Support to the review of Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive)

Final deliverable under Contract No 340201/2014/679421/SER/CLIMA.C1

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Glossary

BECCS (also BioCCS) – Biomass Energy with CCS

CA – Competent Authority

CCS – Carbon Capture and Storage

CCSA – Carbon Capture and Storage Association

CCR – Carbon Capture Readiness

CDU – Carbon Dioxide Utilisation

CO_2 – Carbon Dioxide

DG CLIMA – Directorate General for Climate Action

DG ENER - Directorate General for Energy

DG ENV - Directorate General for the Environment

DG RTD - Directorate General for Research and Innovation

DG ENTR - Directorate General for Enterprise and Industry

EEPR - The EU Energy Programme for Recovery

EHR – Enhanced Hydrocarbon Recovery (EOR – Enhanced Oil Recovery)

EIB – European Investment Bank

EPS – Emission Performance Standards

EUA – EU Allowance (under the EU-ETS)

EU-ETS – European Union - Emissions Trading System

FEED - Front End Engineering Design

GCCSI – Global Carbon Capture and Storage Institute

GD – Guidance Document

GS – Geological Storage

IA – Impact Assessment

IEA – International Energy Agency

IEAGHG – International Energy Agency Greenhouse Gas R+D Programme

IED – Industrial Emissions Directive

ISO – International Organisation for Standardisation

JRC – Joint Research Centre

LCPD – Large Combustion Plant Directive

MMV – Measurement, Monitoring and Verification

MS – Member State

NER300 – New Entrant Reserve 300

OGP – International Association of Oil and Gas Producers

NGO – Non Governmental Organisation

R+D – Research and Development

REFIT – Regulatory Fitness and Performance Programme

SG – Secretariat General

ToR – Terms of Reference

ZEP – Zero Emissions Platform

Contents

Key points

This project serves two main purposes. The first purpose is a backward-looking evaluation of the Carbon Capture and Storage (CCS) Directive (2009/31/EC), including the specific issues raised in the review Article (38) of this Directive. The second purpose is more forward looking and focuses upon preparing a set of recommendations for the future of the CCS Directive, and wider CCS enabling policy for the Commission to consider. The CCS Directive focuses on the health, safety and environmental risk aspects of CCS, particularly transport and storage – as these were considered the most novel regulatory aspects of CCS.

When the CCS Directive was agreed in 2009 there was a clear expectation that by now (2014/15) there would be up to 12 large scale CCS plants operating in Europe. This has not been the case and to date there are only two large scale CCS plants operating in Europe (both in Norway), and 13 operational in the world, the majority of which are associated with Enhanced Oil Recovery (EOR) operations. The consensus view on the main reason for this lack of progress is that the low price of CO_2 emissions achieved in the European Union Emissions Trading System (EU-ETS) has made the financial case for CCS unattractive for developers. This lack of progress has made it difficult to evaluate the Directive because there has been virtually no practical testing of its content – apart from one recent permit (the ROAD project in the Netherlands) and two ongoing permit applications in the UK which have complied with the initial stages of the Directive. This has meant that the evaluation has been limited, relying mainly upon stakeholder's opinions and their limited experience with the Directive, in combination with the lessons that can be learnt from projects and project preparation inside and outside Europe.

The conclusion on the evaluation of the Directive is that the overall need for CCS (and European CCS regulation) to decarbonise power production and heavy industry in Europe (in line with the 2050 emission reduction targets) remains genuine and urgent. Given the lack of practical experience it would not currently be appropriate, and could be counterproductive, to reopen the Directive for significant changes. The non-regulatory Guidance Documents (particularly Guidance Document four) would benefit from some revision now and there are a number of issues of potential concern in the Directive that should be examined in the light of greater practical experience in approximately five years' time. There are also issues which affect CCS in other Directives (particularly the EU-ETS Directive) that should be considered now.

With regard to forward-looking CCS enabling policy, the policy recommendations that were suggested and broadly supported by the CCS stakeholders consulted, are as follows:

Issues for immediate / short term attention by the European Commission

- Request Member States to develop national 2050 roadmaps, based on an 80% emission reduction target and including an assessment of whether or not CCS is required.
- Develop an EU roadmap for CCS with binding targets for 2030 and integrate CCS in the on-going 2030 national roadmaps if needed.
- Finalise the New Entrant Reserve (NER) 300 successor as soon as possible, learning lessons from the original NER 300 programme.
- Develop an EU-wide 'CO_2 storage: appraisal of CO_2 injectivity and storage capacity' document.
- Strengthen the provisions for CO_2 capture readiness.
- Investigate how to substantially strengthen the ETS to support the business case for CCS.
- Investigate the possible use of Emissions Performance Standards (EPS) under diverse scenarios and its relationship to ETS.

Recommendations for the Member States

- Develop national 2050 low carbon roadmaps – as requested by the European Commission.
- Consider capture readiness regulation for new industrial installations.
- Consider making data on existing oil and gas fields available to enhance the CCS exploration phase.

Executive summary

Purpose and structure of this report

This report presents the consultant's work in supporting the Commission in their review of the CCS Directive. The work under this contract consists of two main parts. The first part is to effectively carry out an interim evaluation of Directive 2009/31/EC on the geological storage of carbon dioxide (the Carbon Capture and Storage (CCS) Directive), including consideration of the Directive under the new Regulatory Fitness and Performance programme (REFIT)[1]. The second part of the work is more forward-looking and focuses on preparing a set of recommendations for the future of the CCS Directive, and wider CCS enabling policy for the Commission to consider. This report contains the results of the work on both parts of the contract. The work is also designed to contribute to the European Commission Review of the CCS Directive, as required by Article 38 of the Directive.

Methodology and constraints

This evaluation part of the work has been structured against a set of questions defined in the terms of reference for the work and structured under the standard EC evaluation headings (effectiveness, relevance, efficiency, coherence, EU added value, utility and sustainability). These questions have been answered via a combination of literature review and stakeholder input. Stakeholder input has been via an online survey, interviews, written submissions, two stakeholder meetings and focus groups. Whilst there was a good response from industry, academia and Nongovernmental Organisations (NGOs), the response from Member States has not been very strong, despite invitations from the consultants and DG CLIMA to participate. This may be due to separate Member State (MS) level consultations that DG CLIMA themselves have been leading in parallel with this work. Another important constraint on the study is the fact that the operational European examples of CCS were either started before the CCS Directive came into force or are below the 100kt of CO_2 stored threshold, which means they are classified as R+D projects and are exempt from the CCS Directive. The only project which has any practical experience of attempting to comply with the CCS Directive is ROAD – this project has been extensively studied for this evaluation report. These constraints have meant that stakeholder opinion, along with the limited available case study examples have been the main source of evidence for the evaluation aspect of this work. With regard to the forward-looking aspect of the work the consultancy team developed a set of potential recommendations based on stakeholder opinion and written submissions. These recommendations were developed via a combination of focus groups and a stakeholder meeting.

Context

Carbon dioxide (CO_2) is considered to be a determinant gas in heating up the atmosphere and biosphere, the evidence for which is unequivocal[2]. As a consequence of fossil fuel combustion, CO_2 is emitted to the atmosphere at ever increasing volumes. Energy savings, more efficient use of energy, and use of renewable energy sources like solar and wind are crucial components of climate mitigation policy. Yet, the use of fossil fuels in energy production and industrial processes will still be very important in this century. According to the International Energy Agency (IEA) baseline scenarios, more than half of the energy produced will still come from fossil fuels in 2050.[3] Almost all international experts[3] feel that in order to deliver deep cuts in CO_2 emissions, contribution from CCS technology will be required.

CCS technology is required in order to achieve the required profile of emission reductions (40% by 2030 and 80% or more by 2050, as per the EU 2050 Low-carbon Economy Roadmap[4]) in a cost-effective manner.[5] Member States that largely depend on fossil fuels are expected to enable

[1] This is a European Commission initiative to identify areas where action is needed to revise legislation; mainly for the sake of simplification and reducing regulatory burdens and to test if regulations are 'fit-for-purpose'. This is an extension of the standard evaluation procedures of the Commission. See: http://ec.europa.eu/smart-regulation/refit/index_en.htm

[2] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

[3] For example IEA (2010). Energy technology Perspectives – Scenarios & Strategies to 2050, 710 p.and IPCC Synthesis Report: IPCC, 2014, Climate Change 2014 - Synthesis report, http://www.ipcc.ch/

[4] EC, 2014: A policy framework for climate and energy in the period from 2020 to 2030, COM(2014) 15 final

[5] ECF (2010). Roadmap 2050 - A practical guide to a prosperous, low-carbon Europe – Technical analysis, 100 p.

commercial deployment of CCS around 2025 and to financially support CCS in the pre-commercial phase.[6]

The key challenges facing the deployment of CCS include technical, environmental, economic and financial, public perception and awareness as well as regulatory barriers. On the technical side, the energy penalty associated with the addition of CCS to power plants as well as industrial facilities is still high and work is underway world-wide to reduce the energy consumption associated with CO_2 capture.

The CCS Directive

The main objective of the EU Directive (2009/31/EC) on the geological storage of CO_2 is to regulate the safe and environmentally sound storage of captured CO_2. The Directive was adopted on 23 April 2009 and entered into force on June 25th, 2009. The Directive sets out a regulatory regime for permitting of exploration of potential CO_2 storage sites, the actual storage operations and post closure obligations. The CCS Directive focuses on the storage part of the CCS chain.[7]

The Directive gives criteria for selection and characterisation of storage sites and obtaining exploration and storage permits (application procedure, conditions, content, and the requirement for the Commission to review permits, and changes and withdrawal of permits).

The Directive also discusses operation, closure and post closure obligations including:

- CO_2 stream acceptance criteria.
- Measurement, Monitoring and verification (MMV).
- Reporting by operator.
- Inspections by authority.
- Risk assessment and measures in case of leakage.
- Regulations around final closure, liability and transfer of responsibility.
- Financial security and financial mechanisms.
- Third party access including access to network and storage sites and dispute settlements.
- Reporting by Member States to the Commission.
- Transboundary cooperation.
- Penalties.

Global progress on CCS

As of November 2014, 13 large-sale CCS projects are in operation worldwide, 2 of which are in Europe (with storage offshore Norway). Four other projects are in the planning stage in Europe, the most advanced is the ROAD project in the Netherlands. Three projects in the UK, Peterhead, White Rose and Don Valley, have advanced into front end engineering design (FEED). The earliest start date of these planned projects is 2017. The number of large-scale storage projects is expanding in North America, with most of them being connected with Enhanced Oil Recovery (EOR) operations such as Boundary Dam. The Lake Charles CCS Project, the NRG Energy Parish CCS Project and the Texas Clean Energy Project in the United States (US) planned a final investment decision in 2014, The Kemper County IGCC Project in Mississippi is planned to be operational in the second half of 2014. The implementation of CCS technology is also gaining momentum in China: two projects, the Yanchang Integrated Carbon Capture and Storage Demonstration Project and the Sinopec Qilu Petrochemical CCS Project, planned a final investment decision in 2014 as well. The following European countries are the most active in research and implementation of CCS technology: Norway, UK, the Netherlands, Germany, France, Italy and Spain.

[6] Ibid.

[7] The capture and transport of CO_2 are covered by Directive 2009/31/EC but under existing regulation. However, there are some provisions concerning the capture and transport phases which are intended to facilitate the integration of the different phases of the CCS chain - capture, transport, and storage. The EC stated that it is of the view that the Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment should be applied to the capture and transport of CO_2 streams.

Conclusions - Effectiveness

Effectiveness[8] considers how successful an intervention has been in achieving or progressing towards its objectives. Since Smart Regulation normally involves a hierarchy of objectives for a given intervention, analysis of effectiveness should look at changes to outputs, results and impacts as appropriate, separately identifying these elements and clearly stating how each is covered.

The number of CCS installations (referring to capture, transport and storage) achieved to date has been much less than expected when the Directive was passed. A number of projects have been proposed, with some being approved for EC support, but most of these have either stopped or are in significant difficulties. Exceptions are the UK project White Rose (supported under the New Entrant Reserve (NER) 300 programme), Don Valley (with EEPR support) and Peterhead and the Dutch ROAD project (with EEPR support). The view among stakeholders is that this lack of progress has been driven by the lack of a commercial case for CCS, largely because of the global economic downturn and low carbon prices (via the European Union Emissions Trading System (EU-ETS)). This lack of practical experience means that it is not possible to identify specific effects induced by the CCS Directive. Given that the CCS Directive is intended to regulate CCS rather than incentivise it the lack of project means it is not possible to assess progress towards objectives such as creating legal certainty and ensuring that installations are safe for the environment and human health. However, there is clear stakeholder concern that reopening the Directive now would bring a period of further uncertainty for CCS, which would not be helpful in a sector where investor confidence is already low.

There are some details of the Directive, e.g. related to the financial securities required for transferring storage sites from operators to the state and carbon capture readiness for new power generating plants where the Directive could be improved in terms of clarity. Of the issues that could be addressed via the CCS Directive it does not appear that any are of sufficient importance to justify the risks associated with reopening the Directive.

Conclusions - Relevance

Relevance looks at the relationship between the needs and problems in society and the objectives of the intervention. As such it considers how the situation has changed over time and what the current needs are.

There are some issues that have risen up the agenda since the Directive was passed, for example Biomass energy with CCS (Bio-CCS), Enhanced Hydrocarbon Recovery (EHR) and CCS in industry. However the majority of these need to be addressed via other legislation (particularly the EU-ETS) or are of insufficient importance (in terms of creating a barrier to CCS) to justify reopening the CCS Directive.

In terms of encouraging CCS and enabling multiple large scale demonstration projects (covering capture, transport and storage) it is apparent that there is much more potential and need for change in other CCS enabling policies than in the CCS Directive. This is not to suggest that the CCS Directive is not an important and useful instrument for enabling CCS, it provides a very useful framework for a common approach to the issues of CCS and therefore plays a crucial role in the development of CCS. The need for action to reduce emissions remains very high, due to their central role in climate change and the most recent analysis[9] suggests that this need is even more urgent than previously thought. If CCS is to become a reality on the scale that analysis suggests is required (and feasible) to achieve the emissions reduction targets it needs to be given a higher profile in energy and climate policy as a whole. The ETS appears to be a credible mechanism to support CCS in the long term but in the short term there is a need for additional support. This support needs to subsidise the capital costs of capture, transport and storage infrastructure and also provide support for the ongoing operating costs.

Conclusions - Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention. Typical efficiency analysis will include analysis of administrative and regulatory burden and look at aspects of simplification.

[8] Example question given in the draft updated evaluation guidelines: http://ec.europa.eu/smart-regulation/evaluation/docs/20131111_guidelines_pc_part_i_ii_clean.pdf

[9] IPCC AR 5 October 2014. http://www.ipcc.ch/

The lack of practical experience of CCS projects going through the regulatory process described by the CCS Directive (only one project – ROAD – has really been any distance through the process) makes this question particularly difficult to answer. As discussed in the methodology section Member State representatives (including competent authorities) were invited to respond to the online survey and to attend the stakeholder meetings. However, very few Member States took part with contributions only being received from the UK, France and the Netherlands. This has made the assessment of efficiency more difficult, as it has not been possible to identify data on the costs of implementation that have fallen on the Member States. The analysis indicates that the administrative costs estimated in the Impact Assessment still appear reasonable. A wider cost benefit assessment for CCS as a whole is deemed beyond the scope of this work.

Conclusions - Coherence

Coherence considers how well interventions which share common objectives work together. Depending on the scope set, it can look at coherence within the intervention; coherence within interventions of the same policy area (e.g. water policy, health and safety); within a wide area including possibly international agreements/declarations (e.g. all EU environmental activities including international treaties, all EU activities related to consumer protection).

It appears that the CCS Directive is internally coherent. As discussed under effectiveness and relevance it is important to realise that the Directive is only one part of the policy framework designed to enable CCS. There do not appear to be any significant problems relating to the CCS Directive and other interventions. There are some issues where changes to other interventions would be mutually beneficial – for example the treatment of CO_2 transport by ship and BioCCS under the EU-ETS regulation. The fact that CCS has not progressed at the expected rate is largely due to the economic downturn and the low CO_2 price. Wider energy policy, for example the support provided to renewable generation, also appears to have had a negative impact on carbon prices.

Conclusions - EU Added value

EU-added value looks for changes which it can reasonably be argued are due to EU intervention, rather than any other influences at work. In many ways, the evaluation of EU added value brings together the findings of the other criteria, presenting the arguments on causality and drawing conclusions, based on the evidence to hand, about the performance of the EU intervention.

It is not possible to be certain on what would have happened without EC level action but support for some EC level action on CCS remains strong. It is clear that for many issues the Member State's Competent Authority (CA) will need to define, agree and implement the site specific details of CCS installations. This approach appears to be the intended (and the appropriate) model for the Directive but care needs to be taken that the accompanying Guidance Documents do not become over prescriptive.

It appears that CCS regulation in other parts of the world, particularly the US and Canada, has been more heavily based on existing oil and gas regulation. This seems to have been a factor in enabling somewhat quicker realisation of projects in these countries, but other factors (mainly the existence of attractive EHR opportunities) appear to be more important. Some of the issues that cause concern with regard to the CCS Directive, e.g. the transfer of long term responsibility for storage sites are also problematical in other countries – largely because of the lack of directly comparable experience.

Conclusions - Other Questions

The remainder of the questions were described in the Terms of Reference (TOR) for this work as 'prospective questions'. Many of the these questions are looking to future options to improve the legislative framework – which could be considered to full under the heading of 'Sustainability' as they are designed to improve the relevance and effectiveness of the Directive, which should in turn enable it to have longer lasting results and impacts.

Many of these questions relate to the wider CCS enabling policy framework, as opposed to the Directive. The important conclusions here reinforce what has been concluded under the other question groups. For example the need to revise the EU-ETS to better enable ship transport of CO_2, the complexities of Emission Performance Standards (EPS) as a possible short term measure to encourage CCS, the potential benefits of a CO_2 storage 'atlas' and the need to ensure that the Guidance Documents are not over prescriptive. For those questions which are more directly relevant to the Directive the conclusions again agree with what has been said under other questions; That

there are some areas that could be slightly improved, but none appear pressing enough to justify a full reopening of the Directive.

Recommendations

Our recommendations are split into two main groups: those relating to the Directive and those relating to CCS enabling policy. The full report contains a discussion of the justification and pros and cons of each recommendation

General CCS Directive Issues

Article 38 on the Review of the Directive

- A full review of the Directive should be conducted in 2020 after a few CCS demonstration plants have been constructed and operated in Europe and after storage of CO_2 has been demonstrated. A fixed date rather than a certain volume or number of installations is suggested as a way or ensuring that a review takes place within a fixed time.
- A review of the CCS Directive is undertaken periodically afterwards (i.e. during the 2020s). Future review should still consider each of the areas listed under Article 38.
- An announcement regarding this future review is made for example in the report of the Commission due in March 2015.

Carbon Dioxide Utilisation

- Carbon Dioxide Utilisation (CDU) policy and regulatory discussions should not be mixed with CCS policy and regulatory discussions.
- Mineralisation of CO_2 is an area, which can be highlighted as a common area between CDU and CO_2 storage.

Capture related issues in the Directive

Article 33 on readiness for CO_2 retrofit criteria

- Do not open a full review process of the Directive just for Article 33. However, if there was to be a review, the following changes to Article 33 are recommended:
    a) Better clarity on what readiness for CO_2 capture retrofit should represent, as at present it is interpreted differently across Europe. Therefore a definition should be developed. The IEA Greenhouse Gas R&D Programme (IEAGHG) has produced guidance on the definition and description of CCS-readiness.
    b) The conditions should more clearly include the availability of geological storage; space, feasibility of CO_2 transport and the requirements for capture readiness.
    c) The CA is encouraged to decline applications if the plant is proven not to be 'ready for CO_2 retrofit'.
    d) Provisions need to be added to apply 'CCS-readiness' to large carbon-intensive industrial installations as well as fossil fuel power plants.
    e) Include that if a MS has the intention to allow a new installation that is not ready for CO_2 capture retrofit it should share the reasoning for doing so with the EC and the EC can comment on this before the permit is issued.

- However…. If the Directive is NOT opened for a full review, the following step-wise approach should be adopted.
- A new guidance document (Guidance Document five) on 'readiness to retrofit for CO_2 capture' should be developed. This document should address the same points as above, with the following adjustments:
    d) MSs are encouraged to see if they want to apply the same interpretation on readiness for CO_2 capture retrofit to large carbon-intensive industrial installations as well as fossil fuel power plants.
    e) Include in the guidance that if a MS has the intention to allow a new installation that is not CCS-ready it should share the reasoning for doing so with the EC and the EC can comment on this before the permit is issued.
- At the next review, the experience of applying Guidance Document (GD 5) is assessed and if evidence shows that a non-binding document is not sufficient, appropriate amendments to Article 33 are then adopted.
- In the next review of the Industrial Emissions Directive (IED), CCS readiness in general for both power production and large industrial installations is to be taken into consideration.

Article 38.3 on the need for EPS

- Discussion on EPS should be part of the future EU CCS policy rather than in the review of the Directive.

Bio-CCS

- The CCS Directive is not amended regarding Bio-CCS.
- Emphasis should be placed on studying the potential of Biomass CCS in future EU CCS-policy.
- The ETS Directive is revised to allow the rewarding of net negative emissions.

Industrial CCS

- The CCS Directive should not be amended with regard to industrial CCS.
- In a new GD 5, MSs are encouraged to see if they want to apply the same interpretation requiring readiness to retrofit for CO_2 capture, to large industrial installations.
- In the review of the IED CCS readiness in general for both power production and large industrial installations is taken into consideration.
- More policy effort to encourage industrial CCS.

Storage related issues in the Directive

Article 10 on the Commission review of storage permits. Articles 17, 18, 19 and 20 on closure and post closure obligations, transfer of responsibility, financial security and financial mechanisms

- These Articles should remain unchanged

Guidance Document Four

- Revise GD4 to ensure that it is not more restrictive than the Directive.
- Liabilities related to leakage (linked to EU-ETS) are restricted or otherwise shared between the operator and the MS.
- The handling of the liability issue should be left to the storage operator and the competent authority.
- Ensure that the revised GD 4 avoids unnecessarily alarming wording.

