DAM: CANADA'S GAME CHANGER

Mike Monea, President of Carbon Capture and Storage Initiatives at SaskPower, addressed SCCS Conference delegates in a video message.

"The [Boundary Dam] project might be small in global scale but very big for the CCS community. There's nothing like building a [capture] plant, there's nothing like having real data, and it's all here. So even though it's the world's first and probably the world's most expensive, we want to show you how to build the next one 30% cheaper."

Tees Valley, UK

Teesside is one of the UK's most important economic regions and one of four key export regions. As Sarah Tennison of Tees Valley Unlimited explained, CCS is viewed as a key component of future plans for the region. The area hosts around 34 industries, which currently emit 12 Mt per year of CO_2 (*Figure 6*). With its proximity to the east coast, the Tees Valley Unlimited initiative would be able to access storage options in the Central North Sea, such as the Goldeneye reservoir, with pipeline corridors connecting industry to shared CO_2 transport and storage infrastructure. The project has attracted significant interest beyond Teesside as an example of industry and local government working together to advance the development of a CCS industrial cluster.

"[In Teesside] we've around 34 major emitters producing 12 million tonnes a year of CO_2 and rising, due to increases in investment. We see CCS as one of the really important technologies, which will help industry move into the future."

Sarah Tennison

However, Tennison raised some salient issues. One key difference between industrial CCS and power CCS is the need to maintain international market competitiveness. With limited options for increasing product prices, industry will struggle to meet the cost of CCS without some form of financial support. Other factors, such as carbon leakage, also enter the equation as an unexpected side effect of the EU ETS. Proactive investments in CO_2 transport and storage will be key to enabling industrial emitters to deploy CCS.

Figure 6: *The proposals for Tees Valley consider several CO_2 capture points, including SSI's steel blast furnace (3–5 Mt per year) and Growhow's fertiliser plant (0.6 Mt per year). Source: Tees Valley Unlimited*

2 The building blocks of a North Sea network

Having explored the opportunities that exist in the North Sea region for developing a long-term, affordable and accessible CCS industry for Europe, conference delegates took part in three themed focus groups (as below). Discussions fed into the development of three sets of recommendations, which are described in the following chapters.

FOCUS GROUP

Incentivising CCS to 2030+: policy options and financial mechanisms for CCS in Europe

THE EU currently has a handful of CCS demonstration projects that are negotiating financial support from Member State governments, EU CCS demonstration programmes and the financial markets. Securing successful investment in these projects is an immediate priority, but to realise their full potential the business case for follow-on projects urgently needs to be created. This session explored how a lack of interest and investment in these follow-on projects might be resolved.

Starting with a discussion of current EU policies in light of October's 2030 council conclusions – and with perspectives from Andrew Green of Energy Technologies Institute (see *A value proposition* on page 22) and Dr Hannah Chalmers, University of Edinburgh – delegates explored how these and other innovative measures could best be applied to generate investment in CCS in the power, industrial and upstream sectors.

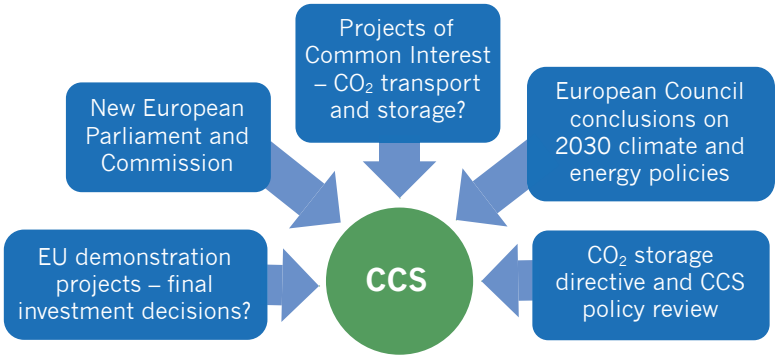


Figure 7: *Mechanisms for success? Delegates in the Incentivising CCS to 2030+ focus group were asked to debate the policy options and financial mechanisms that the European Commission and Member States could support and utilise*

CCS in low-carbon electricity markets

The EU-ETS has proven inadequate to secure investment in CCS projects. There is a pressing need to create a financial support mechanism to incentivise CCS in power generation by rewarding low-carbon electricity output. To date, only the UK has proposed a CCS-targeted reward in the form of the CfDs feed-in tariff. Dr Hannah Chalmers provided a perspective on designing incentives for CCS electricity generation, highlighting some of the issues to consider. These include: the choice of definitions for low-carbon electricity; how EPS policies, capacity markets, feed-in tariffs and carbon prices interact; and the implications of creating a "level playing field" among technologies.