Enhanced Hydrocarbon Recovery (EHR)

- Do not include further reference to EHR in the Directive.

Permanence (reference to 'permanently' contained in several places in the Directive, e.g. Article 1, Article 13(g))

- No changes should be made to the terminology regarding 'permanent' in the Directive. A specific number of years should not be defined.

Recommendations for actions related to CCS enabling policy

The recommendations for actions are related to the following three policy-related themes: General governance and CCS roadmap, financial support of CCS and regulatory measures on CCS.

G**eneral Governance and CCS Roadmap**

EC to propose to MSs that they develop national 2050 low carbon roadmaps

- All MSs develop national 2050 low carbon roadmaps.
- The Commission should give guidance on this process and should propose that each Member State explicitly looks at a possible role of CCS in power and industrial sectors from 2020 onwards.
- Such roadmaps should be completed before mid-2016 in order to be able to feed in the two following steps.

Development of an EU CCS Roadmap

- Develop a European roadmap for CCS with quantified EU targets for both 2030 and 2050.
- Regional cooperation following from the MS's capture needs and storage options are actively supported by the EC.
- This CCS roadmap for Europe should be ready by the end of 2017.

CCS better incorporated in the EU 2030 Framework for Climate and Energy

- The EC propose to the MSs that they include the results of the 2050 roadmaps, including industrial abatements and including the possible role of CCS and associated targets in their 2030 plans.
- In the iterative process proposed within the 2030 Framework , the 'end goal' for MSs during the development of the plan should be to reach an 80% reduction in GHG emissions by 2050.
- The EC should develop a CCS strategy paper to clarify the role of CCS in Europe and to give guidance to the above mentioned processes.

Develop a 'dynamic storage atlas'

- Developing a project to establish an EU-wide 'CO_2 storage: appraisal of CO_2 injectivity and storage capacity' focussing on promising sites and field characterisation including injection tests. Priority should be given to promising areas which are the closest to CO_2 point sources.
- This appraisal should ideally consider the whole CCS value chain with special reference to the transport and storage infrastructure.
- Encouragement from the EC to MSs to make data available for detailed site characterisation where practicable within commercial confidentiality requirements.

Financial Support for CCS (The 'carrots')

Continue research and expand EU funding for CCS demonstration projects

- Sustained support from H2020 for CCS projects which need to be linked to actual demonstration of CCS.
- A NER 300 type of funding for demonstration projects, with a better match between required volume of the project and the available funding per project. Predictability of the actual financial contribution is important. Funding of smaller projects could also be considered.
- A better combination of funding and regulatory measures which connects short-term and long-term support of CCS deployment in a coherent way.
- Specific support for developing CCS transport infrastructure, which could include EU level capital grants (such as the EEPR or projects of common interest) and research on viable business models for CO_2 transport infrastructure.
- A more active, and progressing over time role for MSs in co-investing with the EC in demonstration projects, which could include feed-in tariffs or contracts for difference.
- Investigation of a further streamlining of the State Aid regulations for CCS deployment.
- The major existing support schemes like 'projects of common interest', regional funds and other EC supporting schemes are open to support CCS.
- More regional level action, e.g. in the North Sea region, similar to renewables and regional clusters.

Strengthen the business-case for commercial deployment of CCS

- Investigating the possibilities of strengthening the ETS system to the level that carbon prices are such that required new mitigation technology like RES and CCS become economically feasible more rapidly and that ETS gives clearer long-term price signals to investors.
- MSs investigate their long term need for CCS (see roadmaps above) and align their national contribution to CCS projects in the early phases, to be able to later meet the long-term GHG abatement requirements. Extended use of operational support, such as feed in tariffs or contracts for difference could be important drivers for the early deployment phase.
- Investigating the possibilities for the European Investment Bank (EIB) to participate in CCS projects to (partly) de-risk the commercial investments of industry.
- CCS should also be included in other future initiatives such as the proposed Jobs, Growth and Investment Package.

Regulatory Support for CCS (Including some 'sticks')

Strengthening Article 33 on retrofit for CO_2 capture

- Readiness for CO_2 capture refit should be strengthened soon, either in or outside the Directive. It should be applied on both industry and power production. It should be formulated in such a way that no new major production facilities are built that do not have a future full abatement option.

Consider EU ETS compatible emission performance standards for implementation toward 2030

- Investigating the possible use of EPS under diverse scenarios, the relation with ETS and the impact on energy security.
- Initial research could widen the scope for a range of incentives, specific support measures for industry to protect their international competitiveness and/or actions for specific CCS components, e.g. transport.

Making CCS mandatory for power and/or large industries

- Develop this policy option now, as a strong possible 'stick' for the future if other policies have not achieved sufficient CCS developments.

Summary of recommendations by recipient
These recommendations are expanded in an annexe of the main report.

Issues for immediate / short term attention by the EC - Directly Related to the CCS Directive

- Do NOT open the full review process of the Directive at this stage.
- Update Guidance Document four.
- Develop a new Guidance Document (GD5) on 'readiness to retrofit for CO_2 capture'
- Clarification of the difference between major and minor leakage in GD3.
- Confirm the appropriate amount of information required for plan approval.
- Share the information provided on the completed applications.

Issues for immediate / short term attention by the EC - Related to CCS policy

- Request member states to develop national 2050 roadmaps, based on an 80% emission reduction target and including an assessment of whether or not CCS is required.
- Develop an EU roadmap for CCS with binding targets for 2030 and integrate CCS in the on-going 2030 national roadmaps if needed.
- Finalise the NER 300 successor as soon as possible, learning lessons from NER 300.
- Develop an EU-wide 'CO_2 storage: appraisal of CO_2 injectivity and storage capacity' document.
- Strengthen readiness for CO_2 capture refit.

Issues for immediate / short term attention by the EC - Related to Wider Energy and Climate policy

- Investigate how to substantially strengthen the ETS.
- Investigate the possible use of EPS under diverse scenarios and its relationship to ETS.

Issues to be covered in a future review / reopening of the Directive - above and beyond the Article 38 requirements.

- Review Guidance Documents, including on readiness for capture retrofit.
- Clarify wording in Article 12 (CO_2 stream acceptance criteria).
- Extent of storage monitoring requirement.
- Duration of Article 18 (Commission review).
- Clarify if an Unincorporated Joint Venture can be the 'operator'.
- Review the R+D project threshold.
- Review of the scope of Article 21.

Recommendations for the Member States

- Develop national 2050 low carbon roadmaps – as requested by the EC.
- Consider capture readiness regulation for new industrial installations.
- Consider making data on existing oil and gas fields available to enhance the CCS exploration phase.

Recommended changes / issues for other Directives and policies

- Five issues for the ETS Directive; status of EHR and CO_2 storage, BioCCS, ship transport, future leakage value and CDU:
- Consider CCS readiness in the review of the Industrial Emissions Directive (IED).
- London Protocol ratification.

Conclusions
The following are the headline conclusions of the evaluation.

- The overall need for CCS (addressing climate change by decarbonising power supply) remains high. The Directive has a useful and important part to play in this.
- Progress in the uptake of CCS has been slower than predicted, but this is largely due to the global economic downturn and the Directive has had little influence on this.
- The lack of practical experience of the vast majority of the practical Articles of the Directive make detailed evaluation very difficult.
- There are some concerns with specific aspects of the CCS Directive but there is not yet enough experience with it to justify high level changes.
- Revising the Directive at this stage will create increased regulatory risk and thus cause additional delays – in a technology where investor confidence is still not well-developed.
- A revision of the Directive should only occur after more experience is gained with CCS in Europe.

Section 1 Introduction

1.1 Purpose and structure of report

This report presents the consultants work in supporting the Commission in their review of the CCS Directive. The work under this contract consists of two main parts. The first part is to effectively carry out an interim evaluation of the Carbon Capture and Storage (CCS) Directive, including consideration of the Directive under the new Regulatory Fitness and Performance programme (REFIT)[10]. The second part of the work is more forward looking and focusses upon preparing a set of recommendations for the future of the CCS Directive, and wider CCS enabling policy for the Commission to consider. This report contains the results of the work on both parts of the contract.

The evaluation has been structured against a set of questions defined in the terms of reference for this work and structured under the standard European Commission (EC) evaluation headings (effectiveness, relevance, efficiency, coherence, EU added value, utility and sustainability). These questions have been answered via a combination of literature review and stakeholder input. Stakeholder input has been via an online survey, interviews, written submissions, two stakeholder meetings and focus groups.

This report has been structured using the evaluation headings with the information and opinions for each method presented under each individual question. This enables readers to quickly see all the information collected on each question.

The report concludes with detailed recommendations relating to the CCS Directive and wider CCS enabling policy.

1.2 Scope of the evaluation

The terms of reference for this study contain the following description of scope.

“The evaluation shall provide the Commission with the necessary background information and analysis so that it will be supported to carry out the review and to prepare for the next phases of the process, including where appropriate the preparation of a proposal for revision, together with the accompanying Impact Assessment, or, where appropriate, preparation of guidance documents.

The main purpose of this service request is therefore:

a) To evaluate the CCS Directive 2009/31/EC. The evaluation shall address, both the specific questions laid down in Articles 38(2), and 38(3), as well as other relevant provisions of the CCS Directive. The evaluation shall also cover, where relevant, the links to other legislative instruments which are part of the enabling policy framework for CCS, such as the ETS Directive;

b) To compile, assess and present information on the Directive implementation in relation to the state of introduction of the CCS technology in Europe, in order to provide stakeholders and the Commission with the necessary background information and analysis so that the Commission will be supported to carry out the review in line with Article 38(2) of the CCS Directive, and followed by, if applicable and justified, the revision of the Directive and/or the enabling policy framework for CCS.

The evaluation shall not only contain factual information and analysis but shall also provide suggestions of possible improvements of the current legal framework or its application by the national authorities and industry with the indication of the most relevant arguments for and against identified options.”

[10] This is an initiative of the European Commission to identify areas where action is needed to revise legislation; mainly for the sake of simplification and reducing regulatory burdens and to test if regulations are ‘fit-for-purpose’. This is an extension of the standard evaluation procedures of the Commission. See: http://ec.europa.eu/smart-regulation/refit/index_en.htm

Section 2 Background to the CCS Directive

2.1 Overview of the CCS Directive

2.1.1 Context

Carbon dioxide (CO_2) is considered to be a determinant gas in heating up the atmosphere and biosphere, the evidence for which is unequivocal[11]. As a consequence of fossil fuel combustion, CO_2 is emitted to the atmosphere at ever increasing volumes. Energy savings, more efficient use of energy, use of renewable energy sources like solar and wind are crucial components of climate mitigation policy. Yet, the use of fossil fuels in energy production and industrial processes will be very important in this century. According to IEA baseline scenarios, more than half of the energy produced will still come from fossil fuels in 2050[12]. Almost all international experts feel that to deliver deep cuts in CO_2 emissions some contribution from Carbon Capture and Storage (CCS) technology will be required.

CCS technology is required in order to achieve the required profile of emission reductions (40% by 2030 and 80% or more by 2050, as per the EU 2050 Low-carbon Economy Roadmap[13]) in a cost-effective manner[14]. Member States that largely depend on fossil fuels are expected to enable commercial deployment of CCS around 2025 and to financially support CCS in the pre-commercial phase[15]. Considering this short timescale and the 5 year or longer lead time for CCS projects, it is clear that if progress is to be made towards this target, actions for realising commercial deployment of CCS need to be taken within the next few years.

The key challenges facing the deployment of CCS include technical, environmental, economic and financial, public perception and awareness as well as regulatory barriers. On the technical side, the energy penalty associated with the addition of CCS to power plants as well as industrial facilities is still high and work is underway world-wide to reduce the energy associated with CO_2 capture. In addition, CCS is associated with high capital and operating costs, mainly due to the additional fuel which needs to be used to produce the same power output.

The lack of comprehensive climate policies that place a significant market value on avoided emissions is the single biggest challenge facing CCS deployment. Without such policies and legislation, economic drivers for CCS are simply lacking, as there is little other reason to capture and store CO_2 for power plants and the major industrial polluters (although a legal obligation could be an alternative route to CO_2 market price).

2.1.2 Objectives and coverage

The main objective of the EU Directive (2009/31/EC) on the geological storage of CO_2 Directive is to regulate the safe and environmentally sound storage of captured CO_2. The Directive was adopted on 23 April 2009 and entered into force on June 25th, 2009. The Directive sets out a regulatory regime for permitting of exploration of potential CO_2 storage sites and storage operations. The CCS Directive focuses on the storage part of the CCS chain[16].

The Directive gives criteria for selection and characterisation of storage sites and obtaining exploration permits; obtaining storage permits (application procedure, conditions, content, and the requirement for the Commission to review permits, and changes and withdrawal of permits).

The Directive also discusses operation, closure and post closure obligations including:

[11] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
[12] IEA (2010). Energy technology Perspectives – Scenarios & Strategies to 2050, 710 p.
[13] EC, 2014: A policy framework for climate and energy in the period from 2020 to 2030, COM(2014) 15 final
[14] ECF (2010). Roadmap 2050 - A practical guide to a prosperous, low-carbon Europe – Technical analysis, 100 p.
[15] Ibid.
[16] The capture and transport of CO_2 are covered by Directive 2009/31/EC but under existing regulation. However, there are some provisions concerning the capture and transport phases which are intended to facilitate the integration of the different phases of the CCS chain - capture, transport, and storage. The EC is of the view that the Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment should be applied to the capture and transport of CO_2 streams.

- CO_2 stream acceptance criteria.
- Measurement, Monitoring and verification (MMV).
- Reporting by operator.
- Inspections by authority.
- Risk assessment and measures in case of leakage.
- Regulations around final closure, liability and transfer of responsibility.
- Financial security and financial mechanisms.
- Third party access including access to network and storage sites and dispute settlements.
- Reporting by Member States to the Commission.
- Transboundary cooperation.
- Penalties.

2.1.3 State of transposition of the CCS Directive

Member States were requested to comply with the Directive by 25 June 2011 and a large majority have completed transposition. Infringement cases against Austria and Poland are ongoing because they have failed to transpose all necessary provisions of the CCS Directive. The Commission is working closely with these Member States to solve the remaining issues and to avoid having to refer the cases to the European Court. The Commission is also checking that the transposing measures – taken by the Member States – are in conformity with the CCS Directive. Any issues which emerge will be taken up with the concerned Member States (through EU-Pilot letters).

2.1.4 Intervention logic

When the original impact assessment (IA) accompanying the proposal for the CCS Directive was performed, certain assumptions were made on the economic climate and the availability of finance to support CCS technologies. However since the IA was published, the economic circumstances have been very different to expectations, which has had an important impact on the uptake of CCS technologies in Europe.

As part of the clarification of the context we have created an intervention logic for the policy as we believe it was originally intended. The intervention logic describes, at the time when the Directive was adopted, the Directive's rationale and objectives, the market failures and other problems that the Directive was designed to address, and the expected outcomes.

The key points that can be drawn from the intervention logic are:

- The central problem - to 'reconcile the need for urgent action to tackle climate change with the need to ensure security of energy supply' – still remains. It could be argued that both aspects have become more urgent.
- That the vast majority of the enabling policy for CCS is outside the direct scope of the Directive – e.g. ETS, NER300. This is not to say that the Directive is not a useful and important part of enabling CCS, but is more to emphasise that the Directive should definitely not be considered the main way in which CCS will be promoted.
- Enabling the use of coal-fired generation is explicitly mentioned as a benefit – because of the security of supply benefits (enabling the use of European coal rather than imported gas).
- The external factors have had a major influence on the results and impacts.
- The only action that has been tested to any significant extent is the promotion of 'capture readiness'

Needs - *Needs in society, problems, issues to address*

The Impact Assessment identified the central problem as being to 'reconcile the need for urgent action to tackle climate change with the need to ensure security of energy supply.'

The target for reducing CO_2 emissions in the developed world, 30% by 2020, rising to 60-80% by 2050, is technically feasible but requires all mitigation options to be harnessed – including CCS.

Fossil fuels will continue to be an important source of energy for electricity generation. Coal plays a role in ensuring a more diverse (and therefore reliable) supply of energy. New and upgraded coal-fired plant will only be acceptable if technologies to significantly reduce CO_2 emissions are developed and widely deployed. Clean coal technologies can help but are insufficient in isolation.

Objectives - *Ultimate objectives at EU level to which the regulatory activity is supposed to be contributing*

To enable the use of CCS two problems must be solved:

1. Manage the environmental, health and safety risks of the technology to ensure that captured CO_2 remains stored and isolated and therefore effective as a climate change mitigation option. The storage stage is the biggest regulatory challenge due to its novelty.
2. Address commercial barriers. Reasons why, if it was left to the market, investment in CCS may be insufficient:
   a. The benefits from developing the technology on the costs and its efficiency (learning by doing – a positive externality) are not captured by the market.
   b. The potential positive externality related to security of supply (by enabling coal to be kept within the generating mix) would not be captured.
   c. The potential positive externality related to export potential (the global market for well demonstrated CCS technology would be very large) would not be captured.
   d. The potential positive impact on achievement of global climate objectives from deployment in the EU would not be internalised.
   e. Any positive reductions in traditional air pollutants for deployment of CCS are not internalised.

Actions - *Actions undertaken (linked to operational objectives) to produce the expected results*

Establish an enabling legal framework (to help remove legal barriers) for CCS which covers the following issues:

- Permitting of geological storage sites, including risk management, site selection, operation, monitoring, reporting, verification, closure and post-closure;
- Liability for leakage from storage sites during operation and post-closure;
- Clarification of the role of CCS under EU legislation, in particular concerning waste and water, and propose appropriate amendments;
- Promoting 'capture readiness' in any new coal (and gas) fired generation.

Expected results - *Direct effect on target group; attributable short- and mid-term deliverables*

- CCS risks are recognised, monitored and regulated – in order to minimise these risks and promote public (and market) confidence.
- Access to transport and storage is regulated and enabled.
- Positive externalities are captured.

Expected impacts - Long-term effects of an intervention (change of state in the target group)

- CCS becomes standard practice
- Europe and global CO_2 emissions stabilise and then decrease.
- Europe has exemplary role in CCS deployment and benefits from export of equipment and expertise.

External factors - *Factors independent of the regulatory activity's intervention which could partly or entirely be the cause of changes (results or impacts)*

- ETS regulation and market, Fossil energy prices
- Renewable energy targets, policies, measures and subsidies
- Economic climate

A description of the key aspects of the Directive is provided in the following sections.

2.1.5 Site selection, exploration permits and storage permits

2.1.5.1 Site selection and characterisation

According to the CCS Directive, Member States that allow storage in their territory shall undertake an assessment of the storage capacity available in parts or the whole of their territory. The suitability for storage of CO_2 will be determined through characterisation and assessment of sites, to be performed in three steps: (i) data collection, (ii) building 3-D static geological earth models, and (iii) characterisation of storage dynamic behaviour.

A geological storage site should only be selected if, under the proposed conditions, no significant risk of leakage and no significant health and environmental risks exist.

2.1.5.2 Exploration permits

In a situation where a Member State determines it is necessary to undertake exploration of a site before it is declared suitable for storage, Article 5 of the Directive states that no such exploration should take place without an exploration permit. Member States should ensure that exploration permits are provided before exploration commences. Monitoring plans may be included in the exploration permits. The period for exploration should not exceed the period necessary to undertake the exploration it is granted for. However, an extension may be granted if exploration has been done according to a permit. The holder of a permit is the only party allowed to explore the potential storage area.

2.1.5.3 Storage permits

After a site is found to be suitable for storage, the Directive emphasises that such a site should not be operated without a storage permit. In the early stages of implementing the Directive, all storage permits should be made available to the Commission in order to ensure consistency amongst all EU Member States. This is thought to 'enhance public confidence'[17]. The contents of such a permit are summarised in the textbox below.

Permits should be withdrawn if leakage or irregularities are detected. The responsible authority should either issue a new permit or close the storage site. During this process, the responsible authority will be legally responsible for the site and any costs incurred should be recovered from the previous operator. Operational, closure and post-closure obligations should be defined at the certification stage. This should include monitoring and reporting requirements as well as remediation following any leakage. In addition, operators must provide financial provision to ensure that all terms of the Directive and the issued permit are adhered to.

According to Article 9 of the CCS Directive, storage permits should include the following information:

- Name and address of operator and precise location of storage site
- Requirements for storage operation and total quantity authorised
- Reservoir pressure limits and maximum injection rates and pressures
- Requirements for composition of CO_2 stream
- If necessary, further requirements for injection and storage to prevent irregularities
- Approved monitoring plan in addition to obligation to implement the plan and requirements for updating the plan
- Requirement to notify authority in case of leakage and the corrective measures plan that will be

[17] The EU CCS Directive highlights important issues related to public acceptance. It states that, in the early stages of implementing the Directive, storage permit applications should be made available to the Commission after receipt by the Member States. The Commission will issue an opinion on these initial draft permits within four months of their receipt and it is expected that this review at Community level should help to enhance public confidence in CCS. The Directive in general emphasises the need for transparency in order to enhance public confidence.

undertaken in case of leakage
- The conditions for closure
- The approved provisional post-closure plan
- Provisions on changes, review, updating and withdrawal of the storage permit
- Requirement to establish and maintain financial security.

2.2 CCS State of play

CO_2 capture and storage requires a chain of industrial processes leading to the reduction of CO_2 emissions to the atmosphere from fossil fuel combustion. The CCS chain consists of:

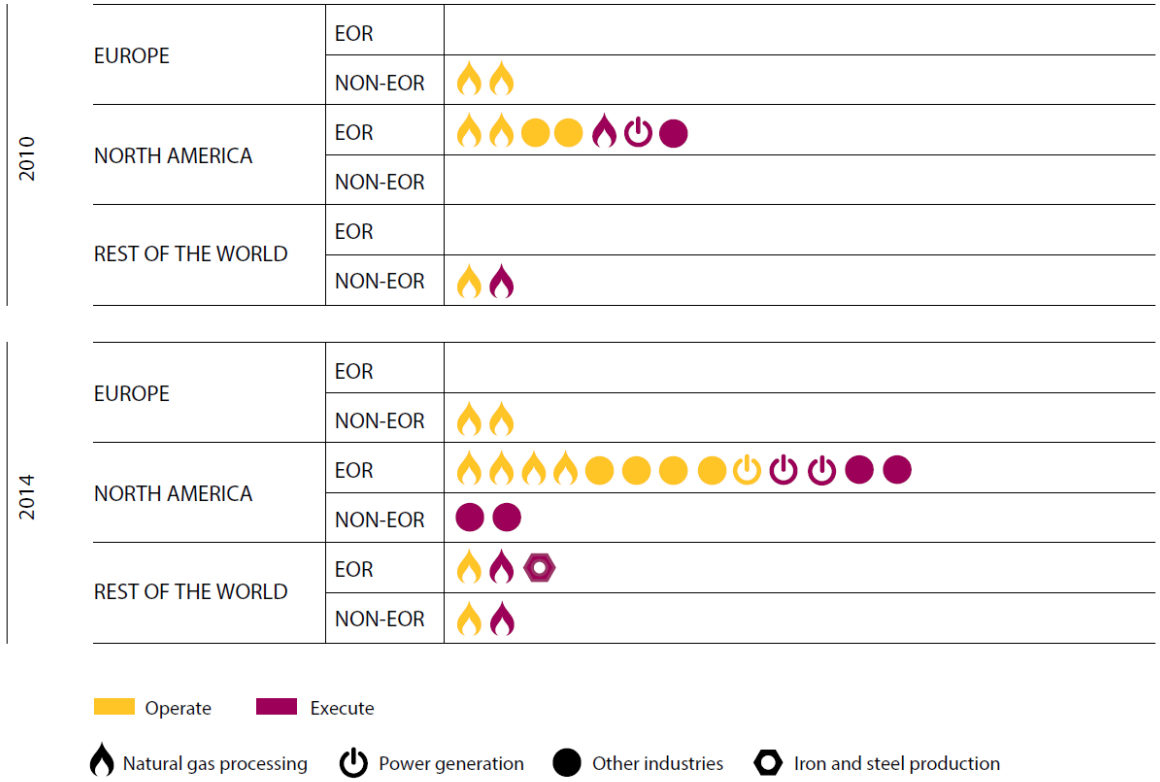
- CO_2 capture (and compression) separating CO_2 from flue gases before or after combustion or by using oxygen instead of air;
- CO_2 transport by pipeline or ship;
- CO_2 storage in the deep subsurface, either in depleted gas or oil fields or in saline aquifers. Storage may be integrated with oil or gas production activities (enhanced oil recovery (EOR) and enhanced gas recovery (EGR), respectively).

As of November 2014, 13 large-sale CCS projects are in operation worldwide, 2 of which are in Europe (with storage offshore in Norway – these were permitted before the CCS Directive came into force, although the Directive does have EEA relevance so is applicable in Norway). Four other projects are in the planning stage in Europe, the most advanced is the ROAD project in the Netherlands. Three projects in the UK, Peterhead, White Rose and Don Valley, have advanced into front end engineering design (FEED). The earliest start date of these planned projects is 2017. The number of large-scale storage projects is expanding in North America, with most of them being connected with Enhanced Oil Recovery (EOR) operations, such as Boundary Dam. The Lake Charles CCS Project, the NRG Energy Parish CCS Project and the Texas Clean Energy Project in the United States (US) may make a final investment decision in 2014, The Kemper County IGCC Project in Mississippi is expected to be operational in the second half of 2014. The implementation of CCS technology is also gaining momentum in China: two projects, the Yanchang Integrated Carbon Capture and Storage Demonstration Project and the Sinopec Qilu Petrochemical CCS Project, may arrive at a final investment decision in 2014 as well. The following European countries are the most active in research and implementation of CCS technology: Norway, UK, the Netherlands, Germany, France, Italy and Spain.

The figure below illustrates the slow rate of progress on CCS in Europe in comparison to other regions in the world. The expectation is that the global rate of progress in CCS implementation will increase from 2016 onwards[18]. Europe seems to have moved away from a leading position in CCS and is now slower than other parts of the world in their development of CCS. This might create tension with the formulated climate and energy goals for 2050 for the EU.

[18] GCCSI (2014). The global status of CCS, 24 p.

Figure 1 Overview of large CCS projects in Europe North America and the rest of the world (China, Australia, Middle East, Other Asia, South America and Africa) in 2011 and November 2014



Source: GCCSI, 2014

Further details on the state-of-play are given in the relevant evaluation sections through literature review and case studies in order to answer the specific review questions.

Section 3 Method

As described in the introduction to this report a number of methods have been used to answer the questions posed in evaluating the CCS Directive. This section describes these methods and includes a discussion of their potential weaknesses.

3.1 Literature review

The work began with a detailed review of relevant Commission, research and grey literature. The results of this review have been placed under the most relevant evaluation question.

As the work has progressed the literature review was supplemented with additional analysis, based in part on the suggestions and references received from stakeholder contributions.

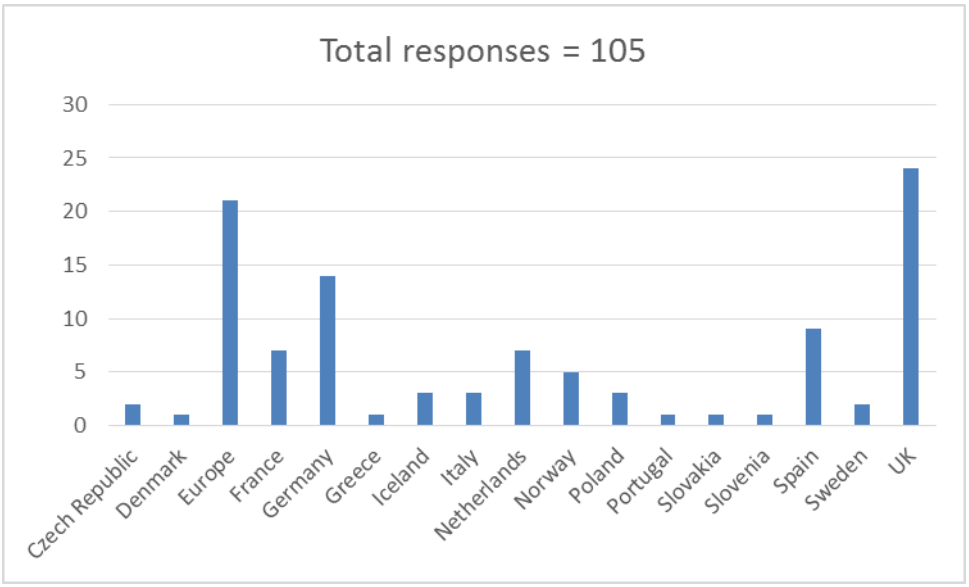
3.2 On line survey

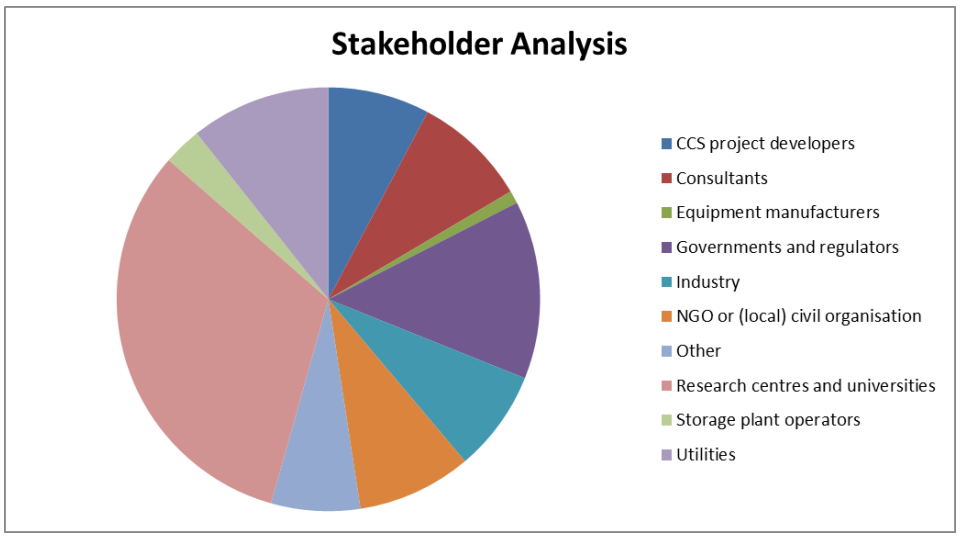
An electronic survey went online on June 16th with access via the project website. Over 300 CCS stakeholders were alerted to our work and invited to register for further information on the process and to complete the survey. The list of stakeholders was assembled from a combination of DG Clima contacts and contacts of the consultancy team.

A total of 105 submissions were received by the closing date of 29th July 2014.

The split in responses by MS and stakeholder group is shown below. As can be seen the most responses came from those MSs (and countries adjacent to the EU) that are most active in CCS, i.e. the UK, Netherlands, Norway and Spain. The large response from Germany relates to the higher profile that CCS has in that MS – partly due to public opposition to proposed projects. The large response from 'Europe' reflects the number of representative organisations that responded. Many of these responses reflected the views of multiple member organisations. The split by stakeholder type shows a broad mix of inputs, with the academic / research nature of work in CCS evident in the large response from research centres and Universities

.**Figure 1: Response to CCS Review Survey by MS and Stakeholder Type**





Annex B of this report details the comments received for each of the 58 questions, with the same summaries as used in the next sections.

The survey questions as they appear on line can be viewed and downloaded from http://www.ccs-directive-evaluation.eu/assets/Uploads/CCS-Directive-Review-Survey.pdf

3.3 Interviews and focus groups

In order to supplement the survey and to add detail and question apparent disagreements we have interviewed 27 stakeholders. The interviewees were selected in an attempt to gain a representative cross section of CCS stakeholders. The interviewees represent:

- CCS Developers and Associations (10)
- Electricity Utilities and Other Industry (4)
- Oil and Gas Companies (3)
- Environmental NGOs (5)
- Public actors (5)

The European Commission initiated a separate formal review process for the public actors. This may help explain their limited response to the consultations led by the consultancy team and hence their low representation in this report.

The interviews are intended to add detail to the survey submissions and written responses. A number of those interviewed were also involved with survey and written submissions. Therefore there is an element of repetition in the views given.

Edited text from the interview notes is presented in Annex B, split by stakeholder type, to illustrate the points. Almost 400 individual points from the interviews have been presented.

In addition to the interviews the initial ideas for recommendations were discussed and fine-tuned in four focus groups, with 8-10 people in each with representatives from a variety of stakeholder groups. The general line of the recommendations received broad support. The rich contributions during the sessions have been included in this report.

3.4 Written submissions

In addition to the questionnaire and the interviews, stakeholders were also given the opportunity to provide input to the process through written submissions. This opportunity was included to give all stakeholders maximum possibility to share their ideas on the Directive.

Inputs were received from the following 17 stakeholders: Alstom, Carbon Capture and Storage Association (CCSA), E-ON, Euracoal, Eureletric, Eurogas, European Geothermal Energy Council (EGEC), (European Power Plant Suppliers Association (EPPSA), Global CCS Institute (GCCSI), International Association of Oil and Gas Producers (OGP), Reykjavik Energy, Royal Dutch Shell Plc. , Statoil, The Crown Estate (UK), ZEP – Zero Emission Platform, Regulatory Assistance Project (RAP), NOAH Friends of the Earth Denmark (8 pages)

These contributions were very valuable for the CCS Directive evaluation, with many of the most active organisations in the European CCS world submitting their ideas. However, these are mainly (not all) inputs from industrial organisations; thus over-representing a specific group of stakeholders. This is taken into account in the analysis to prevent bias.

3.5 Case studies

In order to try and ensure that as many lessons as possible were learnt from practical experience of CCS we prepared short case studies on a number of projects from around Europe and elsewhere. The projects were selected on the basis of achieving a representative mix of locations, technologies and stages in the CCS cycle.

The case study profiles were created against a standard template, mainly by desk research (as most are well reported) but in some cases this material was supplemented by information from interviews.

The full case studies are presented in the annex to the report. Key points from the case studies are included against the relevant questions in the body of the report. The selected case studies are:

Country	Name	Description
ES	Compostilla-Hontomin	Capture and storage pilots
NL	ROAD	CCS demo project (not yet operating)
DE	Ketzin	Storage pilot
CA	QUEST	Gasification with pre-combustion capture and storage in saline aquifers
FR	Lacq pilot	CCS pilot
RO	Getica	Eastern Europe CCS demo
UK	White Rose	CCS demo project (not yet operating)
US	Air Products Steam Methane Reformer EOR project	Pre-combustion and EOR
CA	Boundary Dam	Coal fired with EOR

3.6 Stakeholder meetings

As mentioned under the on-line survey a list of over 300 stakeholders was drawn up by the consultancy team, with DG CLIMA input. All of these stakeholders were invited to register their interest via a project website. The 170 stakeholders who did so were invited to complete the on line questionnaire and were also invited to attend a stakeholder meeting in Brussels on September 8th 2014. Those who indicated they would like to attend were asked to review the draft task 2 report – which contained a summary of the views collated from the on line survey, the interviews and the written submissions.

Over 50 stakeholders attended the meeting. Following summary presentations of the opinions collected to date, were asked to comment. A summary of the meeting and a list of attendees is annexed to this report.

Those that attended the First Stakeholder meeting were given two weeks to submit any points to clarify or expand anything said in the workshop - or to raise points they felt were missed. Submissions were received from the following ten groups: Bastor 2 Project, CO2GeoNet, DNV GL, European

Environmental Bureau, Euracoal, IEA Greenhouse Gas R&D Programme, National Grid Carbon Ltd., WWF (and others), International Association of Oil & Gas Producers (OGP) and Vattenfall. The points in these submissions have been summarised and added under the written submissions sub heading for each question.

A second stakeholder meeting was held in Brussels on November 7th. This meeting focussed on the draft recommendations. The presentations given at the meeting, the attendance list and a summary of the discussions are available on the project website. Many of the suggestions made at this meeting have been incorporated into the recommendations. As with the first meeting attendees were invited to submit any points they felt would benefit from additional clarification. We received written submission from the following seven groups: the CCSA, CO2GeoNET, Eurelectric, GCCSI, OGP, National Grid Carbon Ltd. and RWE.

3.7 Approach to analysis

It is important to stress that there are two main aspects to this work. The first is a backward looking evaluation of the Directive and the second is forward looking review of the future options for supporting CCS.

As discussed in the next section the backward looking evaluation has been seriously constrained by the lack of progress in terms of CCS installations, although this appears to have very little to do with the Directive. This has meant that we have had to rely on stakeholder opinion as the main source of input, supplemented with evidence from small scale CCS pilots, the one project that has progressed through the CCS Directive (ROAD) and case studies from elsewhere in the world. This means that the evaluation conclusions are less evidenced based than is typical.

The forward looking review has also been based on stakeholder opinions in combination with recent policy views from the literature. DG CLIMA asked that the policy options should be developed with an attempt to achieve as strong a consensus as possible. This was achieved by presenting policy options based on stated positions from leading stakeholders. On many issues it was possible to achieve a position that all of the stakeholders agreed with. However this was not possible for all policy issues, particularly those with the greatest implications for the energy market as a whole.

The proposal for this evaluation contained an evaluation matrix which listed all 40 of the questions from the terms of reference and indicated which of the methods and data sources (literature review, on line survey, interviews, case studies) would be used to answer each question and what indicators could be used to evidence this.

3.8 Methodological limitations

Although Member States (and their Competent Authorities (CAs)) were invited by both the consultants and DG CLIMA to take part in the survey, interviews and stakeholder meetings only three MSs responded in any meaningful way. As stated above this may be because of separate MS level consultations that DG CLIMA themselves have been leading in parallel with our work.

With regard to the case studies it is important to stress that the operational European examples were either started before the CCS Directive came into force or are below the 100kt of CO_2 stored threshold, which means they are classified as R+D projects and are exempt from the CCS Directive. The only project which has any practical experience of attempting to comply with the CCS Directive is ROAD – this project has been extensively studied for this evaluation report. The White Rose project (also profiled) is likely to be the next project to need to comply with the CCS Directive, but this has not yet reached the stage where this is necessary.

Section 4 Evaluation answers - Effectiveness

Effectiveness considers how successful an intervention has been in achieving or progressing towards its objectives. Since Smart Regulation normally involves a hierarchy of objectives for a given intervention, analysis of effectiveness should look at changes to outputs, results and impacts as appropriate, separately identifying these elements and clearly stating how each is covered.

4.1 Q1 – Effects correspond to objectives

1. How do the effects of the Directive correspond to the objectives?

4.1.1 On line survey

QA1. The original Impact Assessment for the CCS Directive described a number of objectives for it. Do you think that these objectives are appropriate?

	Yes	No	Don't Know
Addressing safety concerns	93	8	4
Addressing environmental concerns	92	10	3
Addressing health concerns	84	11	10
Addressing public acceptance concerns	77	20	8
Helping to create harmonised procedures to ensure a common approach	81	14	9
Helping to increase the speed and scale of CCS uptake	70	20	15
Do you think there are other objectives not listed above?	35	39	25

35 respondents considered that there are relevant objectives for the Directive other than the ones listed above. 36 respondents provided comments in this regard. 13 respondents mentioned that the Directive should help to establish CCS infrastructure especially that relates to trans-boundary transportation and storage – creation of hubs for all Member States to use. The importance of the Directive creating commercial structure was mentioned 4 times. 3 respondents also highlighted that the legal framework should enable 'new technologies to be tested' and 'encourage the investigation of CCS technologies'. Liability issues were mentioned twice, one respondent noting that at present the Directive is 'very restrictive in aims to reduce all possible risks thus creating a high Level of liability for operators'.

There were some comments on defining the role of CCS in contributing to the EU's climate and energy policy objectives, with respondents noting that the Directive should 'contribute to achieving EU energy policy goals', 'enable and facilitate the storage of CO_2 for the purpose of climate mitigation' and 'specify the role of CCS in contributing to the EU's climate and energy policy objectives'. It was also mentioned, though less often, that the legal framework should address the conflict of interest with other underground use; describe common methodology/criteria for site selection; help the coal industry to transform the EU into a low carbon society; increase the speed and scale of biomass CCS; aim at CO_2 handling transparency; contribute to the development of sound and practical methods to estimate regional storage capacities and increase security of clean energy supply.

QA2. How well do you think the current Directive has performed against each of these objectives?

	Not in current scope	Negative effect	No effect	Positive effect	CCS context has changed making the objective less	Don't know

					relevant	
Addressing safety concerns	3	2	27	56	0	17
Addressing environmental concerns	2	3	27	58	0	15
Addressing health concerns	2	1	45	33	1	23
Addressing public acceptance concerns	10	8	55	14	1	17
Helping to create harmonised procedures to ensure a common approach	1	7	31	54	1	11
Helping to increase the speed and scale of CCS uptake	4	31	42	11	4	13

27 respondents provided comments to this question. 8 respondents noted that it is too early to undertake any performance analysis as no large scale projects have progressed into operation, one respondent further noting therefore that 'it would be premature to revise the text at this stage'. Further, the speed of update has been specifically mentioned and criticised by 3 respondents, one specifying that 'there is no economic incentive to build CCS'. Closely related, the liability issues were addressed by 4 respondents 'liability issues addressed in Directive prevent investment decisions in CCS', 'Companies are reluctant to accept the uncapped liability'.

One respondent noted that 'In coordination with EU research funds, the Directive has had a positive effect in encouraging R&D activities in areas such as risk assessment, monitoring, etc.' It was however also mentioned on 3 occasions that the current Directive does not take into account different injection methods and consequently different need for monitoring. One respondent commented that even though they noted a positive effect on health, safety and environmental concerns as a result of the Directive, they believe it relates more to the storage, not capture. 1 respondent further commented that the Directive 'failed to address concerns with a view to drinking water availability'. 2 respondents found that although the Directive has had a positive effect on safety concerns, more efforts are needed on this.

4.1.2 Interviews

The question put to the interviewees asked them to consider a list of objectives and ask if they considered them appropriate and in line with what they think the Directive is attempting to achieve.

Industry

- Considered the objectives appropriate.
- Effects achieved have been limited, but this is not because of the design of the Directive, but due to the lack of a commercially viable case for CCS.
- The Directive has done very little to improve this commercial case.
- What CCS development has (and is) occurring is concentrated in a small no. MSs, so it is too early to push for harmonisation and there should be a presumption in favour of flexibility (of approach between MSs).
- Some issues are missing – e.g. public acceptance, EOR, industrial process CCS, but its premature to regulate these in advance of any experience.

Environmental NGOs

- Would like to see some regulatory efforts to improve public acceptance, e.g. compensation for localities affected by storage.
- One NGO would also like to see tighter regulation of capture and transport.

4.1.3 Written submissions

NOAH Friends of the Earth Denmark contributed to the review of the CCS-directive with some fundamental objections to the concept of carbon capture and storage. Their main objections are:

The timing and the urgency - If CCS is deployed in the manner prescribed in "IEA CCS Roadmap 2009" than only roughly 10% of the CO_2 from the large point-sources in electricity generation would be stored - and not reach the atmosphere.

The climate effects - The climate efficiency of a single plant is still far from the promised 85-90%. This is mainly due to the energy penalty that comes with CCS.

The environmental effects - CCS will inevitably cause a series of effects on the environment – before, during and after the capture. The greater part of these adverse effects are inevitable results of the energy penalty of CCS. But the capture process itself also has harmful effects with the large amounts of chemicals involved.

CCS and water - Thermoelectric generation without CCS is already responsible for the largest freshwater withdrawal in the US. With CCS it would basically double for some of the technologies.