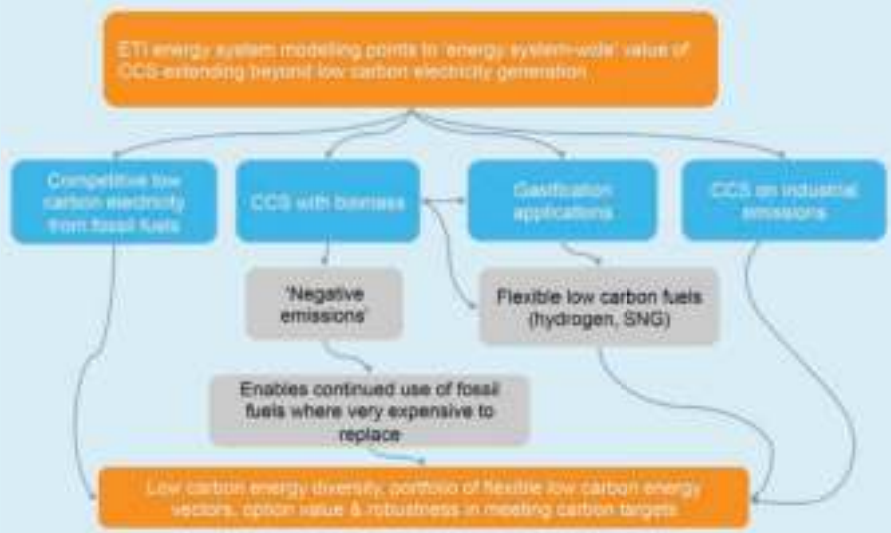
Delegate discussions highlighted the following:

- The UK CfD is a "crucial test case that the world is watching". The value of the CfD in passing finance down-chain to develop transport and storage for additional projects must be emphasised.
- Electricity markets are being forced to change so there is value in examining how measures, such as EPS or "clean" capacity markets, that reward negative emissions could enable innovative entries to the market.
- A level playing field should not mean the same price for all electricity – different generation types have different values that must be recognised, and power plants with CCS will be able to provide both significant capacity and flexible output in support of renewables, and would therefore have a high value for overall security of supply.
- An effective incentive model for CCS on power generation as part of a credible climate policy could attract significant investment from the financial sector as CCS projects will provide long-term value.

A VALUE PROPOSITION

Andrew Green, of ETI, provided a perspective on a recent study of CCS infrastructure scenarios. He explained to the focus group the reasons why CCS is a high-value climate change mitigation technology. He then outlined how CCS is unique in enabling: the explicit decarbonisation of emissions from thermal power generation, retaining security and flexibility in the energy mix; the preservation of vital industrial and manufacturing processes; and developments that realise the potential for negative emissions, whereby CO_2 can be removed from the atmosphere. The timely deployment of CCS, he said, is essential to attaining a climate-secure future.

Andrew Green
Energy Technologies Institute



CCS in industrial sectors

Industrial emitters currently have no business case for considering CCS. The EU-ETS is insufficient to provide incentive, and free allocations of EU allowances to sectors at risk of carbon leakage simply facilitate inaction. However, the value in securing a low-carbon and climate-proof future for industry, its economic output and its workforce is huge. Delegates discussed opportunities and measures for industrial CCS, including:

- The need to secure government finance for technology demonstration projects – for example, could a specified industrial category be part of the NER400 mechanism?
- The need to explore sectorial agreements on decarbonisation rather than waiting for a "one-size-fits-all" carbon price.
- Growing pressure from some end-users of industrial chemicals to reduce their lifecycle emissions: this could provide useful policy focus.
- The need for financial flows between end-market product and the CCS process to be direct and visible to secure investment, rather than made up of multiple incremental payments through each part of a supply chain.
- Strategic pre-investment in CO_2 transport and storage to reduce risks and costs, and allow industrial "low-hanging fruit" emissions to be gathered; for example, in the USA, where CO_2-EOR pipeline networks are providing "plug-in" options to industrial emitters.
- The capture of industrial emissions being managed to provide a stable supply for CO_2-EOR, which augments CO_2 from the power sector.

CCS in the upstream sector

The oil and gas sector is a crucial player in delivering CCS given its expertise in sub-surface operations, pipelines and CO_2 injection. Both CO_2 storage and CO_2-EOR in the North Sea represent significant opportunities for the industry, but they need a specific focus. Delegates discussed the following points:

- Decommissioning timetables and costs need to be examined from the perspective of CO_2 storage and CO_2-EOR. Incentives to delay decommissioning of valuable offshore assets should be examined.
- Aggregating sufficient CO_2 (at least 3–5 Mt per year for 10–20 years) to enable EOR is best achieved through using early CCS projects to seed clusters. Clusters of sources can also address issues of securing stable CO_2 supply.
- Funding for transport and storage could be obtained from a hypothecated percentage of tax receipts from new licences.
- The Commission should examine how a certificate model – requiring storage of a percentage of CO_2 by fossil fuel producers – might operate.

EU 2030 CLIMATE AND ENERGY PACKAGE

In October 2014, the European Council agreed EU climate and energy targets and measures for the period 2021 to 2030[1]. Those of relevance to CCS include:

- At least a 40% reduction in EU domestic greenhouse gas emissions by 2030 relative to 1990 levels, with reductions in sectors both under and outwith the EU-ETS
- Reform of the EU-ETS, including: creation of a market stability fund; strengthening of the annual reduction factor from 1.74% to 2.2% per annum from 2021; continuation of free allocations for sectors at risk of carbon leakage; creation of a reserve to finance energy system modernisation in low-income Member States; and renewal of the NER financing programme to support technology innovation, with the inclusion of CCS and industry
- An enhanced role for PCIs in achieving energy security
- Recognition that energy security can be increased by having recourse to indigenous resources as well as safe and sustainable low-carbon technologies

This first mention of CCS by the European Council since 2008 was welcomed by delegates. Depending on the success of EU-ETS reform, NER400 could deliver greater value than the previous scheme. However, it was noted that CCS remained framed in the "technology development and demonstration" space, with no inclusion in EU technology targets or deployment strategies.

[1]2030 framework for climate and energy policies, European Commission, 2014

Recommendations

The value of CCS cannot be underestimated: no other technology provides such significant decarbonisation options for power (secure, on-demand, concentrated, negative emissions) and industry (enables a climate-proof future). The immediate priority is to secure final investment decisions on current demonstration project proposals in the North Sea region. With sufficient support, they could rapidly secure the linking-in of additional projects. Without this, Europe will again lose momentum and struggle to realise CCS deployment in the timescale required.

Europe's ambition, particularly in the North Sea nations, should be to accelerate the first CCS clusters in the mid-2020s to deliver economies of scale; to increase the potential for CO_2-EOR to deliver returns on investment and augment domestic energy resources; and, crucially, to secure industry engagement in lasting deployment efforts.

The following recommendations, as part of an EU CCS deployment strategy, are made to the European Commission as a means of helping to deliver Europe's low-carbon ambitions:

Recommendation 1: Ensure rapid delivery of renewed NER400 programme

Ensure that the renewed NER400 programme is initiated as soon as possible to support power generation and industrial projects, and is able to support operational as well as capital expenditure.

Recommendation 2: Support creation of CO_2 transport and storage infrastructure through PCIs

Support the creation of CO_2 transport and storage infrastructure, through PCIs, both before and after 2020, with specific focus on facilitating the development of clusters around the first demonstration projects.

Recommendation 3: Undertake analysis of different incentive mechanisms for CCS

Undertake analysis of different incentive mechanisms for CCS, such as feed-in tariffs, EPS, industrial sector-wide decarbonisation agreements and CO_2 storage certificates, to provide advice and support for Member States as they develop CCS financing policies.

"The existing NER300 facility will be renewed, including for CCS and renewables, with the scope extended to low-carbon innovation in industrial sectors… endowment increased to 400 million allowances… projects in all Member States, including small-scale, will be eligible."

European Council 2030 climate and energy conclusions

FOCUS GROUP

Destination North Sea: from industrial clusters to full-chain networks

THE clustering of CO_2 emitters within a geographical area provides an unparalleled opportunity to share the cost of CCS development and infrastructure, and a shared route to North Sea storage. There have been several studies of CCS for emission clusters, as well as analyses of CO_2 transport networks and North Sea storage, and there are a handful of European projects seeking to develop the cluster approach. This focus group considered the learning from these studies and how it might encourage other CCS clusters to develop, with progress on demonstration projects leading towards the general deployment of industrial CCS (ICCS) to 2030 and beyond.

ICCS CHAMPIONS WILL DRIVE PROGRESS

Our discussions set out to define some of the activities, challenges and objectives needed to move towards deployment of CCS in industrial areas. We worked under the assumption that an effective financial incentive mechanism will be available to fund CCS in the near future, allowing us to focus on practical steps.

Andrew Purvis
Global CCS Institute

Although we were thinking principally about actions for ICCS clusters and related transport and storage infrastructure, most of the ideas generated are applicable to CCS in general since clusters will likely be a mixture of power generation and industry. One thing is very clear: the immediacy of the issues. Most of the actions proposed need to start now; we cannot park this for five to ten years.

Three themes emerged from our discussions, the first being **technology**. There are things we can learn from existing clusters or networks in North America, such as how to deal with combining CO_2 streams from different sources and how to set acceptable network specifications for captured CO_2. However, in these areas we need to ensure that technology choices take account of regional differences and do not preclude future development. We also need to understand the opportunities and limitations of reusing existing infrastructure.