The proponents and their reports - Most reports and papers about CCS seem most occupied by the costs of different technologies as opposed to their mitigation potentials. None of them contain assessments of the mitigation potential of CCS over time.

Euracoal believes the European Commission should support CCS, and not overstate its risks, which are relatively minor.

4.1.4 Summary and conclusion

The evidence and the stakeholder views support the conclusion that the objectives are appropriate.

Looking at the intervention logic – the central problem of the needs to address climate change and to ensure security of energy supply remains in place, with increasing evidence[19] of the need to address climate change. The original IA for the Directive explicitly mentions that a clear benefit of CCS is seen as the ability it offers to use European coal as a fuel for electricity generation as opposed to imported gas – because of the security of supply benefits this brings.

The literature and stakeholder views support the conclusion that the Directive does little to help establish CCS infrastructure (other than first steps in a regulatory framework) or define its role in the EU's climate and energy policy.

The Directive has had some positive effects on addressing health and environmental concerns and harmonising procedures between MSs.

The Directive appears to have had very little (or even a slightly negative) impact in terms of public acceptance and increasing uptake of CCS. This is arguably not surprising as the Directive does not have the tools to directly do that. The Directive should have some positive impact on public acceptance but the evidence of this is only likely to become apparent when sites become operational and (if the Directive works) well regulated.

The liability issues raised in the Directive are another barrier to CCS but the assumption that it is legitimate that for storage site operators to bear some responsibility for potential harm to the environment is reasonable. It can also be concluded that, based on the weight of opinion and evidence found, that the liability issues are a much less significant barrier than the general economics of CCS. The major reasons for lack of progress in CCS installation are not related to the Directive. These reasons include the economic downturn and wider energy policy issues such as the ETS.

[19] "Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks." IPCC AR 5 October 2014. http://www.ipcc.ch/

4.2 Q2 – Progress on CCS

2. As recalled in the Consultative Communication on CCS published by the Commission in March 2013, CCS technology demonstration in Europe is not progressing at the pace as envisaged at the time of European Council of March 2007. How can we rate progress on the validation of cost and technical projections for CCS technology in Europe? (Elements of capture-transport-storage to be distinguished).

4.2.1 On line survey

QC1. How much do you think knowledge of the potential costs of the different elements of the CCS chain in Europe has developed over the last five years (since the Directive came into force)?

	Good development	Some development	Very little development	No development	Adverse development	Don't know
CO_2 Capture	26	36	19	2	1	20
CO_2 Transport	13	35	27	8	1	21
CO_2 Storage	8	50	22	6	1	18

Most people responding to this question thought that there was some development in all parts of the CCS chain.

Respondents were split between those who believed knowledge has improved as a result of FEED studies, capture pilots and other developments outside Europe and those who highlighted a lack of progress due to absence of real demonstration projects. Many respondents highlighted the fact that several FEED studies exist and that this information is freely available. Reference was also made to the IEAGHG reports, Alstom electricity study and the CCS Cost Reduction Task Force. However, some respondents emphasised that progress in knowledge has been slow due to the lack of demonstration projects. It was highlighted that most cost estimates are based on engineering designs which usually under-estimate costs.

It was highlighted that there has been some progress but mainly due to developments outside Europe. Some additional insights are as follows:

- Storage sites will be site specific.
- The costs estimates of the ROAD project did not change in the past five years (cost confidence).
- Lessons learnt from the Don Valley project indicate the need to take into account the risks resulting in cost premia for the industry; cost savings could be achieved by temporary relaxation of the criteria of the Directive and associated legislation.
- Transport and storage are mature but most progress was made on understanding capture costs through the work done by Mongstad Test Centre (TCM) and UK FEED studies
- Developments varied from one Member State to another.
- Costs for building CO_2 transport pipelines are already quite developed through knowledge gained through the USA CO2-EOR industry and building hydrocarbon pipelines.
- Advances have been made in analysing costs for shipping CO_2.

- In the UK the CCS Cost Reduction Task Force initiative identified cost reduction opportunities and the CCS Commercial Development Group is working on how to reduce costs to make CCS a commercial and bankable technology.

- Significant cost savings could be realised in early projects by the relaxation of these criteria. They could be tightened again if necessary, once economies of scale have driven down.

QC2. How much do you think knowledge of the technical feasibility and performance of the different elements of the CCS chain in Europe has developed over the last five years (since the Directive came into force)?

	Good development	Some development	Very little development	No development	Adverse development	Don't know
CO_2 Capture	24	36	17	1	2	24
CO_2 Transport	12	36	24	7	1	24
CO_2 Storage	8	48	20	5	1	22

Most people responding to this question thought that there was some development in all parts of the CCS chain.

There is disagreement amongst respondents. Respondents were split between those who believed knowledge has improved as a result of FEED studies, capture pilots and other developments outside Europe and those who highlighted lack of progress due to absence of real demonstration projects. While some respondents believed that significant advances have been made in all parts of the CCS chain, other believed that FEED studies in the UK and Norway provided significant knowledge and understanding of CO_2 storage but there was little progress in other parts of the CCS chain over the past 5 years. While some believed that capture and transport have and will always remain technically feasible, others thought that there is little experience with transport and storage in Europe as there are no new large scale demonstration projects. Some respondents believed that technical feasibility and performance are well understood and the key issue is commercial. Additional insights are as follows:

- Good development in the understanding of benefits and technical feasibility in relation to saline formation appraisal has been reported by the Don Valley project.

- While the knowledge on technical feasibility, consenting and regulation has progressed and continues to grow, the understanding of technical performance will require implementation of early projects.

- There has been no new, large-scale injection in Europe in the last five years and as a result there is still a void in terms of knowledge of technical performance of the CO_2 transport and storage elements of the CCS chain.

- Technical feasibility is well understood and knowledge continues to grow as a result of successful R&D both within and outside Europe.

- Understanding has improved as a result of the Lacq project by Total.

- Technical feasibility is well understood and knowledge continues to grow as a result of successful R&D both inside and outside Europe.

- Useful performance data is available from Mongstad, Snohvit, Ketsin, Hontomin, UK FEED studies and DoE projects in the US.

- Realisation of CCS means integrating three activities with their own peculiarities, capture, transport and storage. Realisation of a project may take a decade. Starting with the assessment of storage capacity to actually injecting CO_2 in the reservoir.

- There have been a number of studies yielding strong lessons. Ultimately though there have been no new live CO_2 injection projects in Europe over the last 5 years. The rest of the world appears to have progressed on this while Europe has been slow to capitalise on the knowledge and expertise it has.

QC3. Looking forward in time, how do you expect the potential costs of the different elements of the CCS chain in Europe to develop between now and 2030?

	Good development (reducing costs)	Some development	Very little development	No development	Adverse development	Don't know
CO_2 Capture	41	33	8	0	0	23
CO_2 Transport	31	28	15	4	1	26
CO_2 Storage	31	31	15	2	3	23

Most people responding to this question thought that there would be some development in all parts of the CCS chain.

There have been several recent studies which identified opportunities for reducing costs. It was highlighted that the UK has made progress in advancing two early demonstration projects, but it is vital that momentum is maintained in the UK and elsewhere in Europe to bring forward the next wave of projects in a strategically co-ordinated manner to unlock further cost reduction opportunities. Respondents believed that a significant influence on costs will be the ability to achieve unit cost reductions through delivering CCS at scale, with efficient sharing of transport and storage infrastructure, which will in turn depend on the strength of support for CCS.

Some respondents believed that reduction in costs will depend on rate of deployment and take-up and will largely depend on successful implementation of demonstration projects. Most respondents believed that real projects will happen in the next 15 years and so costs will be reduced. Many have emphasised, however, that this will only happen if a CCS demonstration programme is implemented in Europe. Additional insights are as follows

- Costs can only be reduced through large scale projects.

- Capture provides the biggest scope for cost reduction. Reductions in unit costs of capture technology cost are likely to be influenced by R&D elsewhere as much, or more than, RD&D in Europe.

- Both transport and storage costs are heavily influenced by geology and geography. Deployment of CCS in Europe is essential to realise lower costs for CO_2 transport and CO_2 storage. Both these activities benefit greatly from increased scale. The development of CO_2 transport networks, transport hubs and CO_2 storage complexes have the greatest impact on reducing costs.

- Growing public opposition to CCS storage, and possibly to transport in the future is likely to lead to an increase in cost estimates.

- Cost advances are best achieved by (a) incentivising economies of scale by pre-investing in infrastructure for expansion and (b) establishing policy to incentivise industry to participate and drive costs down to suit identified needs.

- If EHR becomes widespread then cost of CO_2 storage could fall to zero. If not then it will not fall in cost by very much.
- CO_2 storage is a challenge, one can anticipate significant cost increases (this will be the case if pressure management needs to be implemented). This illustrates that a lot of effort must be focused on sound methodologies to appreciate regional CO_2 storage capacities.
- Developments in cost reductions are predominantly contingent on the introduction of further EU policy measures, which incentivise investment in CCS and increase the speed and scale of CCS deployment. In the absence of projects it will be extremely difficult to realise any progress on cost reductions.

QC4. Looking forward in time, how do you expect knowledge on technical feasibility and performance of the following aspects of CCS in Europe to develop between now and 2030?

	Good development (improving knowledge)	Some development	Very little development	No development	Adverse development	Don't know
CO_2 Capture	56	19	8	1	0	21
CO_2 Transport	46	22	9	4	1	23
CO_2 Storage	48	24	8	2	1	22

Most people responding to this question thought that there will be good development and some development in all parts of the CCS chain.

Responses to this question were similar to the responses on costs (Question C3). Some respondents believed that the potential to increase knowledge on technical feasibility and performance on the different elements of the CCS chain will depend on EU and MS action to support and encourage CCS development. Demonstrations are required to drive knowledge forward.

It was highlighted by several respondents that knowledge on technical feasibility and performance in capture will progress because of the worldwide activities. However, progress in knowledge on transport will require early projects implementation, followed by next stage projects and achieving economies of scale. Establishing a viable business model, not technical feasibility, is a key challenge for storage.

Others highlighted the fact that this will depend on whether additional measures such as EPS are put in place. Additional insights are as follows

- Improving understanding of performance and technical feasibility can only be done through large scale projects.
- Lots of learning will be obtained from the projects that are actually happening outside Europe.
- Developments in terms of technical feasibility and performance are contingent on the introduction of further EU policy measures, which incentivise investment in CCS and increase the speed and scale of CCS deployment. In the absence of projects it will be extremely difficult to realise any progress within the EU.
- For CO_2 storage, the major challenge is enabling economically viable business models; not technical feasibility constraints.
- Advances in capture knowledge will continue, even with little CCS progress in Europe, because of activity elsewhere.

- Progress on transportation and storage cost knowledge will require implementation of early projects, followed by the next stage of projects in quick succession. Improved knowledge will come with learning from achieving economy of scale for transport and from actual operation.

4.2.2 Interviews

This question was investigated via the interviews by asking for opinions on the progress relating to knowledge of costs, technical feasibility and performance of CCS over the last five years (in the EU and globally).

Industry

- The only practical experience gained is from outside Europe.
- Work in Europe has been useful but desk based. Real progress (on cost reduction and building a commercial case) needs demonstration projects – and these need to occur as soon as possible.
- Understanding of storage costs has not progressed as well as for capture and transport.
- Some in industry feel the over prescriptive requirements of the Directive are a factor in making the commercial case for CCS non-viable.

Environmental NGOs

- Agree with the lack of, and need for, practical demonstrations.
- Feel that industry has been over optimistic on the costs (in the past). CCS policy needs to face the need for commercial viability (even if via regulation) or stop.
- Recognise the wide variation in MS interest and activity.

Public actors

- Agree with the lack of, and need for, practical demonstrations.
- Have a more nationalistic view on the Directive (what does it mean for me in my situation).
- Make comments on industry being behind on their original intensions.

4.2.3 Written submissions

Alstom feel that a new revision of the Directive must be set up, they suggest when we have reached a 10Mt/year storage level.

CCSa starts by stating that the 'CCSa strongly believes that the key driver for CCS in the short- to medium-term will be the introduction of policies and incentives designed to increase the speed and scale of deployment; not revisions to the CCS Directive.' The Directive is workable and there is insufficient evidence to justify major changes.

E-ON supports the further development of CCS and stresses that the outcome of the questionnaire must be carefully analysed as some questions contain different elements. They feel transposition of the Directive to national legislation has been slow and has hampered projects.

Eurelectric Europe's CCS demonstration programme has not progressed in line with expectations, but it remains important that the technology is developed and demonstrated on an industrial scale.

EURELECTRIC considers the CCS Directive to provide a satisfactory framework for ensuring the safe and secure geological storage of CO_2; however it should be taken into account that the application of the Directive has not yet been tested for projects of industrial scale.

Eurelectric While the Directive has some shortcomings, EURELECTRIC thinks that it would be premature to revise the text at this stage, particularly given the lack of operating experience with CCS installations.

Eurelectric - EU policy should currently focus on positive incentives for demonstration and not on obligations.

European Power Plant Suppliers Association (EPPSA) The barriers to ensuring sufficient demonstration of CCS in the EU are not technical in nature, but are financial and legal. In particular, the lack of commercial application and the lack of a revenue stream for CO_2 capture is a significant financial barrier.

Global CCS Institute (GCCSI):- believes a detailed review of the Directive is too early, as not enough experience on the implementation of the Directive has been gained in Europe.

(GCCSI):- They stress the growing recognition for the need of CCS and that Europe has fallen behind in developing projects in the last years.

(GCCSI):- The ROAD project's importance is stressed as one of the most advanced and relevant projects in the world (deserves more financial support), and also the two UK projects (Peterhead and White Rose) are mentioned as promising.

International Association of Oil & Gas Producers (OGP) say that they think that more experience with demonstration is required before re-opening discussions on the current Directive. The current directive provides: 'an acceptable degree of clarity to investors' but at the same time they say the Guidance Documents ' become a significant barrier to deployments of CCS in Europe'.

They also state that the Directive should not be used for other issues than safe storage and that CCS enabling policy and Public acceptance should be regulated in a CCS policy but NOT in the Directive.

Key messages from Shell regarding review and evaluation of CCS Directive:

- Overall, European institutions have delivered a robust regulatory framework in the form of the current CCS Directive, which provides the necessary clarity to investors for building and operating CCS projects in Europe.
- A reopening of the Directive should only be considered after the first demonstration projects have started operation. At the time of first agreeing the CCS Directive in 2009, the Commission had originally planned to review the Directive in 2015 after having had experience of operating up to 12 CCS projects. Today, there are no CCS projects in operation, so it would seem to make little sense to reopen the directive at this stage, before having gained any experience of demonstrating CCS under the current legislation.
- Reopening the CCS Directive now would introduce a substantial element of investment uncertainty that may undermine progress with existing projects.
- The CCS Directive currently has sufficient flexibility to allow Member States to implement it in a cost-effective way. It is crucial that Member State flexibility is maintained so that the Directive can be applied in a pragmatic manner, in line with national regulations and practices. Reopening the Directive would unnecessarily put this at risk.

The Crown Estate (UK) - Describe the Directive as being 'fit for purpose' and have the opinion that the two UK projects which are starting are not being delayed because of any regulatory uncertainty. They feel that the UK is ahead of the rest of Europe on CCS.

Zero Emissions Platform (ZEP) begins by saying that it would be premature to review the Directive now and the EU should wait till a larger number of large scale projects have been tested (they suggest later after 50MTon is stored). Opening the Directive now would create further uncertainty for investors. CCS remains very important for Europe and thus CCS policy needs to be redefined and improved and this should go hand in hand with the 2030 energy and climate package.

(ZEP) - The Directive is a largely workable framework, most barriers come from the guidance documents and the (inflexible) interpretation of these by MSs.

Even if many stakeholders feel we are 'very far behind the rest of the World' in terms of progress in CCS, CO2GeoNet would like to see some mention/recognition of the World Class research and development being undertaken in Europe on geological storage of CO_2.

National Grid Carbon state:

- The regulation already in place in the Directive is sufficient to progress CCS projects safely without harm to the environment or human health.
- In the absence of real projects, there is limited/no evidence to justify change to the Directive.
- The near term focus should be on progressing the first phase of projects within the existing regulation.

The International Association of Oil & Gas Producers (OGP) made the following points in their submission:

- OGP welcomes the emerging finding, in line with the majority of stakeholders' views, that "there is not yet enough experience with the CCS Directive to justify high level changes." OGP considers that, before re-opening discussions to improve the existing CCS Directive, additional work related to demonstration projects is required.
- The CCS Directive, as it is, provides an acceptable degree of clarity to investors for building and operating CCS projects in Europe and is flexible enough to allow Member States to overcome the financial constraints generated by such projects. The CCS Directive ensures the necessary flexibility for Member States to manage storage permits at national level.
- OGP recommends separating the wider CCS policy development discussion from the review of the Directive. In OGP's view, the CCS Directive itself should not be regarded as a specific vehicle to drive policy improvements aimed at supporting CCS demonstration projects in Europe. They think that this would go beyond the Directive's original scope and would increase risks to defer current investment decisions rather than enable them.

4.2.4 Case studies

White Rose Project - The White Rose CCS project has received funding from DECC to undertake FEED studies. There have been two previous FEED studies undertaken in the UK for Longannet and Kingsnorth. In addition there have been additional FEED studies conducted in Europe and worldwide in addition to some pilot construction/ data gathering. Projects elsewhere in the world have progressed and inform learning.

Key progress has been made in understanding the risks that industry is willing to take and the premium for accepting other risks. Several of these risks that have resulted in cost premia created by the application of criteria from the Directive, associated legislation including Procurement/ State Aid and Guidance. Significant cost savings could be realised in early projects by the relaxation of these criteria. They could be tightened again if necessary, once economies of scale have driven down.

In terms of CO_2 storage, it is found that there has been a transformation of attitude to saline formation storage with increased understanding of the benefits (scale, few well penetrations, and availability) and what is needed to appraise saline formation storage sites. It is also found that the key issue in terms of CCS progress is to get to financial close on a project and learn from plant operation. The learning in Europe has centred on knowledge of feasibility, regulation and consenting with little learning on performance, which mainly comes from outside Europe.

The White Rose project has reported that, based on cross-industry thinking and UK Government learning from its CCS experiences, three phases to CCS evolution are anticipated

- Commercial Scale Demonstration phase with heavy government support to incentivise industry to participate and invest. This is the phase where the White Rose project is now with NER300 and UK Commercialisation Programme funding,
- Transition phase bridging to the full Commercial phase, and
- Fully Commercial phase, when CCS costs have been driven down to be affordable in an ETS price driven market.

In the context of **Romania's Getica** CCS Application for NER300 funding, a regulatory test toolkit exercise[20] was undertaken by the Romanian government to test and improve the legislative framework governing the implementation of CCS projects in Romania. The following was identified to improve the permitting process: authorities need a better understanding of the CCS technology; the engagement of the local communities in the area of the project is crucial - surveys performed at EU level indicate that Romanians have little knowledge/only a few have heard of CCS technology and Romania's intentions in this respect; cooperation and joint working across Government departments and regulators is essential and early engagement of local authorities and agencies involved is key to streamlining the regulatory process and improving design.

[20] Carbon Capture and Storage Regulatory Test Toolkit for Romania, available at http://decarboni.se/sites/default/files/publications/25421/ccs-toolkit-ro-final-report-2-nov-4.pdf

4.2.5 Stakeholder meeting

- The Directive can be interpreted flexibly. Most problems can be solved via negotiation between the Member State and the CCS developers.
- Re-opening the Directive may cause problems via an increase in risk perception. Therefore it may be better not to re-open it.
- Another risk of re-opening the Directive, is that the same anti CCS views exist in the parliament – so the Directive could become more restrictive.
- The need to speed up the demonstration and uptake of CCS remains.
- There is a view among stakeholders that the Commission does not give CCS a high enough profile.
- Many directives have a review in the light of regulatory experience – this experience hasn't happened for CCS. Would the Commission be able to commit to a future review when some experience has been gained?
- The Directive is generally fit for purpose and there is no need to substantially review it.
- The point was made that the European research work that has been completed on CCS is of a high quality and this quality should be recognised in the review. However the point that there is a need for more CCS demonstration projects remains.
- At the moment the focus should be on supporting demonstration and early deployment.

4.2.6 Summary and conclusions

Only two of 13 current CCs projects in the world are in Europe, both of these are in Norway, where the CCS Directive is applicable, but the projects were permitted before the CCS Directive came into force. One final investment decision appears close in Europe. Activity is focussed on a small number of MSs (UK and NL are most active). There has been more activity in the rest of the world and Europe is falling behind.

There has been good quality research work done in Europe, but this is desk based work on feasibility and regulation. There is more information on practical experience coming from outside the EU. The non EU knowledge gained on capture is more transferable (to the EU) than the knowledge gained on storage.

The European Council of June 2008 called on the Commission to bring forward as soon as possible a mechanism to incentivise Member State and private sector investments to ensure the construction and operation by 2015 of up to 12 CCS demonstration plants. This has not occurred, although as discussed elsewhere (mainly questions 21(on relevance) and 22 (on CCS enabling policies) this lack of progress has very little to do with the Directive As also discussed elsewhere if the EU (and the rest of the world) is to address climate change this need remains valid. Future progress needs large scale demonstration projects. It appears that the most pressing need is for steps towards developing transport networks and storage complexes – as these are the first stage in creating a CCS system.

4.3 Q3 – Public acceptance

3. How is the CCS Directive (and its implementation in national legislation) contributing to fostering public acceptance of CCS as a climate change mitigation technology across Europe (e.g. in the process of authorisation of a storage site)? Is the EU regulatory framework for CCS effectively and practically taking into account public safety and environmental concerns which may arise?