The second theme was **creating acceptance**, and it was agreed that good communications and leadership are essential to making progress. We need to engage broad support in industrial areas through local government, development agencies, trade unions, green groups and others – and identify ICCS champions from industry to drive progress. Fundamentally, we also need to be able to show the social benefits of ICCS and create a groundswell of public support.

We also need to look at managing the risk profile for ICCS and the governance of cluster networks, so **distribution of income and risk** was our third theme. Income and risks in the CCS chain need to be managed with transparency. Commodity risks and the risk of future industrial closures need to be understood and managed. How would transport price regimes be structured to avoid possible punitive charges for later entries to a network? What would be the role of the aggregator and what body would be best suited to that role? Would it be a strong regulator within the private sector, or would a public utility be best? These are questions that urgently need answers.

Recommendations

Recommendation 4: Devise a clear pricing mechanism for CO_2 transport and storage

A mechanism is needed that controls pricing of, and access to, transport and storage infrastructure so that emitters and investors have a clear view of costs.

This mechanism might feature charging structures for CO_2 transport and storage infrastructure, including for third-party use, and a clear framework for negotiating third-party access. It would also need to manage the effect on costs of changes in capacity utilisation. In addition, there should be a system for trading capacity in transport and storage infrastructure. Visible commodity price forecasts, including carbon price risks, are also recommended.

Industry needs to see that a transparent and fair pricing mechanism – one that can adapt to changing demand for capacity as new partners adopt CCS or as industrial rationalisation occurs – will exist. Investors need visibility of risks and confidence that they are managed appropriately. A well-designed financial mechanism for transport and storage will allow early adopters of ICCS, such as lower-cost capture from concentrated CO_2 sources, to establish demonstration projects, thereby hastening wider uptake (*Figure 8*).

Proposals have been made for transport and storage infrastructure pricing mechanisms, which could apply in the UK and other Member States[1]. Further development of financial mechanisms is expected from the Teesside Industrial CCS Project. The EU should consider adopting proposals from the UK to achieve rapid agreement of a pricing mechanism for the region.

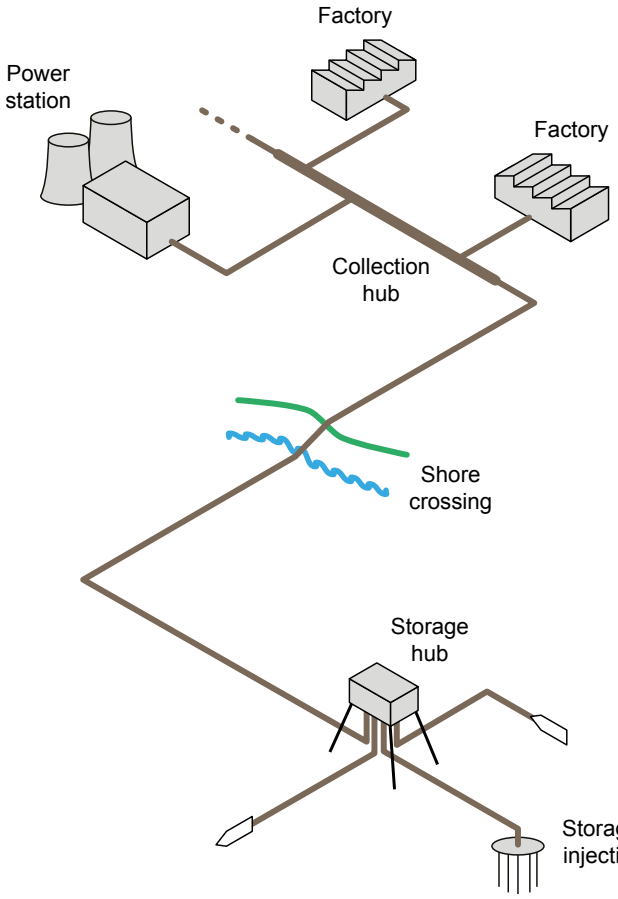


Figure 8: *An envisaged CO_2 transport network, offering an example of where a charging mechanism would apply. Source: SCCS graphic based on schematic, Hughes, 2013[1]*

TECHNICAL CONSIDERATIONS:

- Adopt existing knowledge and practice from the USA on specifications for CO_2 input to common infrastructure, taking account of local issues such as different impurities from a mix of industries
- Ensure existing assets that may be re-used for CO_2, such as existing pipelines, are maintained and their capability is promoted
- Use existing transport corridors, as far as possible, when planning new pipelines

[1] *Capacity Charging Mechanism for Shared CO_2 Transportation and Storage Infrastructure*, Hughes, 2013

Recommendation 5: Develop a CO_2-EOR plan for the North Sea

A North Sea framework plan of potential demand for CO_2-EOR is needed, promoting development of new markets and allowing optimal development of transport networks.

This framework should cover location, capacity and timing of potential CO_2-EOR demand and its compilation could be an activity for the UK's new regulator, the Oil and Gas Authority. Similar activity would also be required in other North Sea states with EOR potential, and these plans should be coordinated across the North Sea basin.

The publication of such a framework plan will give visibility of CO_2 demand to emission clusters considering CCS development, allowing transport networks to be developed in a coordinated fashion. It will also act as an incentive to increase oil company engagement by showing the potential to delay decommissioning costs and gain additional revenue from EOR. This will attract financial investment to fund infrastructure at the cluster and network levels.

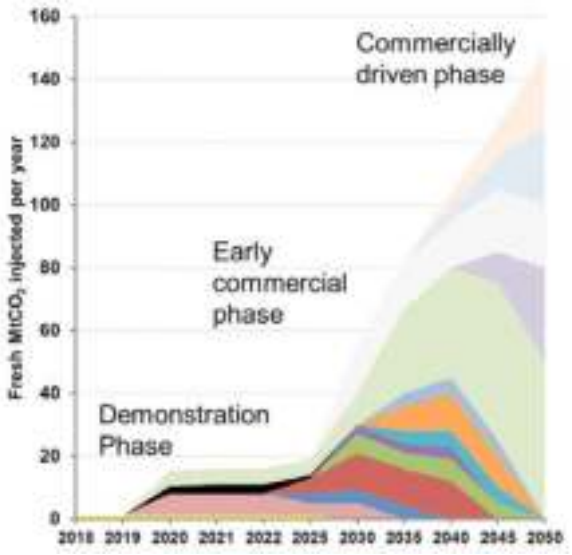


Figure 9: *The coloured areas indicate CO_2 demand for both EOR and storage by different fields in one aggressive CCS with CO_2-EOR scenario. Source: Element Energy, 2014*

Recommendation 6: Create a CCS cluster plan for Europe

A European vision statement should be created by the Commission setting out how CO_2 emissions will be reduced using CCS clusters.

This vision should acknowledge issues of global competitiveness and proposals for how these will be addressed. It should also refer to CCS cluster models already developed, for example, for Le Havre and Rotterdam, and to proposals under development for Teesside.

As part of an EU CCS strategy, the Commission should set out a clear expectation that Member States will prioritise development of CCS through capture at emission clusters with associated CO_2 transport and storage networks. The explicit inclusion of this CCS cluster approach in national climate and energy plans would support achievement of CO_2 emission reduction targets as required by the EU 2030 framework. Specific funds should be made available for identifing and developing appropriate clusters and projects (*Figure 10*).

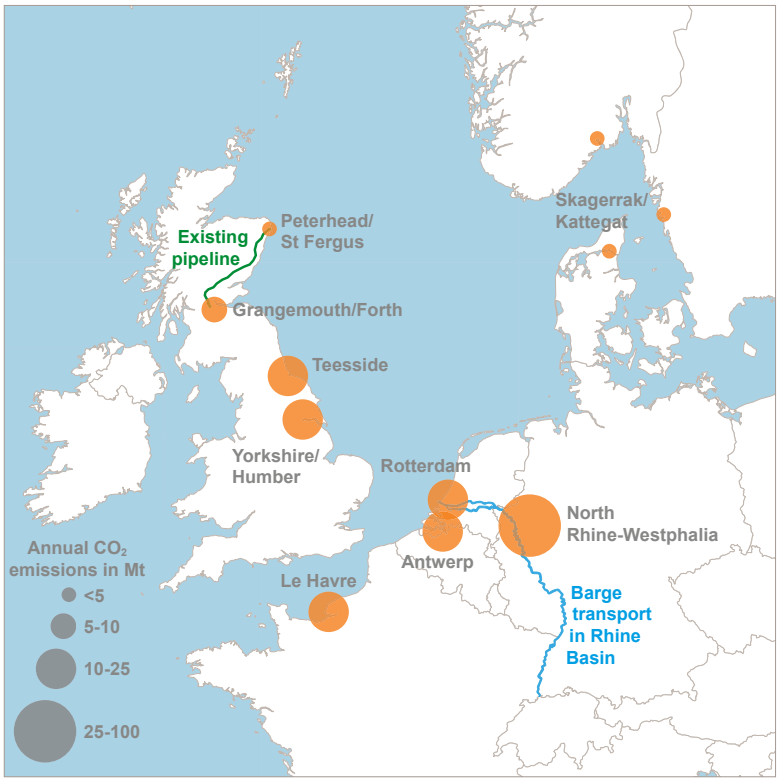


Figure 10: *Existing studies of CCS clusters around the North Sea. Source: SCCS*

Recommendation 7: Provide specific funding support for developing local carbon capture clusters

Specific funds should be made available from European and/or Member State governments to initiate and support formation of regional forums to lead CCS cluster developments.