4.3.1 Literature review

Public acceptance is one of the challenges facing the deployment of CCS. CCS is usually viewed negatively by the public as it is seen as a contributor to continued use of fossil fuels (an 'end of pipe solution'). In addition, it is perceived as dangerous by many locals, with onshore storage in particular raising public concerns. Public opposition in the Netherlands, Germany and the US has led to the cancellation of several CCS projects. There are a number of conditions that appear to need to be achieved in order for CCS to gain wider public acceptance, these include: That the public believes in global warming as a threat and that CCS can play a key role as a mitigation option and a bridging

technology and that it is a safe technology. Recent studies on public acceptance[21,22,23] show that people in general accept CCS if the storage is offshore rather than onshore. This could be seen as an example of the phenomenon known as the NIMBY (Not-In-My-Back-Yard) effect. It was also found that the source of the information on CCS (NGO, industry or government) was an important factor in public acceptance.

Onshore storage has recently met with public opposition in countries like the Netherlands and Germany but seems less troublesome in other countries (like Spain). In Spain a successful public communication and engagement programme was set up. Offshore storage has not been confronted with the same level of public opposition. Overall, the awareness of CCS among the public appears to be low[24]. Visualisation of subsurface activities is considered to be helpful in communication of CO_2 storage operations.

An extensive literature review of social research on CCS by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in collaboration with a large number of other international research organisations highlighted the following themes of relevance to public acceptance of CCS[25]:

1. *Framing of CCS*: Communicating CCS as a standalone technology will probably not be accepted. A proper framing for the various types of stakeholders is key.
2. *Local context:* A profound understanding of the communities living near CCS projects is essential in the development of such projects.
3. *Trust:* This is generally recognised as critical to project success and relates strongly to how the public engagement is enrolled including using trusted sources of information and messengers, building trusting relations with stakeholders and honest and interactive engagement.
4. *Communication and engagement process:* This theme deals with how (and when) stakeholders and the public are engaged and the availability of dedicated and experienced people in the project team.
5. *Information:* Access to multiple sources of information on CCS and the energy and climate context which is of good quality, relevant and factual.
6. *Risk perception*: It is crucial to understand the factors influencing the perceptions of stakeholders.
7. *Governance:* Regulatory guidance for all processes in the CCS chain must be well established with processes which are fair and transparent to the stakeholders and the public.

The CCS Directive does not give directions on public participation procedures in the decision-making process but the EIA Directive[26] which applies to CCS projects, does refer to participation of the public concerned, in environmental decision making. Likewise the public has the opportunity of appeal in the granting of a CCS permit.

4.3.2 On line survey

QB1. Do you think that the EU regulatory framework for CCS adequately takes the following issues into account?

	Yes	No	Don't Know
Public concerns over safety and environmental impacts	45	40	20

[21] Terwel, B. W., & Daamen, D. D. L. (2012). Initial public reactions to carbon capture and storage (CCS): differentiating general and local views. *Climate Policy, 12*, 288–300.
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[23] Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology, 19*, 426–441.
[24] EC, 2013: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Future of Carbon Capture and Storage in Europe, COM (2013) 180 final
[25] Ashworth P, Dowd A-M, Rodriguez S, Jeanneret T, Mabon L and Howell, R (2013) Synthesis of CCS social research: Reflections and current state of play in 2013. CSIRO EP134303, Australia
[26] European Parliament and the Council of the European Union (2011). Directive 2011/92/EU of the European Parliament and the Council of the European Union of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment [EIA Directive], in: Official Journal of the EU, 28 Jan 2012, L26/1-21

Seven respondents felt that the current regulatory framework is sufficient '*to ensure that CCS is deployed in safe and environmentally acceptable way*'. Five respondents pointed to key barriers for public acceptance being a lack of large-scale deployment of CCS, education by Member States on perceived risks, the perceived ability of industry to manage risk, and leadership by Member States in developing concrete measures to address public concerns.

QC5. One of the key objectives of the CCS Directive is to help expand the understanding of the technology and improve public acceptance of the technology. Do you think the CCS Directive has helped improve public acceptance of CCS?

Yes	No	Don't Know	Comments
13	73	19	49

A key comment was that overall the approach of the Directive has been to treat CO_2 as a hazardous activity and so the public has approached the topic with caution. On balance this has not been helpful in promoting a balanced approach by the public to the risks of CO_2 storage. Others commented that through the transposition process, MSs had the opportunity to engage the public but few appear to have done so in an organised way. One respondent highlighted that while the Directive enhanced awareness of CCS it did not improve acceptance.

It was also highlighted that there is a need to inform to the public at an EU-level how CCS fits into the overall GHG solution and increases security of supply. Some additional comments include:

- Cancellation of projects in Europe had a very negative influence. The directive could not compensate but also did not support.
- The opposition mainly arises at the local level, and the awareness of the CCS Directive is not given there.
- The CCS Directive has not helped to expand understanding or knowledge of the technology, nor improved the public acceptance. Positive actions have been led at Member State level, in relations with demonstration projects (e.g. UK, Spain).
- Public resistance to CCS appears to have increased after the EU CCS directive was made official.
- The various project cancellations have been very damaging for the public perception of CCS, despite the Directive.
- Public acceptance of on-land CCS is deteriorating as the Directive assumes use of supercritical CO_2 storage with its risks of gas leaks. Dissolution of the CO_2 prior to injection greatly increases the storage security and improve public acceptance.
- Public does not know that the Directive exists.
- The implementation of the CCS directive actually blocked the development of the Vedsted project and lead to its closure. (*This is an isolated view and the majority of stakeholders would say that public opposition was the main reason why the project has failed to progress).*
- Surveys indicate little public knowledge of CCS. There is a danger of opinion cross-over (inappropriately) from the public response to shale gas fracturing.
- In order to increase public acceptance, CCS should be limited to sites where competition with more sustainable underground resources, e.g. geothermal energy, does not happen. CCS should especially privilege off-shore storage sites wherever feasible, notably in the North Sea, where a concrete potential exists.

4.3.3 Interviews

This question was presented to the interviewees as a question on their opinion of progress regarding public acceptance of CCS.

Industry

- Focus on the risks in the legislation may not be helping.
- Public opposition has been very vocal to on shore storage, particularly in Germany. Much less (or no) opposition to off shore storage. Capture often happens in industrialised regions, so there are limited concerns.
- The risk of confusion with the negative image of fracking is raised as a concern.
- In general public awareness and knowledge is regarded as low.
- It is recognised that CCS is most associated with coal fired combustion plant, with its wider role in the transition to a decarbonised society not recognised or promoted.

Environmental NGOs and other

- Agree with low level of awareness and knowledge among the public – and that there is a need to address this, including the role of CCS in wider energy policy.

Public actors

- Policy makers argue that public acceptance is something to be dealt with on national, regional or local level.

4.3.4 Written submissions

Eurogas -Public acceptance:

- There is strong resistance in some MSs, especially to on shore storage.
- This is mostly due to lack of information and the EU could play a more active role (e.g. communication toolkit for MSs) to inform EU citizens.
- Industry should also help, by full disclosure of their information.
- We should try to learn from US and Australia about public acceptance.

European Power Plant Suppliers Association (EPPSA) CCS stakeholders should put more emphasis on the fact that CO_2 is not a toxic compound and thereby counteract the misleading parallels that are made far too often between long-term storage of CO_2 and long-term storage of nuclear waste.

4.3.5 Case studies

For the **Compostillaa** project - Ciuden spent significant time and effort in understanding the local community and working with the Hontomin City Council to raise awareness and understanding of the Hontomin facility, the properties of CO_2 and CCS more generally. Initial early concerns about onshore CO_2 storage were largely abated through transparent and inclusive public engagement, resulting in what now appears to be widespread community support for the operation. The CIUDEN team and Hontomin City Council, with the assistance of funds from the Spanish Foundation for Science and Technology (FECYT), created a cultural education program including activities and community science and innovation events focused on explaining CO_2 storage.

The **Ketzin** project reported the following lessons regarding important elements of public outreach:

- Transparency towards the regulator and the public are of highest important to build up confidence.
- Transparent information about the Ketzin project, the monitoring concept and results from the very beginning.
- Community level engagement – presenting results at the district council, on Wednesday everybody is welcome at the test site, annual open house for the locals.
- Extension of visitor centre (1000 visits/year), set-up of new website (www.co2ketzin.de), further press relations.
- Extensive publishing of scientific results.

The Quest Project - *Public engagement* - After seeing a project cancelled due to public opposition in Barendrecht (NL) Shell took a different approach to public engagement with Quest.

1. Timing was very important for engagement activities during all parts of the project. Consultation began very early (prior to any project design), and was designed with local stakeholders in mind (e.g. to accommodate the rural constituency, Quest 'World Café' sessions were held before the start of the harvest season in June, and then after the harvest season in October 2011.)
2. A mutual understanding of outcomes by the project team allowed all members to engage effectively with stakeholders. For example, the construction manager participated in engagement activities from an early stage (years before construction activities would take place), which allowed for diverse perspectives to be heard and acted on throughout the process.
3. Using the appropriate terminology tailored to different audiences minimised miscommunications between project proponents and stakeholder groups (e.g. using 'storage' as opposed to 'disposal' so the CO_2 would not be thought of as waste, or using 'rock formation' as opposed to 'saline aquifer' as the latter was found to be too technical and misunderstood by some audiences).
4. Engaging stakeholders at their own events (e.g. agricultural fairs, community events) helped reach a broader set of community members than traditional engagement meetings.
5. Having a process to work with stakeholders who may have reservations about the project, or may be in opposition to it, can be beneficial if conducted properly.
6. Engaging local government representatives early on in the process ensured that they would be knowledgeable about issues when speaking with constituents.
7. Ensure there are multiple avenues for local stakeholders to learn about and engage in the project early (e.g. local events and festivals, town council meetings, open houses, website, telephone number, etc.) and that there are ways to incorporate feedback from local stakeholders into the project design.

The Lacq project - A good level of acceptance by the stakeholders (which includes French administration and public representatives) was obtained. The main reasons for the good level of public acceptance for this onshore project were:

1. A great emphasis on meeting inhabitants and their political representatives at all levels of Total hierarchy (From project manager up to Sustainable Development Executive director)
2. A constant transparency in Total communication with local populations and with ONG and public stakeholders representatives though a Follow-up Information Committee - The tools developed by Total for explaining the project (Movies, Brochures, Quarterly information letters send directly to the local population, Total internet site and French Authorities internet site..)
3. The industry background in this area, and particularly the records of Total in terms of HSE (more than 50 years of extraction of a high pressure, very toxic gas containing more than 15% of H_2S and 9% of CO_2, with no major accident.)
4. The fact that the Rousse injection site has ideal characteristics (4500 meters deep, 2000 meters of very thick impermeable structure, reservoir used for production for more than 30 years, only one drilled well) against the fear of CO_2 leakages.
5. The strong support of French public institutions regarding the CCS industry.

The White Rose project - Members of the public had several opportunities to provide consultation feedback on plans being put forward for the White Rose project at public exhibitions during July 2014. Individuals were given the chance to provide consultation feedback in several ways until 1 August 2014. The public exhibitions enabled visitors to review the latest details of environmental and technical studies that have been carried out over the last few months. The studies form an important element of the design work that has been conducted by specialist members of the White Rose project team and the conclusions were on display so that the local community could view and provide comment on the differing topic matters. All feedback received is being considered as project design options are finalised before an expected development consent order (DCO) application is made to the Planning Inspectorate in October 2014 seeking consent to construct and operate the White Rose plant.

Based on the experience of the White Rose consortium and National Grid, there seems to be little public knowledge of CCS and there might be a danger of opinion cross-over from the public response to hydraulic fracturing as used in shale gas. There is a need to inform the public at an EU wide level how CCS fits in the overall GHG solution and security of supply. It is important that there is a joined up approach, across the energy industry, across member state governments and across Europe, to communicate a clear, compelling, consistent energy strategy. There needs to be a better explanation of why significant investment is needed and the trade-offs that will need to be made in order to achieve a safe and sustainable energy future.

The White Rose consortium believes that the current storage permit procedure does not help enhance public confidence. The Member State competent authority is more directly accountable to the public in the Member State and is more familiar with the local circumstances. The EC review team is less accountable to the relevant public and also lacks the experience of the Member State Competent Authority.

Getica - The proper engagement of the local communities in the area of such a project is crucial. According to a Eurobarometer poll, however, Romania has the second lowest public awareness of CCS in Europe, with only 4% of respondents claiming to know what it was (Eurobarometer, 2011). The Government has recognised the need to involve the public in the permitting and planning of CCS projects. The Government has commissioned a social study in the region of the proposed Getica project, it is hoped that the information produced will help project developers more effectively communicate the benefits of the project with local stakeholders and the public in general (METBE, 2011)[27].

4.3.6 Summary and conclusions

It appears that overall opposition to CCS, particularly onshore storage, has increased.

General public awareness (and hence knowledge of) CCS is low. Most Member States have done little or nothing to improve CCS awareness. This needs to be addressed and CCS needs to be placed in a wider context as an important part of climate policy. This evaluation's recommendations for both EU and MS level actions on this point are included in the sections related to CCS enabling policy.

For prospective project sites communication and openness is very important. There are some good examples of successful public education and engagement at sites, with frequent, targeted and honest engagement being very important.

The Directive has not helped to improve public acceptance. In part this relates to the tone (and focus) of the directive on the risks of CCS. This (almost inevitably) gives the impression that CCS is hazardous. The industry view is that the risks involved are not uncommon and are not any higher than many industrial sectors (including energy). This focus on risks appears to be part of the reason why public perception is to equate CCS more with fracking and nuclear waste than with natural gas transport and use.

Cancellation of CCS projects has not helped confidence (though this is not the fault of the Directive).

4.4 Q4 – Legal barriers to CCS

4. One of the main original objectives when setting up the EU legal framework was to ensure that legal barriers for CCS deployment would be removed (recital 8 of the CCS Directive). To which extent is EU regulatory framework on CCS effectively supporting CCS projects under development? In terms of comprehensiveness of the framework, have additional (legal) challenges been identified on the basis of project experience, which are not yet sufficiently addressed by the EU regulatory framework on CCS?

[27] Our Future is Carbon Negative: A CCS Roadmap for Romania, available at http://bellona.no/filearchive/fil_Romania_final2.pdf

4.4.1 Literature review

The lack of appropriate and proportionate regulation is a potential barrier to the deployment of CCS. Over the past few years, countries around the world have been developing legislation to facilitate the capture, transport and storage of CO_2. This was mainly achieved through amending existing regulation to allow CO_2 storage.

The key developments since 2009 are:

- Inclusion of CCS in the London Protocol and OSPAR Convention (related to maritime pollution).
- Adoption of rules for including CCS in the CDM.
- Establishing an ISO Technical Committee to progress the standardisation of CCS.

Some issues remain unresolved (e.g. trans-boundary-movement under the London Protocol). A comprehensive review of recent developments in CCS legal, regulatory and policy developments is available from the Global CCS Institute report on the Status of CCS[28].

Competent authorities for the permitting of CO_2 storage rely on their knowledge of permitting mining and oil and gas projects. Transfer of responsibility after definite cessation of injection requires specific attention, in particular on the transfer requirements and the duration of the period between cessation of injection and responsibility transfer. The procedures and tools for showing conformity between modelled and measured behaviour of the storage site are to be specified in more practical terms. Methods and tools for emission quantification offshore are to be established.

From experience in permitting of storage to date, which is in the EU limited to one storage permit in the Netherlands, it appears that the requirements for technical specifications may be too high for the phase before the final investment decision. A lot of evidence on the performance of underground storage projects is gathered during operations. The importance of 'learning by doing' needs to be recognised in storage regulation.

4.4.2 On line survey

QC6. Do you think the EU legal framework for CCS helped remove legal barriers to CCS deployment in the EU?

Yes	No	Don't Know	Comments
51	25	29	33

Several respondents believed that while the Directive has removed a number of legal barriers to CCS deployment, such as those associated with the OSPAR Convention, it has also created significant barriers to investment in the form of legal and regulatory requirements (for example the creation of long term liabilities for storage operators and lack of legal clarity around transfer of responsibility criteria). Cross-border CCS (shipping) and the inclusion of storage sites under the EU Emissions Trading System (EU ETS) were also named as barriers. Transfer to MS policies and its implementation were also highlighted as issues.

Some respondents believed that legal barriers were not sufficiently addressed when member States transposed the Directive into national law.

Additional comments

- The Sleipner project experience indicates that the CCS Directive has helped to address legal barriers, such as those associated with the OSPAR Convention, and has put in place the legal framework to enable CCS deployment in the EU.

- The framework assumes a specific injection method and puts unnecessary restrictions on those that apply other injection methods (e.g. injection of dissolved CO_2).

[28] http://decarboni.se/sites/default/files/publications/121016/global-status-ccs-february-2014_0.pdf

- ROAD published several reports on these barriers and these included for example the transfer of responsibility and liability.

QC7. Have any other legal barriers been identified via project experience that were not apparent when the Directive was prepared?

Yes	No	Don't Know	Comments
34	19	52	32

It was highlighted that very little experience exists. One respondent stated that some Network projects highlight the need for better procedures and know-how amongst national regulators. The following barriers were highlighted by respondents (split into legal and other barriers):

Legal barriers

- Liability and transfer of responsibility issues.
- The inclusion of storage sites under the EU ETS.
- The uncertainty around post-closure monitoring period and costs.
- The lack of differentiation between major and minor leakages.
- Cross-border transportation of CO_2.
- Pipeline safety standards.

Other barriers

- Access to depleted hydrocarbon fields (the majority of hydrocarbon fields in the North Sea are still producing and are unavailable for CO_2 storage)
- Conflicting spatial demands (the southern North Sea, and other shallow inshore areas, have the potential for competition for space between CCS and offshore wind (and possibly marine)
- Access to existing geological data, competing interests to the subsurface.
- It is not allowed to store in a non-MS (for instance, storage in the Baltic Sea is not likely since potential storage sites are on the border to Russia).
- Low price of CO_2.

Additional comments:

- Cross-boundary transport of CO_2 was not an issue for a proposed project with transport from Finland to a storage site in Denmark (offshore).
- The experience from the Don Valley project helped identify the following barriers: storage liabilities and monitoring costs, conflicting spatial demands, restricted access to depleted hydrocarbon filed and to production data that are critical for storage appraisal.
- Exploration permits should be carefully described. CO_2 storage needs strong and complex methodologies to explore subsurface.

4.4.3 Interviews

This question was posed to the interviewees as 'Do you think the EU legal framework for CCS helped remove legal barriers? Have any other legal barriers been identified that were not apparent when the Directive was prepared?'

Industry

- The Directive has provided a framework for MSs to regulate and allow CCS.
- No practical experience to test the framework.
- There are still some areas of legal uncertainty – some relate to ETS, some to storage liabilities. Monitoring, access to depleted HC fields.
- London protocol amended to allow subsea transfer of CO_2 – but not yet ratified.

4.4.4 Case studies

In [GCCSI, 2013], it is noted that "According to the environmental impact statement of March 2012, the necessary pipeline permit is not covered by the existing Spanish legislation. As the Compostilla project transports CO_2 by pipeline to the storage site (Phase II), it can be argued that, under current Spanish legal framework, the permitting process for CO_2 transport is not possible for the moment."

The White Rose project - As the proposed White Rose plant exceeds 50 MW gross electrical output, the Planning Inspectorate will report to the Secretary of State who will ultimately make the decision about whether the plant gains development consent. The Planning Inspectorate will examine the proposals once the application is submitted by Capture Power after the public consultation process is completed. The public consultation will contribute to the decision eventually made by the Secretary of State about whether planning permission for the plant is granted.

The plant will also require an environmental permit from the Environment Agency. To be awarded this permit, Drax must demonstrate that the plant can meet the stringent environmental conditions set by the Environment Agency and that the plant will be operated under an Environmental Management System which will be audited by the Environment Agency.

4.4.5 Summary and conclusions

There were legal barriers to CCS and the Directive has defined a common framework designed to help address these. However there has been virtually no practical experience of the detailed implementation of this framework. There are a number of areas where uncertainty remains and the lack of practical experience in Europe means that these are hard to address until this experience has been had. Areas of uncertainty include – trans-boundary transport of CO_2, liability issues, treatment of leakage, access to depleted hydrocarbon fields and conflicting spatial demands for storage sites. The trans-boundary transport is partly an issue, which needs to be addressed by existing trans-boundary transport and marine treaties such as the London Protocol. OSPAR and others (see question 39). The EC could help to push the agenda forward in all related international treaties. The issues of access to depleted hydrocarbon fields and conflicting spatial demands are issues for MS spatial planning and mineral access policy. The other areas of uncertainty require practical application (and MS and operator level interpretation) of the Directive before they can be assessed.

4.5 Q5 –'Permanence' of storage

5. Among the original objectives when setting up the EU regulatory framework for CCS, was to ensure that this novel technology would be deployed in an environmentally safe way (recital 9 of the CCS Directive). What evidence can be gathered, on the basis of the technical progress and latest scientific knowledge, and including via CCS demonstration projects, that geological storage of CO_2 leads to permanent containment of CO_2 in such a way as to prevent and reduce as far as possible negative effects on environment and human health, and any resulting risks for environmental and human safety? Is there sufficient consensus about the definition of "permanent" containment of CO_2 on the basis of the experiences acquired so far (in Europe and beyond)?

4.5.1 On line survey

QE1. One of the original objectives of setting up the EU regulatory framework for CCS was to ensure that this novel technology would be deployed in an environmentally safe way (Recital 9 of the CCS Directive). What is your view, on the following statements on whether geological storage of CO_2 leads to permanent containment of CO_2 in such a way as to prevent and reduce as far as possible negative effects on environment and human health, and any resulting risks for environmental and human safety?