Following models such as that developing at Teesside, such forums would bring together emitting industries and infrastructure providers at a local level to develop region-specific CCS plans. They would enable engagement with a wide and diverse community, including the public, making the link between CCS and continued regional employment. Industry champions should be identified to provide leadership and credibility to plans. The forums should display the benefits of proposals in terms of society, environment, employment and value, while fostering public acceptance and building confidence in CCS.

The establishment and support of regional groups to develop and promote plans for industrial CCS clusters will be fundamental to realising ambitions for achieving emission reductions, but this will only be effective in parallel with other actions, such as those recommended above and the development of a suitable model to provide financial incentive.

“The establishment and support of regional groups to develop and promote plans for industrial CCS clusters will be fundamental to realising ambitions for achieving emission reductions.”

FOCUS GROUP

R&D catalysts: linking academic focus with industry vision

THE CCS sector is fortunate to have the strong involvement of industry and other stakeholders, who work with academia through the auspices of a number of bodies: in the UK through the Advanced Power Generation Technology Forum (APGTF), the Carbon Capture & Storage Association (CCSA), the UK CCS Research Centre (UKCCSRC) and SCCS; and in Europe enabled by, for example, the Global CCS Institute (GCCSI), the IEA Greenhouse Gas R&D Programme (IEAGHG) and the Zero Emissions Platform (ZEP). These stakeholders seek to realise commercial-scale CCS, so how do we ensure that R&D programmes target the needs of those developing large-scale projects now and in the future?

VIEW FROM INDUSTRY

Dr Bryony Livesey
Costain

This workshop helped me clarify in my own mind some of the issues around how to prioritise R&D for CCS. Many of the participants appeared not to have thought about this before, which reminded me that we all tend to think whatever we are working on ourselves must be a priority. This does not mean there is no value in "blue sky" thinking: of course, that must continue, but we also need to make sure that the overriding priority of delivering commercial-scale CCS is achieved.

At this crucial time for CCS, we need to understand what is needed to ensure the success of the first projects, and what will then drive down costs for the next ones. I believe that industry and academia can work together more closely to build on the important work of the APGTF in establishing priorities. One of the many useful outputs from the workshop was a recognition that both industrial and academic input could be improved through focused discussion on key topics, and by taking more account of what is coming out of international programmes.

VIEW FROM THE R&D COMMUNITY

Jonathan Pearce
British Geological Survey

Our discussion focused on the mechanisms for identifying research priorities, rather than attempting to identify the priorities themselves. It was recognised that a researcher-led process for identifying issues can often lead to long wishlists, rather than necessarily addressing the priorities that industry and other stakeholders might want. So the challenge we posed was to identify what processes might ensure that academia's role in anticipating research needs can also meet the needs of the nascent CCS industry.

In addition, approaches to enabling industry to come together to form a more holistic view of research priorities were also discussed. There have been a number of "bottom-up" exercises to identify research priorities at UK and European levels. However, in some cases, the results have lacked clarity on what is needed to meet short-term industry priorities and a longer-term research focus to address future issues. I see one of the roles of academia as being to anticipate future challenges and propose research that will address these in a timely manner, within the current context of taking the first steps towards demonstration and subsequent wider deployment.

There are already several reports and analyses[1] that identify, for example, the R&D steps needed to underpin early-phase CCS projects in the UK. This focus group discussed how CCS stakeholders should navigate this complex environment of R&D priorities, and what mechanisms could enable strategic prioritisation of R&D to support CCS commercialisation. An assumption was made that policy drivers and/or market forces will create an incentive for CCS in the first place.

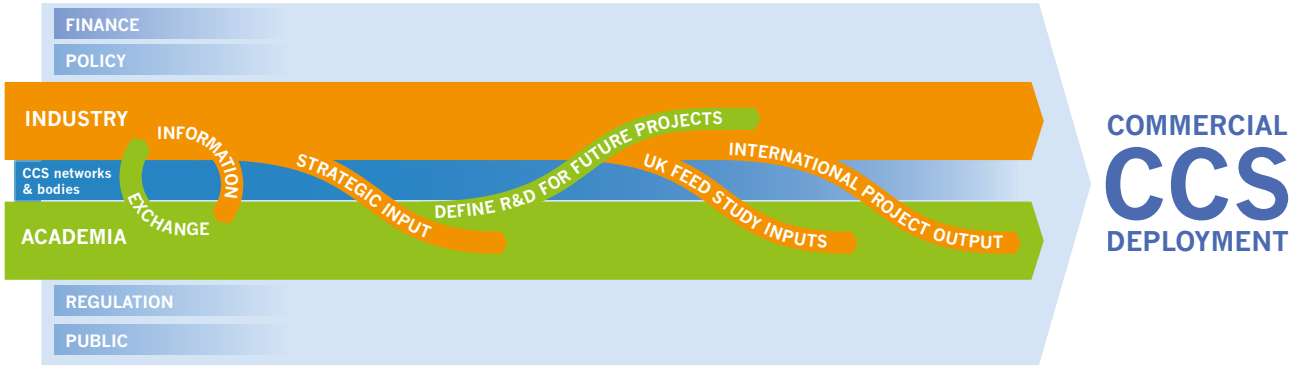


Figure 11: *Linking academic focus with industry vision: exchanging information to enable prioritisation of R&D. Source: SCCS*

[1] *Cleaner Fossil Power Generation in the 21st Century – Moving Forward*, APGTF, 2014; *The Potential for Reducing the Costs of CCS in the UK*, UK CCS Cost Reduction Task Force, 2013; *CCS Cost Reduction Taskforce Final Report*, 2013; *European Strategic Energy Technology Plan*; *RAPID Handbook*, UKCCSRC, 2012

Recommendations

Recommendation 8: Research community to take lead on defining future R&D needs with strategic industry input

Findings from front-end engineering and design (FEED) studies for the UK's Peterhead and White Rose CCS projects will be published too late to guide the prioritisation of research that needs to start now for follow-on CCS projects and longer-term delivery. The academic community would be unable to initiate new research to deliver outputs within 10 to 15 years. As it is keen to provide industry with the solutions it needs, in a timely and useful way, it is proposed that academia lead on defining R&D that will be essential within longer timescales but with ongoing "sanity checks" through CCSA and APGTF. At the same time, industry should clearly communicate its technical needs and the associated timescales.

A research plan will require iterative updating and review, being informed by industry needs as they emerge and taking into account learning from large demonstration projects, both international and in the UK. There should also be consultations with other stakeholders including policy makers, regulators and the public. There are clear differences between near-market issues and longer-term research priorities that are likely to be identified as experience in CCS grows. The identification of future research needs and priorities must therefore anticipate the needs of second generation CCS projects, and should be done without delay.

Recommendation 9: R&D priorities to be steered by industry needs as demonstration projects proceed

Research priorities and future focus will emerge from publicly funded large-scale CCS demonstration projects, both UK and international. The timely sharing of information between industry and academia during the front-end engineering and design process, through improved multi-way knowledge exchange mechanisms (see Recommendation 10), would lead to a more strategic approach to R&D, which would, as a result, be better informed by industry needs.

Conversely, there is a need for the research community to feed back their thoughts on R&D prioritisation to industry at appropriate intervals, and various techniques should be investigated to encourage this, using groups and networks such as SCCS to capture information from researchers through, for example, interactive workshops. This approach would also aid potential funders as they negotiate a complex R&D landscape in order to identify key research needs and priorities.

Recommendation 10: Existing CCS networks and bodies to have a key role in developing mechanisms for information exchange between industry and academia

Industry and academia must collaborate to achieve the shared objective of commercialising CCS for both power and industry sectors. Research priorities need to be based on learning from pilot and demonstration projects, and must also recognise the differences between R&D needs for individual projects and the global deployment of CCS. Novel and effective communication mechanisms will enable this exchange of information, with CCS networks and groups providing neutral supportive forums.

The sharing of commercially sensitive information is a challenge that industry continues to face. Nevertheless, industry has a key role in delivering significant technical data and learning. Both industry-driven bodies and CCS networks[1] can provide "anonymised" routes for the exchange of data between industry and academia.

[1] There are key communication roles to be played by industry-driven bodies, such as APGTF and CCSA in the UK and GCCSI and ZEP in Europe. Academic groupings such as SCCS (in the UK) and the European Energy Research Alliance (in Europe) can also provide forums for defining and prioritising research.

Conclusions

THERE have been welcome signals from the European Union in recent months with regard to CCS in future climate and energy plans. There is a renewed commitment to support the technology's development as part of the EU's 2030 framework. The European Commission has acknowledged that CCS must form part of any industrial strategy. And there is now an awareness of the need to provide adequate CO_2 transport and storage networks, using PCIs as one potential pathway. These encouraging signs must now be translated into actions.

Last year's SCCS conference recommended the development of targeted policy and financial options aimed at creating a credible business case for CCS investment and unlocking the significant storage assets of the North Sea. One year on, Europe continues to play catch-up while large-scale projects elsewhere in the world begin operating or near completion.

The UK and Norway have identified CO_2 storage assets in the North Sea of around 130–150 billion tonnes; enough to store decades' worth of carbon emissions from Europe's power generation and industry sectors. After decades of oil and gas production in the North Sea, and several storage studies, these assets are now ready to provide Member States with a safe and secure destination for their CO_2 emissions. Yet, despite a mood of optimism at this year's conference, speakers pointed to the need for swift progress on first, second and subsequent waves of commercial-scale projects if CCS is to realise its potential.