	Agree	Disagree	Don't know	Comment
There is a lack of consensus on the definition of "permanent" containment of CO_2	46	34	25	23
The term 'permanent' should be replaced by a number of years like 500 or 1000 years	26	51	28	26
The Directive should make a distinction between the risk of minor leakage and major leakage.	52	28	25	32

In total, 71 qualitative responses were received to this question. Responses suggest that there is some ambiguity regarding the definition (and interpretation) of 'permanent'. Some suggest that the wording leads to an expectation of perfect storage which is difficult to prove and unrealistic. One suggests technical systems are never 100% tight whereas another believes that leakage is merely a concern. A participant highlights that ambiguity may create legal issues and as such further clarification could be beneficial. Some respondents suggest the word 'permanent' could be replaced/clarified with alternatives based on something more directly applicable to human safety. However, some suggest that further clarification may not be needed given widespread understanding derived from the Directive as it stands: 'There is widespread agreement across jurisdictions that risk assessment and risk management processes should be used to select appropriate storage sites with excellent integrity, and design/operate/monitor storage sites so as to minimise any risks associated with leakage, and provide assurance of effective long term containment'.

In reaction to the second statement, some respondents supported the introduction of a numeric value to qualify 'permanent'. Some of those that supported the current wording felt that it better suits the purpose of CCS: 'CO_2 is being stored in order to mitigate climate change, not to be stored permanently as an end in itself'. 'Some CO_2 being released over a longer timescale like these numbers should be easily manageable from a climate change perspective'. However, the majority of respondents disagreed, for a number of reasons. Many suggested that any numeric value would be difficult to justify and measure, and would suggest liability for developers much beyond the period over which they could guarantee it. Others suggested a numeric value would not make any difference, with the wording being adequate as it is, i.e. with permanent meaning permanent.

The response to the third statement expressed a range of views. Some respondents would not support distinguishing between different forms of leakage due to the comprehensiveness of existing systems ('within the context of such comprehensive risk management, setting arbitrary timescales or leakage categories is unnecessary, and potentially misleading.') or due to a belief that we should strive for zero leaks. Others considered that a distinction should not be made in the Directive as it should leave responsibility to MS to either determine the differentiation of risk and mitigation action in response. However, some respondents believe that the Directive should 'better reflect current knowledge on possibilities and risks', systematically considering the potential impacts, in particular with respect to longer-term environmental impacts and taking into account wider (seismic) risk.

4.5.2 Interviews

In the interviews the most relevant material for this question focussed on views on the meaning of 'permanent and safe' storage.

Industry

- Recognise that what appears to be a simple phrasing is in reality complex.
- Want a flexible definition to reflect reality and variance between sites.
- Appears that a workable solution can be found, but that setting fixed targets (e.g. no. years) would not be appropriate, especially while still learning from experience.
- Needs to work for Enhanced Hydrocarbon Recovery (EHR) – where the CO_2 is initially recirculated - in and out of 'storage'.

Environmental NGOs

- Need to retain the 'permanent' for public confidence and credibility, but recognise the need for some flexibility.
- Some support 'minor' vs. 'major' leaks, others don't.

Public actors:

- The definition of permanent is good and workable, and gives the right signal for public acceptance.

4.5.3 Stakeholder meeting

- Discussions on the definition of 'permanent' storage confirmed theoretical concerns, but stakeholder opinion appears to be that these will not be a 'show stopper' and can be addressed via practical discussions during implementation.

4.5.4 Case studies

Question 9 (on transfer of liabilities) contains some useful information of relevance to this question. For it is interesting to note that the Ketzin site already complies with the following three minimum criteria as defined in Article 18 for transfer of responsibility:

- Site is evolving towards a situation of long-term stability.
- No detectable leakage.
- Observed behaviour of the injected CO_2 conforms to the modelled behaviour.

Lacq project - After a one year preliminary baseline survey, three years of monitoring during the injection period and one year of monitoring post-injection, the monitoring of the CCS Lacq which comprised microseismic monitoring, well pressures monitoring, CO_2 measurement into the soil and into the atmosphere around the well, as well as environmental monitoring into aquifers, the French pilot has demonstrated that:

- The CO_2 remained well confined within the reservoir.
- There were no well integrity issues.
- As a consequence, none of the numerous monitored environmental parameters show any anomalous behaviour.
- The CO_2 injection did not affect injectivity into the reservoir.
- The pressure into the reservoir evolved as predicted.

Beyond those operational results, the R&D activities undertaken demonstrated that cement resistance characteristics will not be affected by the presence of CO_2 and that geochemical evolution of the reservoir due to the injection of the CO_2 does not raise any issue for the long term integrity of the storage. From the perspective of the CCS directive, it is too early to consider that significant lessons have been learnt: the test will be how the responsibilities will be transferred after the 3-year post-injection observation period. This will occur in March 2016.

4.5.5 Summary and conclusions

There is not yet sufficient practical experience to answer the question as to whether geological storage of CO_2 is permanent and low risk. The work that has been done to date helps to improve the knowledge required to reduce the risks. Results to date from R&D scale storage sites (e.g. Lacq) indicate that safe and long-term storage is possible. Although there is still lack of consensus on the use of the term 'permanent', it appears to be the best compromise as it helps public confidence and allows enough flexibility in terms of practical implementation. The majority opinion that 'permanent' should not be replaced with a specific number of years appears to be the best solution.

The definition needs to be made workable for EHR – where the CO_2 is initially recirculated (in and out of 'storage'). The US EPA has developed criteria to allow for this (see question 19).

About half of the stakeholders who responded agreed that a distinction needs to be made between minor and major leakage. A minority remarked that the re-start of the 10-year period described in the Guidance Documents should be reworded accordingly and be more dependent on the cause of the problem. It is reasonable to conclude that if a distinction was made between minor and major leakage, the Directive would be improved.

4.6 Q6 – Biomass and CCS

6. What has been the experience, in Europe, as well as outside Europe, of application of biomass as a fuel used for CCS (large-scale demonstration) projects? What do these experiences prove in terms of techno-economic feasibility of CCS when biomass is used as a fuel in comparison to CCS in fossil fuels-based installations? What types of incentives and support measures have been put in place (across Europe and beyond) to realise projects of CCS with biomass? How can we evaluate, if appropriate, the effectiveness and adequacy of the provisions of the CCS Directive for projects for which biomass are used as a fuel?

4.6.1 Literature review

Combining use of *biomass* and CCS in energy generation (also referred to as bio-energy and CCS, Bio-CCS or BECCS or renewable-CCS) could lead to truly negative CO_2 emissions. The combined application of biomass and CCS in energy generation is not expected to be commercially viable before 2030 although all its components are already commercially applied[29]. Several projects demonstrating combined biomass and CCS are underway including the *Decatur project* in Illinois, US and the *White Rose project* in the UK.

Decatur project: A pure CO_2 stream from the fermentation of corn to produce bio-ethanol. Described as the world's first commercial scale Bio-CCS project. The captured CO_2 is transported via a pipeline to a storage site where it is injected in an aquifer at a depth of 2 km. The current demonstration plant is being scaled up to a commercial plant, increasing the capture rate from 0.3 to 1 Mt CO_2 per year.

White Rose project: Will have the potential to co-fire up to 15% of biomass. It is most likely that biomass co-firing will take place mainly in the non-CCS parts of the power plant (to save CO_2 allowances). Up to 450MW out of the total 3960MW power plant complex will be equipped with CCS. The Drax website states a "co-firing capacity of 500MW, enough to produce 12.5% of the power station's total generation output from renewable and sustainable biomass"
Funding has been granted by the UK government and detailed engineering studies are underway. 90 Percent of the produced CO_2 will be captured, which would result in an annual captured CO_2 stream of 2 Mt. CO_2. The CO_2 will be transported by pipeline to a storage reservoir under the North Sea.

[29] Pinder, C (2014). Moving Below Zero: Bioenergy with carbon capture and storage, report of The Climate Institute, 36 p. ISBN 978-1-921611-31-5

4.6.2 On line survey

QB1. Do you think that the EU regulatory framework for CCS adequately takes the following issues into account?

	Yes	No	Don't Know
Applying CCS to plants fuelled by biomass	15	55	35

Twelve respondents commented that the EU ETS does not specifically incentivise CCS with biomass, and that there is a need for a revision to directly support this technology. The call for revision was focussed on the EU ETS and not the CCS Directive. Ten respondents felt that biomass CCS is crucially important as it is '*the only technology able to "remove" CO_2 emissions'* (i.e. the only source of negative emissions). This is not taken into account by EU regulations.

4.6.3 Interviews

- The negative emissions of biomass CCS are not adequately accounted for in the ETS.
- There seem to be no major barriers in the CCS Directive for CCS with biomass.

4.6.4 Written submissions

Alstom see no need to regulate CCUS *(NB we believe they refer only to the Carbon Dioxide Utilisation, CDU part)* nor Bio CCS in the CCS directive. In their view this is a better fit in the ETS directive.

Eurelectric - The Commission should ensure the inclusion of negative carbon emission from Bio-CCS in the ETS.

Statoil ASA CCS on Biomass: As CCS on biomass is so far the only large scale negative emission option they advise the EU to stimulate and incentivise this (possibly via ETS) to send a clear signal to industry.

The Bastor 2 project states that: Incentivising Bio-CCS by including it in the ETS, or by other means, would for the Nordic countries remove an uncertainty and, at best provide an additional opportunity for sharing the costs for common infrastructure for transport and storage of CO_2. This is of particular significance in the Nordic region.

4.6.5 Stakeholder meeting

- There are some issues where policy (including the Directive) could be better developed, for example Biomass and CCS, EOR, etc. However some stakeholders made the point that these things are not prohibited by the CCS Directive, and it is not appropriate to attempt to more strictly regulate them via the CCS Directive.

- The importance of BioCCS for Europe (due to the nett negative of CO_2 emissions it enables) was raised. It was pointed out that the recently approved (for NER 300 funding) White Rose project in the UK includes BioCCS. The suggestion was made that the ETS directive should be adjusted to properly credit the negative emissions that BioCCS should give.

4.6.6 Summary and conclusions

There is one Bio-CCS project working in the US and there is one plant with some Bio-CCS under development in Europe (the White Rose project in the UK). It appears that there are no apparent barriers to Bio-CCS as a result of the Directive. There is a clear consensus that the ETS regulations need to be adjusted to give full credit to Bio-CCS.

4.7 Q7 – Storage permits

7. How many storage permits have been issued in the EU so far? How could the CCS Directive support the increase of the number of storage permits?

4.7.1 On line survey

QC8. Do you think that the CCS Directive could do more to support an increase in the number of storage permits?

Yes	No	Don't Know	Comments
46	25	34	32

Respondents highlighted the fact that HSE provisions should not be weakened in order to encourage storage permit applications. The main barrier to the deployment of CCS in this question was again highlighted as being the lack of a commercially viable business case. The key recommendations were, in order of importance, given as below

- By solving leakage liability. One of the main hurdles for CCS is the long-term liability for stored CO_2, both in size and duration. This is one of the main reasons why so few of the companies that have the expertise to store CO_2 safely have indicated willingness to do so.
- By providing proper support as for renewables.
- Other policy measures have to be installed to guarantee a reasonable CO_2 price.
- Revising and improving the Guidance documents Allowing MSs flexibility.
- Allow sharing liability between MS and operator.
- Develop guidelines to make local authorities increase the number of storage permits.
- By giving consideration to whether all of the clauses of the Directive should apply to early CCS demonstration projects.
- By enabling competent national authorities (e.g. UK, NL) to issue their own storage permits without a three month trip to Brussels for review.
- Allowing different viable injection and monitoring methods.
- To be more precise for easier transposition into national legislation.
- Set emission standards.
- Revise some of the unrealistic and legally doubtful requirements e.g. complete and permanent storage.
- Grants should also be awarded to support upfront appraisal.
- Withdraw Guidance documents.
- Allowing access to an EU storage permit template and existing permits submitted within the EC would promote the number of storage permits.
- Guide and encourage site pre-characterisation within member states, e.g. SiteChar, www.sitechar-CO2.eu, and CO2Stored, www.co2stored.co.uk , projects, and maximising wider benefit by access to information from the existing demonstration projects.

- The introduction of an appraisal license with the ability to store a few million tonnes of CO_2 (derived as a slip stream from already existing projects) for appraisal (to assist with seismic imaging, testing of long distance subsurface connectivity, and validation of storage security) could be an enabler in assisting with the development of the next generation of stores.

4.7.2 Case studies

Lessons from ROAD Storage permit priority for exploration permit holders

The CCS Directive states that priority for granting a storage permit for a particular site is given to the holder of an exploration permit for that site, under certain provisions. This leads to the situation that when no exploration is needed for characterisation of the storage complex (as is the case with ROAD's intended storage reservoir), applying for an exploration permit of the site would give the applicant priority and hence a potentially decisive head start over competitors.

4.7.1 Summary and conclusions

From the literature review and interviews it is apparent that only one permit has been awarded (to the ROAD project). There are numerous suggestions for how enabling policy could support an increase in the number of storage permits but it does not appear to be appropriate to expect the CCS Directive to play a direct role in increasing the number of storage permits because the Directive is intended to regulate CCS rather than incentivise it.

4.8 Q8 – Risk management framework

8. How can we evaluate the legal practicality of the risk management framework of the CCS Directive as experienced for CO_2 storage demonstration projects for both storage operators and competent authorities? How has the interaction between competent authorities and operators worked out in practice?

4.8.1 On line survey

QE13. Guidance Document no 1 on the Storage Directive defines risk management as the identification, assessment, and prioritisation of the risks to secure storage, together with the application of resources to prevent, monitor, and correct leakages or significant irregularities throughout the project life cycle. Do you have any experience of the risk management framework for CO_2 storage operators (e.g. via demonstration projects – as an operator or competent authority)?

	Yes	No	Don't know
If yes did you find the framework legally practicable?	12	18	75
Has the interaction between competent authorities and operators worked well?	11	9	85

Of the 105 responses to this question, the majority of respondents did not have experience of the risk management framework for CO_2 storage operators. Of those that did have experience, 60% responded that the framework is not legally practicable, although 55% responded that the interaction between competent authorities and operators worked well.

Overall comments received for these two questions are as follows:

Did you find the framework legally practicable?

- It is not practical and counterproductive and unwise to expect all the details of monitoring to be clear at the time of permit application. Between application and actual storage could be years.

- The framework provides a common language (familiar to the oil and gas industry) for risk which is practically helpful and the Guidance Document is legally practicable in that it explicitly states that it is not legally binding. However, the Guidance Documents are treated as de facto extensions of the Directive and provide additional constraints.

Has the interaction between competent authorities and operators worked well?

- Interaction between the UK Member State Competent Authority and the EC review team has not commenced and this provides a significant potential risk to approval of storage permits.
- We have a good process with the authorities on the NCS for the storage activities we actually are undertaking. The storage is a part of the field's discharge permit. So far, the dialogue with the authorities in this respect has been positive.

4.8.2 Written submissions

Statoil ASA - The definition of 'operator' in the Directive is not clear; especially the question if an Unincorporated Joint Venture can be the operator. This has important implications for issues in the Directive regarding a. operators technical competence b. financial requirements c. tax treatment, liabilities and financial securities.

National Grid Carbon state:

- Member State Competent Authorities need to be empowered to operate flexibly in their application of regulation based on local knowledge and circumstances.
- Commission involvement in the implementation of the Directive should be focused on facilitation of knowledge sharing, both for Competent Authorities and for industry.

OGP stated - The oil and gas industry has contributed to the development of CCS, particularly because of its unique experience in storage technologies. One of the key concerns for the oil and gas industry is how to deal with any potential overlap between CO_2-related storage activities and oil and gas production. OGP believes the EU should ensure that the rights and interests of oil and gas operators and license holders have sufficient protection in this regard, as they do not want to create conditions where CO_2 storage could impact the production of oil and gas.

4.8.3 Case studies

Lessons from ROAD Permit process and timing of FID

Issue

In ROAD's opinion there is a huge gap between the requirements of the CCS Directive and the feasibility for a concrete project such as ROAD to comply with these requirements. According to ROAD, the permitting process in the CCS Directive is not realistic for a project, because the Directive requires that all the required plans (i.e. monitoring, corrective measures, etc., as described in paragraph 5.3) are fully ready at the moment a project submits its application. In reality, developing all the studies, collecting all necessary information, and issuing reports will only be done after a FID is taken, and in order to take a FID, a granted storage permit is necessary.

Solution

To overcome this issue, ROAD have suggested the following solution: lower the level of details of all plans (i.e. monitoring, corrective measures, financial security etc.) in the application and update these plans prior to injections. The plans (not operational yet) in the permit application provide sufficient information and prove that CO_2 can be stored safely, complying with the CCS Directive requirements, but do not include operational parameters, choices for specific monitoring instruments, all of which will be elaborated in the final plans.

Way forward

At this time, the competent authorities and the EC have stated that they are satisfied with the current level of detail and have granted the permit. The EC concluded in its opinion that the application "..confirms the suitability of the chosen storage location for the permanent storage of CO_2 as was demonstrated by a detailed characterisation and assessment of the storage site and complex".

It has been agreed that the final plans will be submitted to the competent authority and the EC a year before the injection of CO_2 starts. The competent authorities must give their approval on the final plans

and before adjusting the permit the state advisors will give their expert advice. Also in 2014, the EC will be able to give another non-legally binding opinion on the update of the storage permit, when all of the plans have been elaborated.

With this agreement, the draft storage permit has been granted to ROAD (which gives them sufficient confidence to take the final investment decision for the ROAD project) and the competent authorities and the European Commission are able to approve the final plans before injection starts (which complies with the CCS Directive).

Lessons from ROAD Risk management plan

In summary, the following plans have to be developed and accepted by the competent authority:

- Risk management plan;[30]
- Monitoring plan;
- Corrective measure plan;
- Closure plan.

There is a high degree of commonality between all these plans. ROAD combined all of these requirements into one integrated ´risk management plan'. The risk management plan consists of the risk analysis (risk assessment) and the corresponding control (risk management). The risk analysis forms the basis for the corrective measure plan and for the provisional closure plan. Together, these plans provide the input for the risk-based monitoring plan.

4.8.4 Summary and conclusions

The only example to date of the permitting process being completed is for the ROAD project. Many concerns were highlighted regarding the high level of detail required on future plans before a project receives a final investment decision. Experience from the ROAD project suggests that the level of detail required should be reduced on the understanding that more detail will be provided (for approval) one year prior to injection. A specific point which could be clarified, either via a guidance document or in a future review is the legal aspect in a permit whether an 'Unincorporated Joint Venture' can be the 'operator'.

4.9 Q9 – Transfer of responsibility

9. How can we evaluate on the basis of the gathered experience the effectiveness of the criteria established for the transfer of responsibility under Article 18 of the CCS Directive? Are there any risks posed to the CCS project development?

4.9.1 On line survey

QE2. Article 18 of the CCS Directive relates to the transfer of responsibility for a storage site.

	Yes	No	Don't know	Comment
Do you think the criteria for the transfer of responsibility are sufficiently well defined?	43	34	28	25
Do you think the criteria laid down under Article 18 effectively address the transfer of responsibility of a storage site?	34	40	31	22
Are the criteria established for the transfer of responsibility workable, given the current level of knowledge on the performance of underground	38	27	40	26

[30] There is actually no obligation under the CCS Directive to develop a risk management plan. Annex I of the Directive requires several risk assessments, characterisations and operational conditions. ROAD combined all of these requirements in a ´risk management plan´.

storage projects?				
Are the recommended default periods for the post-closure pre-transfer phase and for the absence of significant irregularities practicable?	23	42	40	30

The views expressed in the comments from respondents as to whether the criteria for transfer of responsibility are well defined was mixed, with several parties expressing contrasting views. For many (around 7 parties), ambiguity remains, in particular related to the term 'permanently' which is believed to have generated a lack of common understanding. One respondent noted a report which suggested that: 'the main regulatory challenge for CCS project developers is the lack of clear criteria for the transfer of responsibility'. On the other hand, a similar number (around 8) reported that the Directive is adequate but that further guidance would be beneficial, produced either at the EU or national level. A couple of respondents note a need for feedback from real projects in determining a robust answer.

A number of key messages are evident in the comments regarding the effectiveness of the criteria. The strongest view is around the minimum period, which a number of participants suggest is too long or arbitrarily defined, and instead should be replaced by a performance based indicator (and defined by MS). A few participants note that the criteria, although clear, need to be reinforced with detailed guidance to remove ambiguity in their interpretation. Several note that the agreement around site stability should be replaced by Permit Performance Conditions for implementation throughout the remainder of the project. One party sought further clarification on the Commission's role in the process, highlighting that secondary review could increase the chance of additional costs and risk to the process.

The majority of comments suggest that the criteria established for transfer are workable, but with conditions. Many respondents caveat their view suggesting it depends on the Competent Authority, in particular whether it takes a pragmatic and facilitative approach, and is granted sufficient flexibility and not burdened by constraints of guidance documents. Some parties also suggest that site specific information needs to be taken into account. Those that suggest the criteria are not workable reference a belief they are 'too stringent' or 'too much room for political intervention' as their reasons. A couple of parties note that further experience of real scale projects is needed before a judgement can be formed.

Most participants focus their response to the question of the practicality of default periods on how the period is set, rather than whether having a period per se is practical. The majority of respondents question the suitability of 20 years, with some suggesting this is too long and others questioning its basis, suggesting it is arbitrary and should instead be based on specific technology, risks and performance criteria of each individual project. Some propose that MSs should be able to define the post-closure period and one believes that: 'This is a main obstacle to CCS in Europe; must be amended to become workable'. In the comment responses, only on a couple of occasions do parties question the practicality of having a time-limit at all.

QE2.1 Given that no CCS site has yet been transferred, is it possible to highlight any parts of Article 18 that would benefit from a revision – such as the following?

	Yes	No	Don't know	Comment
Definition of 'complete and permanent containment'	44	28	33	13
Definition of 'minimum period'	59	11	35	22
Contents of the transfer report	30	33	42	11

Parties expressed contrasting views in their supporting comments to the revision of 'complete and permanent containment'. Some encourage permanent to be clarified using quantitative criteria whereas others suggest this could be equally as problematic. Other participants suggest that 'permanent' should be revised to better reflect the risks to human health and the environment whereas another requests clarification on how complete storage is demonstrated. Several participants note that at this stage it may be more beneficial to wait until further experience is evident or the ISO standards have been sufficiently developed, and any further guidance could place additional de facto constraints on MS in making their own judgements.