Securing investment for Europe's remaining demonstration projects, including ROAD, Caledonia Clean Energy Project (CCEP) and Don Valley, is an obvious priority. But there must also be planning for the next phase. So it was refreshing to hear Summit Power's follow-on plans for CCEP while it awaits a decision from the UK government on CfDs in order to progress with its investment plans. The CCS sector needs to address investors' reluctance to back first-of-a-kind projects and allay concerns over risk. Only by undertaking multiple projects can issues of uncertainty, risk and cost be addressed and a case for future investable projects made.

Capital investment costs will be reduced through knowledge-sharing and learning from publicly funded projects, which will also steer the prioritisation of essential research and development. Other routes to cost reduction for the establishment of a European CCS network include the reuse of existing infrastructure and the clustering of industrial emitters to enable shared CO_2 transport and storage infrastructure. The USA experience suggests that a strong case can also be made for properly investigating how CO_2-EOR might accelerate the development of CO_2 capture clusters and storage hubs in Europe. Such developments should be supported by fair and transparent pricing mechanisms for CO_2 transport and storage, and could build on existing cluster models.

In conclusion, CCS has the potential to deliver low-carbon energy for Europe while fostering energy security and European industry's market competitiveness. Indeed, a failure to incorporate CCS as part of the transition to a low-carbon economy will result in a doubling of costs. CCS is an essential part of an integrated energy system, alongside renewable energies, and even has the potential for negative emissions when combined with energy from biomass. To realise this ambition, CCS requires coherent and supportive policies at European level, which promote its deployment within individual Member States.

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Our researchers are engaged in high-level CCS research as well as joint projects with industry, with the aim of supporting the development and commercialisation of CCS in the UK and abroad.

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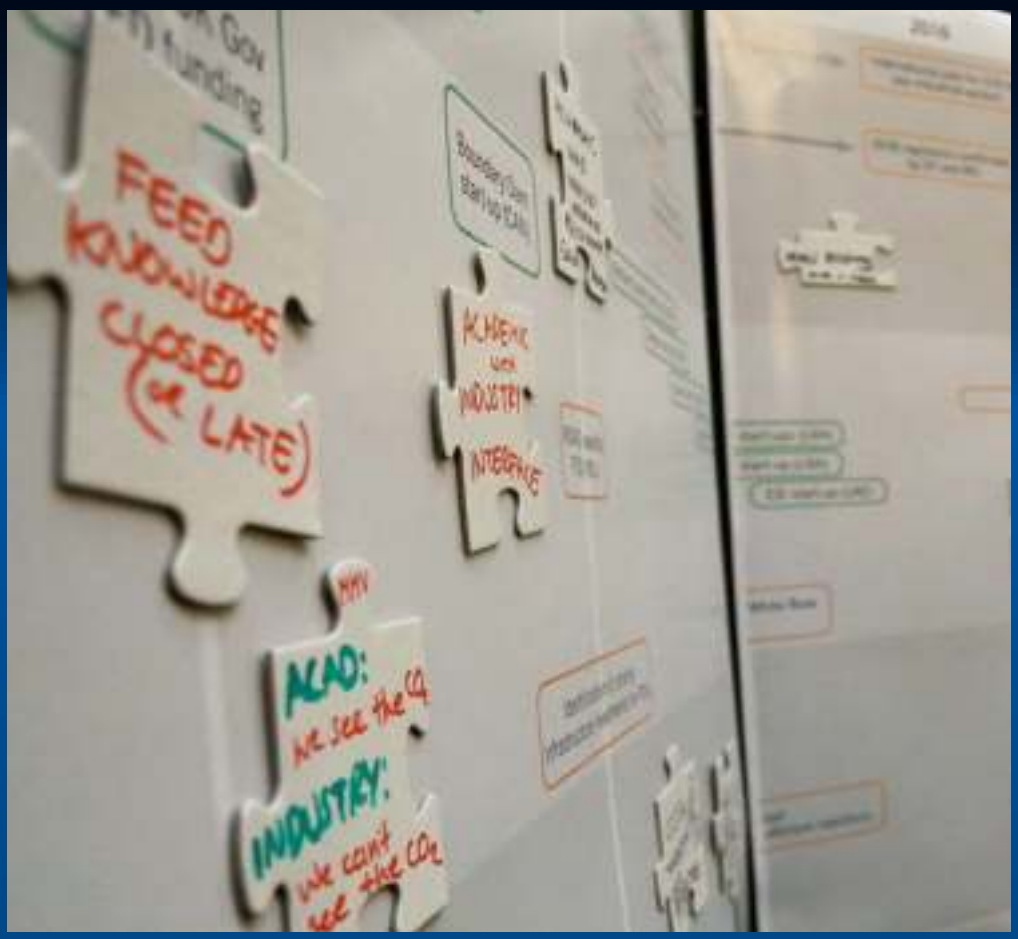

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