The survey received a clear response to the 'definition or minimum period' through the supplementary comments. The vast majority agreed that the 20-year period was arbitrary and inappropriate and should be removed in favour of transfer being based on site-specific performance based tests (including technical and local geologic factors). In this case transfer would occur once conformance between predicted and observed store site performance is achieved. However, a couple of responses note that the Directive already allows MS some flexibility in this area.

Several possible improvements to the contents of the transfer report were suggested, for example: including a provision for providing data to the CA with a view to it being made available for research and improving the definition of modelling requirements. One suggested the PPCs developed as part of the SiteChar project could provide a valuable reference and another noted that a transfer report jointly written by operator and CA would be more comprehensive.

4.9.2 Interviews

This question was addressed in the interviews by asking for views on Article 18.

Industry

- 20 years is ok, but MSs need some flexibility.
- Would like clarity that the state will assume responsibility.

Environmental NGOs

- Some not convinced that the state should take responsibility (though some are).

4.9.3 Written submissions

CCSA - The length of the post closure obligation period is an unnecessary burden, it is not scientifically based and should be replaced by performance-based criteria.

Eurelectric - Art. 18: There are uncertainties regarding the transfer of storage sites to the state. This applies to both the duration and cost of this phase.

Global CCS Institute (GCCSI):- information from the early demonstration projects show that there are some issues related to transfer of responsibility and liabilities after closure that need attention.

GCCSI:- In more detail on the Directive:

- They highlight the importance of flexibility in the permitting process at MS level (they give the Road/Dutch approach as a good example).
- They express that some investors are worried by the '20 years minimum period' (art. 18) as 20 years is a long period with possible policy uncertainties/changes.
- They mention the financial lack of clarity surrounding the price of EUA's and the financial security that needs to be realised in a project (art. 19).
- They state that some projects felt the financial mechanisms (art. 20) are limiting the transfer of responsibilities.

International Association of Oil & Gas Producers (OGP) - The long period of uncertainty for the transfer of responsibility is hampering CCS developments.

Statoil ASA - surrender of EUAs: In the event of seepage the financial risk for the storage party is not in balance with the commercial benefits of storage. As the probability is very low this could be arranged between the MS and storage party under the ETS system.

Zero Emissions Platform (ZEP) - The 20 year minimum period (post closure) is arbitrary and could be replaced by performance based criteria.

ZEP - The way the liability, in the event of CO_2 seepage, is formulated in GD4 is a major barrier for investors. They suggest GD4 should allow for sharing this risk between operator and competent authority.

ZEP - A managed minor leakage should not automatically reset the 10 year period for transfer of responsibility.

4.9.4 Case studies

Lessons from ROAD Transfer of responsibilities

The CCS Directive states that when a storage site has been closed, the responsibility for all legal obligations can be transferred to the competent authority of the Member State, subject to several conditions:[31]

- All available evidence indicates that the stored CO_2 will be completely and permanently contained;
- A minimum period after closure, to be determined by the competent authority has elapsed. This minimum period shall be no shorter than 20 years, unless the competent authority is convinced that the first condition above is fulfilled;
- The financial obligations under the financial mechanism have been fulfilled;
- The site has been sealed and the injection facilities have been removed.

In ROAD's opinion, clarity on the transfer of these responsibilities to the competent authority is a crucial issue, which has yet to be resolved. The main concern of the ROAD project is how and under which conditions the minimum period of 20 years can be reduced.

The CCS Directive raises the possibility of reducing the minimum period of 20 years. If all available evidence indicates that the stored CO_2 will be completely and permanently contained, the minimum period can be reduced. The key questions ROAD have include:

1. Which evidence is taken into account?
2. What if the competent authority is not convinced, although all available evidence indicates that the stored CO_2 will be completely and permanently contained, for example due to leakage in another CCS project (what if for example in Canada stored CO_2 leaks and the Dutch public/politicians get worried?)
3. Who is going to assess this evidence?

The Guidance documents provide some clarity on the first question. However, due to the long term nature of CCS, it is expected that technologies and techniques could have changed by the time the transfer of responsibilities becomes relevant. As of now, the regulation on the transfer of responsibility is not detailed enough, according to ROAD. The competent authority needs to decide upon all of these issues and ROAD is concerned that decisions made today may change over time.

ROAD tried to reduce these risks in the storage permit, as the storage permit application included a plan for closure and post closure. ROAD described this process, including a timeline, which was accepted by the competent authority and the European Commission adopted a positive opinion on the draft storage permit.

This still does not provide sufficient certainty according to the ROAD consortium. In ROAD´s opinion, the CCS Directive still leaves too much room for Member States to reject permits based on the handover criteria even if all evidence indicates that the stored CO_2 is completely and permanently contained. The competent authority could simply reject the abandonment request in order to keep the well and the monitoring possibilities open. This creates unlimited liabilities and provides no certainty that the transfer of responsibilities will be established overtime. According to ROAD, this is unacceptable, certainly for proponents of demonstration projects. ROAD is of the opinion that this issue should be taken into account in the review of the CCS Directive.

[31] Article 18 CCS Directive

Lessons from the Ketzin project - The fundamental regulatory principles surrounding future site closure, transfer of responsibility to the competent authority and post-closure obligations are set out in the CCS Directive. It is interesting to note that the Ketzin site already complies[32] with the following three minimum criteria as defined in Article 18 for transfer of responsibility:

- Site is evolving towards a situation of long-term stability.
- No detectable leakage.
- Observed behaviour of the injected CO_2 conforms to the modelled behaviour.

These conditions appear to give a satisfactory high-level definition of long-term site performance. However, the CCS Directive does not give any technical criteria based on real site performance data, which could demonstrate that a storage site meets the three requirements. In order to close this gap, the Ketzin pilot site is part of the portfolio of nine international sites within the European project CO2CARE (2011–2013). The main objectives of CO2CARE are the development of site abandonment procedures and technologies, which guarantee the fulfilment of these criteria as well as so called dry runs or virtual implementations of the abandonment process at real storage sites.

The EU funded **CO2CARE project** carried out a series of dry runs mimicking the process of transfer of responsibility after definite cessation of CO_2 injection. These dry runs involved representatives of industry and regulatory entities. The dry run exercises for the Sleipner large-scale storage site and for the K12-B and Ketzin injection pilots resulted in several recommendations including (op. cit.[33] CO2CARE, 2013):

- *"The minimum periods in the Directive and its Guidance Documents (GDs) to fulfil certain key criteria are not based on scientific arguments. The CO2CARE project participants recommended that these criteria should be based on technical considerations only and should not be linked to a prescriptive time span.*
- *The added value of the evidence from hydrocarbon exploration and production in meeting the requirements for the transfer of responsibility of CO_2 storage in hydrocarbon reservoirs should be better acknowledged.*
- *To include the system of site-closure milestones and related criteria which were developed in CO2CARE, in an updated version of Guidance Document 3.*
- *A generic template for the (preliminary) risk, closure and transfer reports would clarify the requirements for passing these steps during the project lifetime and would allow the operator (and the regulator) to work towards these from the start of the project.*
- *As CO_2 storage is a multi-generational operation, consideration should be given to what tools and data should be transferred to the CA at site transfer. Models used up to the point of transfer may also need to be used post-transfer if a significant irregularity or leakage is detected."*

The White Rose project - Uncertainty over post closure monitoring period, and monitoring costs in project development have also become major barriers. The Directive provides for Member State Competent Authorities to determine on these areas. However, no precedent exists yet.

- The southern North Sea, and other shallow inshore areas, have the potential for competition for space between CCS and offshore wind.
- The majority of hydrocarbon fields in the North Sea are still producing and are unavailable for CO_2 storage. Regulatory processes are not in place in the UK to promote relinquishment of fields that have been closed and therefore, they are inaccessible to new entrants.
- The transfer of hydrocarbon closure liabilities to a future CO_2 Storage operator would make the storage business unaffordable.

[32] S. Martens, T. Kempka, A. Liebscher, S. Lüth, F. Möller, A. Myrttinen, B. Norden, C. Schmidt-Hattenberger, M. Zimmer und M. Kühn, et al., 2012, Environmental Earth Sciences 2012, DOI: 10.1007/s12665-012-1672-5 - Special Issue

[33] CO2CARE (2013). D5.4 Best Practice Guidelines, 52 p.

4.9.5 Summary and conclusions

Important concerns exist on the transfer of responsibility. The main concern is that the minimum period (20 years) is too long and/or not justified. There are calls for it to be replaced by site specific performance criteria to be set by the Member State competent authority. This would allow appropriate flexibility based on experience and the nature of the site. The Competent Authorities already have the flexibility to reduce this 20 year period. The future role of ISO standards (under development) was also mentioned. The ROAD project (with practical experience) of the permit process asked for clarity on whether the 20 year period could be reduced, on what evidence and who would decide?

The suggestion that MSs should consider their regulatory processes with regard to the relinquishment of closed hydrocarbon fields (to enable access to new entrants) appears to be a good idea and this should be raised with Member States.

4.10 Q10 – Exploration permits

10. How can we rate the ease of application of the procedures of approval of exploration permits of storage sites in the Member States pursuant to Article 5 (Exploration permits) of the CCS Directive, and how have these procedures worked out in practice? Are there any challenges which have been identified, and how could these be overcome?

4.10.1 On line survey

QE3. Do you have any experience of the application procedures for approving exploration permits for storage sites?

Yes	No	Don't Know	Comments
21	66	18	22

22 additional qualitative responses were received in response to this question. Of those that responded, many reported (or displayed) some understanding of the permitting procedure, in places through current operation of storage sites. It was suggested in a couple of instances that projects operating without knowledge of application procedures were able to advance through positive engagement with authorities or coverage under existing permits. Some also passed comment with respect to the ease and speed of the permitting process, with suggestions that the process is relatively simple, a barrier to development or neither, expressed. One respondent noted that: 'The Directive is not clear that exploration permits are not always needed'.

QE4. Are there any challenges associated with the application procedures for approving exploration permits for storage sites?

Yes	No	Don't Know	Comments
26	5	74	22

22 respondents added detail on the types of challenges associated with permit application procedures. These included:

- Lack of technical skills in involved regulators and competent authorities.
- Financial requirements being proportionate to work programme (and not carrying over inappropriate arrangements from existing industries).
- Local authority halting of projects for non-technical reasons.
- Conflicting use of sub-surface.
- Competing storage applications for the same site introducing uncertainty in application process.
- Trans-boundary and/or trans-national co-ordination issues.

- Time required and delays due to EC checking.

One respondent noted that: 'the directive and the corresponding regulations can increase the complexity in [the dialogue with local authorities] and give regulatory elements far beyond what up to now have been considered sufficient'.

4.10.2 Interviews

This question was phrased as 'What are you views on the procedures for getting exploration and storage permits?

Industry

- Some resistance to using oil and gas derived procedures because of the different stage of CCS vs, oil and gas (i.e. CCS is a new sector).
- Local opinion is unpredictable and can stop projects progressing.

4.10.3 Written submissions

EGEC remarks:

- The CCS projects publicly financed under EERP and NER should make their exploration and storage research public.
- CCS exploration licenses must only be granted for defined area and a specific period of time; related to the size and type of the project (like oil and gas licenses).
- The potential for deep geothermal in Europe must be evaluated (with an emphasis on Enhanced Geothermal Systems; (EGS)).

EGEC included two maps without comments, one on CCS potential and one on Geothermal potential. One could conclude from these two maps that they suggest that CCS is better developed more off shore and geothermal more on-shore.

Zero Emissions Platform (ZEP) - The permitting procedures should be reviewed to avoid any unnecessary delay.

4.10.4 Case studies

The White Rose project - In the UK, the 2 party approach (licensor and landlord) places additional burden on projects. The rights in UK exploration permits are issued by DECC as regulator pursuant to an Exploration Licence. The Exploration Licence is held in tandem to a Lease option with the landlord (The Crown Estate). The roles of the two organisations can become muddled in the matter of optimal asset utilisation. This needs clarification with both bodies adhering to their respective roles.

4.10.5 Summary and conclusions

It appears that there are examples of sites being explored under other MS controlled (presumably oil and gas) licensing arrangements. Although some concerns that the exploration licence requirements for CCS are overly complex were raised this does not appear to be a significant problem. Given the lack of practical experience there is not sufficient evidence to justify any changes in the Directive with regard to exploration licences.

4.11 Q11 – Storage permits

11. Application process. How can we rate the ease of application of the procedures of approval of CO_2 storage permits pursuant to Articles 6 to 11 (storage permits) of the CCS Directive, and how have these procedures worked out in practice? Are there any challenges which have been identified, and how could these be overcome?

4.11.1 On line survey

QE5. Do you have any experience of the application procedures for approving storage permits for storage sites?

Yes	No	Don't Know	Comments
25	60	20	22

If yes, how would you rate the ease of application for a storage site?

In response to the question, those that provided comments showed varying degrees of experience with the application procedures for approving storage permits, noting experience through operation of current projects or initial conversations with regulators. Where experience was highlighted, respondents presented varying opinions on the ease of the application procedure. One noted a perception that relevant authorities would have issues processing several licences simultaneously, whereas others noted high expectations of detail where little data is available, large time requirements and the potential local-political risks. Others noted that the system was clear and worked, but required additional testing. One party noted: 'There also seems to be a lack of experience sharing on behalf of the Commission and its approval of the first permit (ROAD)'.

QE6. Are there any challenges associated with the application procedures for approving storage permits for storage sites?

Yes	No	Don't Know	Comments
34	4	67	30

If yes, how could these challenges is addressed?

Parties that provided additional comments in response to this question highlighted a number of potential challenges associated with the application procedure for storage permits. These include:

- Procedures for monitoring being inconsistent with current legislation.
- Additional burden of requirement to refer draft licence to EC.
- High expectations of detailed numerical modelling.
- Homogeneity of criteria based on a single particular methodology.
- Unclear and immature relationship between MS CA, EC reviewer and applicant.
- Public acceptance.
- Ambiguity in Directive requirements and definition of storage.
- Mismatch of timelines for storage exploration and application and capture planning and investment.
- Transnational issues.

Some suggested that the Directive: 'has provided a logical and formal structure which intends to ensure a common approach' 'and the process will become easier as the number of applications increases'. In response, participants also offered a number of actions which could address the challenges raised, for example:

- Proper training of involved regulators and authorities.
- Greater and earlier co-ordination between MS CA, EC reviewer and applicant.
- Greater information sharing, including making applications available at a single co-ordinated location in a uniform language.

QE14. Are you aware that a procedure is in place for the Commission to review of draft storage permits (Article 10)?

Yes	No	Don't Know	Comments
54	23	28	42

More than half of the respondents were aware that a procedure is in place for the Commission to review draft storage permits. The majority of comments received for this question believed that this procedure is a positive step in fostering a uniform implementation. However, each site will have individual requirements as determined by its geological characteristics and thus each site will require some flexibility. There was also some resistance to this procedure, with respondents stating that it will slow down the whole process and delay project implementation. The secondary review only serves to test the competence of the MS Competent Authority or to gather information. Testing the MS CA competence can be done without delaying decision processes. Sharing of best practices developed by MSs around the EU can be achieved with parallel regulatory knowledge transfer process rather than sequential review.

QE15. Do you believe that this procedure can help enhance public confidence in CCS?

Yes	No	Don't Know	Comments
33	14	58	20

The majority of respondents answered that they did not know whether the procedure to review draft storage permits would enhance public confidence in CCS. Most respondents noted that there are other actions within Member States that will be more influential in public confidence in CCS. If the Commission's review of storage permits can increase the deployment of CCS, then there is potential that it can enhance public confidence. Real world projects are necessary to build public support in a technology.

However, if such a review led to public discord over the suitability of a potential storage site then this procedure could also greatly undermine public confidence. Social researchers and risk communication specialists frequently highlight the important role of trust for enhancing public confidence in new technologies. Therefore, enhancing confidence in CCS involves more than simply establishing frameworks and regulation. It requires an understanding of the people impacted or interested in each project and their concerns, it involves consistent, clear, communication and maintenance of relationships, and of course transparency of information, procedures and timelines.

One respondent pointed out that the Member State competent authority is more directly accountable to the public in the Member State and is more familiar with the local circumstances. The EC review team is less accountable to the relevant public and also lacks the experience of the Member State CA.

4.11.2 Interviews

Industry

- Not convinced of the value or purpose of involving the EC in permitting.
- MSs need flexibility to account for the nature (the geology etc.) of the storage site. Some stakeholders note that the current wording of the Directive allows for this flexibility, whereas others perceive the structure of the Directive as more rigid (also due to the specifications in the Guidance Documents).

Public actors:

- The process is still time consuming. One policy officer noted that there is a learning curve on the regulatory side too.

4.11.3 Case studies

Lessons from ROAD - Centralised communications

In ROAD's experience, several different sets of expertise need to be brought together to successfully obtain storage permits. These include: technical, legal, communication, regulatory, and commercial negotiations. When organising a project the interactions and relations between all of these different experts should be taken into account. Structured weekly meetings during the permitting process (especially to enable input from the external advisors) have been crucial, these included: technical experts meetings and monthly meetings with the competent authorities. Communication to stakeholders or other third parties was centralised. Communications would only be undertaken by a key team. This was highly appreciated by the competent authorities. ROAD experienced the same with the competent authorities, as they also appointed one general CCS manager. Discussing every topic of the storage permitting process with the same person was very effective.

The White Rose project - National Grid is in the process of applying for a storage permit. This process is complicated by the fact that it is the first saline formation CO_2 storage permitted in the EU and only the second EU storage permit. One of the issues is that there appears to be no sharing of experience (fully and in English) from the first storage permit (the ROAD project).

There will be several first of kind permitting procedures before applications are made easier for follow on projects. The relationship between the Member State competent authority, the EC reviewer and the applicant is immature and unclear. These challenges could be addressed by early coordination between Member State Competent Authorities, the EC and the applicant(s) and by sharing learning to date from successful and unsuccessful applications between these groups.

4.11.4 Summary and conclusions

There has only been one example to date of the process being completed (ROAD). There are some concerns over Competent Authority (CA) requiring more detail than is available at this stage of a project. There are also concerns over the additional burden of referring the permits to the EC for review (industry stakeholders question the value and purpose of having the EC involved in permit approval, seeing it as superfluous, while some others were happy with the role of the EC as an extra 'safeguard'), the lack of knowledge among CAs and transnational issues. The permitting process requires a multidisciplinary set of skills from the applicant. The EC involvement in the process is discussed elsewhere (question 30).

The relationships between the applicant, CA, MS and EC reviewer are (understandably given the lack of experience) immature. The suggestion made by stakeholders that the information on the applications made should be made publically available (ideally by the Commission) in one language is a strong one. This would be of great use to future applicants (and the CAs in these MSs).

4.12 Q 12 – Stream acceptance criteria

12. What has been the practical experience in Europe with the provisions on CO_2 stream acceptance criteria and procedures pursuant to Article 12? Have the provisions of the Directive related to risk assessment proven effective and consistent for the determination of acceptable CO_2 stream compositions by competent authority?

4.12.1 Literature review

Article 12 of the Directive discusses the acceptance criteria for CO_2 that is to be injected into storage. According to the Directive, the composition of the CO_2 stream should be verified before injection. A CO_2 stream should mainly consist of carbon dioxide. No waste or other matter may be added. Incidental impurities from the source capture or injection processes and substances used for MMV should be below levels that will adversely affect the integrity of the storage site or transport infrastructure. Impurity levels should not pose a risk to environmental or human health or breach existing legislation. In addition, the Directive states that no injection should be allowed unless a risk assessment is undertaken regarding the composition of CO_2 streams. A register must be kept of properties and quantities of CO_2 streams delivered and injected including composition of these streams.

Project data on the composition of captured CO_2 streams are difficult to acquire. In most capture processes moisture has to be removed to avoid corrosion and hydrate formation during transportation. Capture processes can deliver CO_2 streams with a purity of 95% or more[34]. Post-combustion and pre-combustion capture results in a CO_2 stream with very low levels of impurities; oxyfuel capture can also, if properly designed, produce CO_2 streams with a very limited amount of impurities[35].

Operational flexibility is an important aspect which has yet to be fully addressed for the CCS chain. Future CCS projects will be confronted with large variations in the supply of CO_2 from fossil fuel fired power plants and industrial installations and the design of the CO_2 transport and storage network should incorporate the required flexibility. Operational management has yet to be addressed in detail in large, multi-component CCS networks.

4.12.2 On line survey

QD1. What is your view on the following statements on CO_2 acceptance criteria and procedures from Article 12 of the Directive?

	Agree	Disagree	Don't know	Comment
The criteria are not strict enough and need to be tightened.	14	65	26	10
The criteria strike a good balance and are ok.	54	22	29	9
The criteria are too rigid and could be important constraints on CCS take up.	10	61	34	9
The criteria need to be adjusted to allow for greater variability and acceptance of certain additional substances.	21	46	38	14

Many respondents stated that the criteria should be made clearer and more precise but not tighter. Specific reference was made to the statement 'a CO_2 stream may contain incidental associated substances' which was thought to be vague. It was also stated that the criteria should also request the operator to publicise any cases of accidents or breaching of Article 12 stipulations and that the EU should also ensure the adoption of internationally agreed procedures for independent verification and monitoring of storage and related activities before CCS technologies are allowed to count towards greenhouse gas reduction targets *(though it could be argued that this is already the case).* It was again emphasised by many respondents that flexibility for MSs to develop country-specific solutions as currently is the case in the Directive should be retained.

Several responses stated that there is no rationale for injecting pure CO_2. These focussed on the word 'overwhelmingly' stating that this means >99% and highlighted the fact the reservoir will contain impurities anyway. One respondent, however, stated that 'predominantly CO_2' seems to be ok. In addition, some respondents stated that the definition of CO_2 stream may conflict with its use in Article 12.

A suggestion was made to review the outputs from the ISO working groups and to consider developing additional Guidance documents as the criteria and procedures seem to be routine for standard measurements, monitoring and verification (MMV).

Member State Competent Authorities should be relied upon to impose requirements on early projects, bearing in mind the potential for future inter-network co-ordination. Defining the proportion of CO_2 in a captured stream may have some relevance to the application of Article 12, Clause 1.

It was thought that a change in the wording that would make it clear that significant amounts of harmless substances can, under certain circumstances, be tolerated, was required. As the majority of CCS costs is due to capture of CO_2 from emissions, by allowing impurities in the CO_2 stream that do

[34] Thambimuthu, K., M. Soltanieh, et al. (2005). Capture of CO2. IPCC Special Report: Carbon Dioxide Capture and Storage. B. Metz, O. Davison, H. de Coninck, M. Loos and L. Meyer. New York, Cambridge University Press: 105-178.
[35] CO2Europipe (2011). D3.1.2 - WP3.1 Report - Standards for CO2, 51 p.

not seriously hinder the storage or sequestration of injected CO_2, the whole CCS chain can be made more economically feasible. It was also recognised that the current wording already allows for some margin of appreciation.

One comment stated that it should be clarified that fluids produced from the reservoir (e.g. brine, hydrocarbons, H_2S) can be recycled for re-injection in order to facilitate EOR or other innovative injection strategies. Another comment stated that the Directive should allow some co-storing of sulphur compounds. This has worked at Weyburn for almost 10 years now.

4.12.3 Interviews

This question was discussed in interviews by asking for views on article 12.

Environmental NGOs and Industry

- Generally happy with the phrasing and feel that it allows for some flexibility with an eye to future standards being developed via experience.
- One industry stakeholder thinks they should be stricter.

4.12.4 Written submissions

Zero Emissions Platform (ZEP) - The actual criteria for CO_2 composition in the Directive are sufficient.

4.12.5 Stakeholder meeting

- With regard to the need for additional specifications and the rigidity of CO_2 acceptance criteria, the general view was that the existing approach is acceptable, as it allows some flexibility in implementation.

4.12.6 Summary and conclusions

The consensus amongst stakeholders that the wording in Article 12 would benefit from clarification, but should not be tightened and MS flexibility should be retained appears valid. A specific suggestion for clarification is with regard to the word 'overwhelmingly' which some interpret as being higher than 99% - which is considered too high. Another suggestion is that the wording could be adjusted to specifically allow any fluids produced from the reservoir to be re-injected (e.g. to enable EHR), although this activity is not prohibited by the current wording. As mentioned by some stakeholders it is sensible to assume that these details will be clarified in future standards (such as ISO). Given the lack of practical experience to date and the mixed views on the current phrasing it would seem appropriate that the wording should be left as it is until further experience has been gained.

4.13 Q13 – Storage site assessment criteria

13. What has been the practical experience, particularly in the development of European CO_2 storage sites and complexes, of using the criteria for the characterisation and assessment of the potential storage complex and surrounding area referred to in Article 4(3) and as outlined in Annex I of the CCS Directive? Has there been sufficient progress in the knowledge basis on issues such as data collection, three dimensional static geological earth models, characterisation of the storage dynamic behaviour, sensitivity characterisation, and risk assessment methodologies for CO_2 storage sites and complexes which could be taken into account in a meaningful and effective way.

4.13.1 On line survey

QE7. What is your view of using the criteria for the characterisation and assessment of the potential storage complex and surrounding area referred to in Article 4(3) and as outlined in Annex I of the CCS Directive?

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
The criteria are not strict enough and should be tightened.	5	13	33	17	29	5
The criteria strike a good balance and are ok.	46	14	7	5	30	46
The criteria are too rigid and could be an important constraint on CCS take up.	8	16	43	4	31	8
The criteria need to be adjusted to allow for them to be practically enforceable.	15	18	30	2	33	15

20 additional comments were provided in response to this question. In general, the majority of comments suggested participants believed the criteria are adequate to ensure safe and environmentally secure storage. However a number of parties suggested that the criteria could provide MS with greater flexibility in applying their own judgement which is important to capture site-specific elements. One party noted: 'Some criteria are rather vague, while others are very specific so some clarification would be welcome'. Others noted that the criteria could be: made more practical, updated in light of existing experience or made more quantitative in nature.

In addition, a number of comments focused on specific elements of the criteria, including:

- 'The level of model coupling requested is far beyond typical practice'.
- 'Art 4(4) … wording implies that all risks can be known at the time of site selection'.
- 'Annex I assumes injection of supercritical CO_2 …. In the case of e.g. injection of dissolved CO_2 …. 3D monitoring of the cap-rock as described in Annex 1 is therefore irrelevant'.
- 'Clarification of the degree of inclusion of the 'footprint' of the increased pressure of CO_2 injection is required'.

QE9. In the last five years (since the entry into force of the CCS Directive), how well do you think knowledge has progressed on the following CO_2 storage issues?

	Very good progress (world class)	Some progress	Minor progress	No progress (since 2009)	Don't know
Data collection	6	52	14	2	31
Three dimensional static geological earth models	17	41	12	1	34
Characterisation of the storage dynamic behaviour	18	37	13	2	35
Sensitivity analysis	12	29	20	4	40
Risk assessment methodologies	13	42	19	2	29
Monitoring technology	17	38	19	2	29
Corrective measures	2	21	25	12	45

Some comments were provided under "other" for this question. The respondents agreed in general that there has been some advances in progressing knowledge. The progress can however differ depending on a country (progress is dependent on political and national financial support). Few respondents however remarked that this is all theoretical knowledge/progress at the moment in

Europe, the largest gains in knowledge are however gained through the increased numbers of demonstration projects (mostly in North America). The slow progress of large scale storage demonstration projects in Europe has placed a constraint on the development of the knowledge. Experience from North American projects has led for example to the publication of a series of best practice manuals which are periodically updated in the light of new project findings; understanding has also progressed through the US DoE projects, the EU CCS Knowledge Share Network projects and Shell's Goldeneye FEED assessment.

Some further examples of areas that have not significantly progressed were provided by some respondents - methodologies to assess regional CO_2 storage capacities & risks. The published studies around the world are not using the same methodologies: many capacities are largely overestimated. Modelling for integrity of the store is a CCS industry specific requirement. New work flows and tools are required for CO_2 storage. The modelling is also far more complex than dynamic reservoir simulation and the computational requirements can be onerous so computational and model formulation developments in this area require improvement.

Several respondents also noted that it is difficult to comment on corrective measures as no leakage has occurred. Also corrective measures outside of well-engineering have little field experience specific to CO_2 storage.

A few respondents suggested that the questions of public acceptance and the evaluation of cost-benefits of CCS storage sites should be added to the list of issues on which knowledge has improved in recent years..

4.13.2 Interviews

This question was partly covered in the interviews by asking for views on how well knowledge related to storage has developed in the last five years, and what gaps remain.

Industry

- Article 4(3) criteria are ok.
- Knowledge has been developing, but the end goal needs to be 'risk based' not 99% containment for ever.
- Less progress on corrective measures.

Environmental NGOs

- Highlight that there are still gaps in the knowledge.

4.13.3 Written submissions

The reaction of European Geothermal Energy council (EGEC) does not directly comment on the Directive review process, but they do comment on the general relation between CCS and Geothermal Energy. Some of these issues directly touch on the Directive.

- They see CCS as a bridging technology (short and medium term) and Geothermal as a sustainable energy with a much longer time horizon.
- A research collaboration for diverse common interests should start.
- The two could be competing and therefore regional planning for the sub surface is required in order to maximise benefits for society.
- When competing directly priority should be given to Geothermal.
- In this regard, where possible, off-shore storage for CCS is preferred.

Reykjavik Energy's main concern with the Directive is that it only looks at CCS as injection of gas in supercritical phase. They use a different approach: CO_2 dissolved in water and then mineralisation via chemical reaction (CarbFix). They use this in combination with geothermal energy.

This technology requires far less safety and monitoring and this should be appreciated in the Directive. The Directive should be differentiated for the different CCS technologies depending on the safety of the injection and storage methods applied.

4.13.4 Case studies

Ketzin project - Four years of CO_2 injection, scientific investigations and communication at the Ketzin pilot site have demonstrated the feasibility of CO_2 storage at the research scale and yielded the following results and lessons:

- Fundamental knowledge about the geological storage of CO_2 in deep saline formations.
- The geological storage of CO_2 at the pilot site Ketzin has been running reliably and safely with no indication of CO_2 leakage.
- Geophysical and geochemical monitoring methods are effective in detecting small quantities of CO_2 and can be used to image the spatial CO_2 distribution and to quantify the amount of stored CO_2.
- Dynamic simulations are capable of describing the temporal and spatial distribution of the CO_2, and underline their suitability to predict the pressure development and the CO_2 behaviour in the reservoir.
- Downhole pressure data prove correlation between the injection rate and the reservoir pressure and indicates the presence of an overall dynamic equilibrium within the reservoir.
- The extensive geochemical and geophysical monitoring program is capable of detecting CO_2 on different scales and gives no indication of any leakage.
- Numerical simulations (history matching) are in good agreement with the monitoring results.
- Storing CO_2 in the subsurface is a lifelong learning-process: predicting -> storing -> comparing ->understanding.
- Down hole temperature and pressure are very important parameters for daily operation.
- Geophysical and geochemical methods used were able to detect the CO_2 plume and gave valuable input for the models.

The Getica Project - The CO_2 storage potential in Romania has been identified as relatively high. The total estimated storage capacity for Romania is 18.6 Gt in deep saline aquifers and 4.0 Gt in depleted hydrocarbon fields[36]. The Turceni power plant is located in the south-west of Romania, an area that is considered the most industrialised region, responsible for approximately 40 percent of the total emissions of CO_2 at the national level[37].

This places the Getica project at the heart of a future possible CCS hub, with further application of CCS to other regional power generators and industry. The appraisal activities to be performed within the Getica project onshore storage system will be valuable for future CO_2 storage activities in the area. Future potential developments include Rovinari PP (1300MWe), Craiova II CHPP (300MWe), Isalnita CHPP (600MWe), petro-chemical and metallurgical industries[38].

According to the Feasibility Study undertaken for the project, there was a high degree of effort needed to acquire the existing geological data for the potential storage area. This is due to the Getica project targeting deep saline aquifer formations in an area where several oil and gas companies have conducted prospecting campaigns in the past. Further, the data collection process itself (data in

[36] Feasibility Study Overview Report to the Global CCS Institute, available at http://decarboni.se/sites/default/files/publications/84541/getica-ccs-demo-project-feasibility-study-overview-report.pdf
[37] Our Future is Carbon Negative: A CCS Roadmap for Romania, available at http://bellona.no/filearchive/fil_Romania_final2.pdf
[38] http://www.minind.ro/invest/new/Electric_Energy_Sector/SC_Complexul_Energetic_Turceni_SA/CCS_Demo_Project.pdf

various formats from different companies) was time consuming. Depending on the source of information, procedures and protocols had to be followed, such as engaging the oil and gas national authority, consolidation of data in a satisfactory database, and the digitalisation of the data in a common usable format. A scenario where geological data is available from a single source and that source is the developer of the CCS project provides an acceptable balance between cost, time and risks during the assessment and characterisation phases.

4.13.5 Summary and conclusions

The criteria are generally viewed as acceptable by stakeholders. However, stakeholders felt that while some requirements are vague, others are very specific and could potentially limit MS flexibility to take account of site specific issues. Some feel that the use of different injection methods (for example CO_2 dissolved in water (as proposed in Iceland in combination with geothermal energy extraction) should be more clearly permitted by the Directive – however there is no evidence that this approach is prohibited so no change would be recommended. There has been some progress on most issues, but it is highly varied between MSs and there has been more practical experience gained in North America than in Europe. The published work that has been done on CO_2 storage capacity has used a variety of methodologies, which makes comparison difficult or not possible. Difficulties have been reported in getting geological data from areas explored (and/or used) by oil and gas companies.

From the Ketzin and other storage tests, it appears that storage can be safely achieved, with no leakage and with a good match between reality and modelled expectations. In conclusion there has been some good progress made with regard to knowledge and small scale pilots of site characterisation but more and larger scale tests are still required.

4.14 Q14 – Site monitoring plans

14. What has been the experience, in the development of CCS projects and their storage sites and complexes, of using the criteria for establishing and updating the monitoring plan referred to in Article 13(2) and for post-closure monitoring plans pursuant to Annex II? What is the experience in using this Annex for the preparation of the storage permits, and has this proven practically enforceable?

4.14.1 Literature review

Article 13 discusses the monitoring requirements and obligations. Monitoring is essential to assess whether injected CO_2 is behaving as expected, whether any migration or leakage occurs, and whether any identified leakage is damaging the environment or human health. Member States are requested to ensure that during the operational phase, the operator monitors the storage complex and the injection facilities. A monitoring plan should be designed, submitted to and approved by the competent authority within the Member States. In the case of geological storage under the seabed, monitoring should further be adapted to the specific conditions for the management of CCS in the marine environment. The operator should ensure monitoring even after the site has been closed and responsibility has been transferred (Article 18).

4.14.2 On line survey

QE8. What is your view on the following statements relating to the criteria for establishing and updating the monitoring plan referred to in Article 13(2) and for post-closure monitoring plans pursuant to Annex II of the CCS Directive?

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
The criteria are not strict enough and should be tightened.	5	6	7	40	18	29
The criteria strike a good balance and are ok.	3	38	19	10	3	32

The criteria are too rigid and could be an important constraint on CCS take up.	6	11	13	30	11	34
The criteria need to be adjusted to allow for them to be practically enforceable.	11	18	13	21	9	32

11 additional comments were received upon reflection of the criteria related to monitoring plans expressing a variety of views. Some consider the criteria adequate with the importance of taking account of site-specific elements, and others suggested it is difficult to judge now due to lack of experience but the monitoring industry will continue to develop with new standard practice. A couple of respondents suggested the criteria need to be reviewed with potential storage operators and regulators and refined where possible and others suggested specific amendments, such as: defining the parts of the monitoring plan that shall apply to the reservoir, to the cap rock and to the superficial aquifers, and incorporating monitoring for attribution of CO_2 source when CO_2 detected at surface.

4.14.3 Interviews

This question was covered by asking for views on article 13(2).

Industry

- Criteria are ok and should not be tightened as this would be over prescriptive.
- Guidance Document 4 may be too prescriptive on this issue.

4.14.4 Written submissions

Eurelectric - Art. 3[39]: Minor/major leakage and 10 year period reset should be changed. They suggest that the 10 year restart counts for geological faults and leaks but not for leakages caused by technology or human action.

The IEA Greenhouse Gas R&D Programme (IEAGHG) provide options for revisions based upon its work in the areas of capture readiness and monitoring. If Article 13 is revised, there is an option to improve the monitoring protocols provided in Article 13 and in Annex 2 [1] and the Guidance Document 2 [3]. New techniques and existing techniques applied in new ways are available in order to identify the source of CO_2 detected at the surface. Monitoring protocols can now be amended to include the practice of 'CO_2 attribution monitoring' as a step to determine the source of the CO_2 before deciding whether to engage upon monitoring for quantification of leakage and assessment of impacts. Whilst the current monitoring protocol as provided by the CCS Directive and the CCS MRG does not necessarily preclude the use of attribution monitoring, clarification and recommendation on the use of such techniques could be helpful to operators and competent authorities, and would have the potential to improve the efficiency of the monitoring protocol and to reduce costs for monitoring and quantification of suspected leakage.

4.14.5 Summary and conclusions

There is general acceptance that the criteria are workable, i.e. fit for purpose. There were a number of comments on areas that could be clarified. For example clarification on which parts of the storage reservoir the monitoring should apply to, e.g. – just the reservoir? The cap rock? The whole aquifer? Despite these questions it is too early (given the lack of practical experience) to more tightly specify technical requirements as it risks being over prescriptive and limiting MS flexibility.

[39] The project review team expects that Eurelectric means Guidance Document 3 rather than Article 3 of the CCS Directive. GD 3 reads that "in order to address a leak, the clock for the ten-year time period should be re-set to start from 'the point in time when the corrective measure has been proven successful'"

4.15 Q15 – 17 Third party access and trans-boundary issues

15. As recalled by recital 38 of the CCS Directive, depending on the carbon price, access to transportation networks and storage operators could become a condition for competitive operation in the EU energy market. What has been the practical experience across Member States of the implementation of the provisions concerning third-party access (Article 21 of the CCS Directive) with the view to ensure that potential users are able to obtain access to transport network and storage sites in a transparent and non-discriminatory manner? How can we rate the procedures implemented by the Member States in terms of adequacy and effectiveness? In general terms, in light of the experiences

16. What has been the practical experience with the settlement of disputes about access to transport networks and storage sites, both within one Member State and across Member States? (Article 22 of the CCS Directive). How can we rate the procedures implemented by the Member States in terms of effectiveness?

17. Pursuant to Article 24 of the CCS Directive, the competent authorities of the Member States shall jointly meet requirements of the CCS Directive and other relevant Community legislation in cases of trans-boundary transport of CO_2, trans-boundary storage sites or trans-boundary storage complexes. Has there been any practical experience of cooperation among Member States, and how effective were those?

4.15.1 Literature review

The technology for CO_2 pipeline transport is well established, both on land and at sea, and CO_2 transportation infrastructure continues to be commissioned and built, particularly in the US and Canada. Carbon dioxide pipelines and ships pose no higher risk than is already managed for transporting natural gas and oil. In North-West Europe alone, recent studies suggest that a network of backbone transport pipelines with a total length of the order of 30,000 km is needed to enable large-scale CCS, by 2030[40]. Therefore, the scale of transportation infrastructure and investment required to enable large–scale deployment of CCS will be extensive.

Adequate incentives are needed for first mover projects to invest in oversized CCS transport solutions capable of accommodating future CCS projects. The construction and operational experience that exists mainly in the US and Canada for CO_2 transport needs to be shared globally by industry as best practice guidelines and standards, especially given the unique engineering and operating conditions for first-of-a-kind CCS plants. Large-scale deployment of CCS in Europe implies a *cross border transport infrastructure* of CO_2.

As CCS has not been implemented on a large scale, more detailed regulation or guidance beyond the minimum required by the Directive on third party access to CCS infrastructure has not yet been a pressing issue. However, for a healthy market, there has to be clear regulation regarding allocation of liability, revenues etc. for when third parties join a CCS project. So far, only the UK has such regulation in place.

4.15.2 Interviews

Input to these questions came from seeking views on articles 21 and 22

Industry

- Lack of experience to date, this is coming up as an issue that needs to be looked at. Appears that some MS regulation will be required.
- One detailed submission on this issue (also in written submission)
    1. CO_2 transport and storage area should be separated as the impact of third party access applies differently in both cases.

[40] CO2Europipe, 2011. Developing a European CO_2 transport infrastructure

2 The current provisions on third-party access ("TPA") do not adequately take into account the distinct nature and characteristics of CO_2 storage infrastructure.

3 It seems challenging for a reasonable and prudent storage provider to be forced by the authorities (or an expert/independent body) to increase the storage capacity, define spare capacity, increase and prolong the time for liability (also for initial volumes) and obligations or overrule terms and conditions offered for these services.

If the Directive is to be revised Article 21 following options should be considered;

- The respective MS can have a right to exclude the provision of TPA on storage in the CCS Directive.
- To the extent that the TPA rules still apply and storage provider is overruled and still disagrees with the conditions imposed by the authorities, then the MS or the third party requiring access rejected by the storage provider should have an obligation to take over the site and all the obligations to the storage provider and indemnify the storage provider for all costs and losses which may occur as a result of such transfer of the site
- That TPA should be applicable only to "Authorised Capacity" in the permit – in other words such Authorised Capacity is linked to both injection capacity and accumulated capacity in the permit.

4.15.3 Written submissions

The International Association of Oil & Gas Producers (OGP) propose a derogation possibility for 'Third party access' in line with second gas directive as at this stage of CCS development it can create an obstacle for CCS deployment.

Statoil ASA - The current provisions on third party access are viewed as problematical because they impose unknown risks to a storage operator. Storage and transport should not be treated as one as they are different. Solutions could be to:

- Restrict the TPA to 'authorised capacity' in the permit.
- The respective MS should have the right to exclude the provision on TPA.
- If it still applies the MS or the Third Party taking over should have the obligation to take over the site and all obligations with it.

4.15.4 Case studies

Lessons from ROAD Transport

Although the Directive gives some general factors that should be taken into account by Member States when regulating third-party access to infrastructure, ROAD observes that many stakeholders in the EU believe that the CCS Directive leaves too many uncertainties if Member States do not effectively translate the coverage of third-party access issues into national legislation. For CCS to become commercially feasible, industry will need more guidance from the legislator, according to ROAD. Legislation must explain under which specific conditions third-party access to infrastructure can be denied. More guidance and regulations could be included in any revision to the CCS Directive, otherwise Member States themselves should develop a regulatory framework that ensures clarity on which conditions third-party access can or cannot be denied.

NB: In the short term this does not seem to be a problem for the Dutch situation; CCS interested parties appear willing to work together on the development of the infrastructure to reduce costs.

4.15.5 Stakeholder meeting

- The point was raised that more attention in the regulatory framework is needed on the issue of trans-boundary CO_2 transport.

4.15.6 Summary and conclusions

There has been no practical experience of articles 21, 22 or 24 yet.

The technology for the pipeline transport of CO_2 is well established and there is experience being gained on the issue in North America. Experience in Europe remains very limited. The industry opinion is that there are no higher risks than for the (very common) transport of natural gas or oil. There is a need for a cross border transport (and storage) network to be available before large CCS is possible, this will require large investment and 'over sizing' to enable future CCS growth.

There are some concerns over the scope of article 21, with regard to allowing third party access to storage capacity. These centre on the inability of the storage operator to refuse access and the arrangements for the sharing of the liability associated with a shared storage site. Suggestions have been made on how these concerns could be addressed. However, there does not appear to be a problem in the short term as developers appear happy to cooperate. The evidence and opinions suggest that the coverage of this issue is left as it is but should be considered in a future review, in the light of experience.

The issues of transboundary transport of CO_2, particularly the London Protocol, are discussed again under questions 38 and 39.

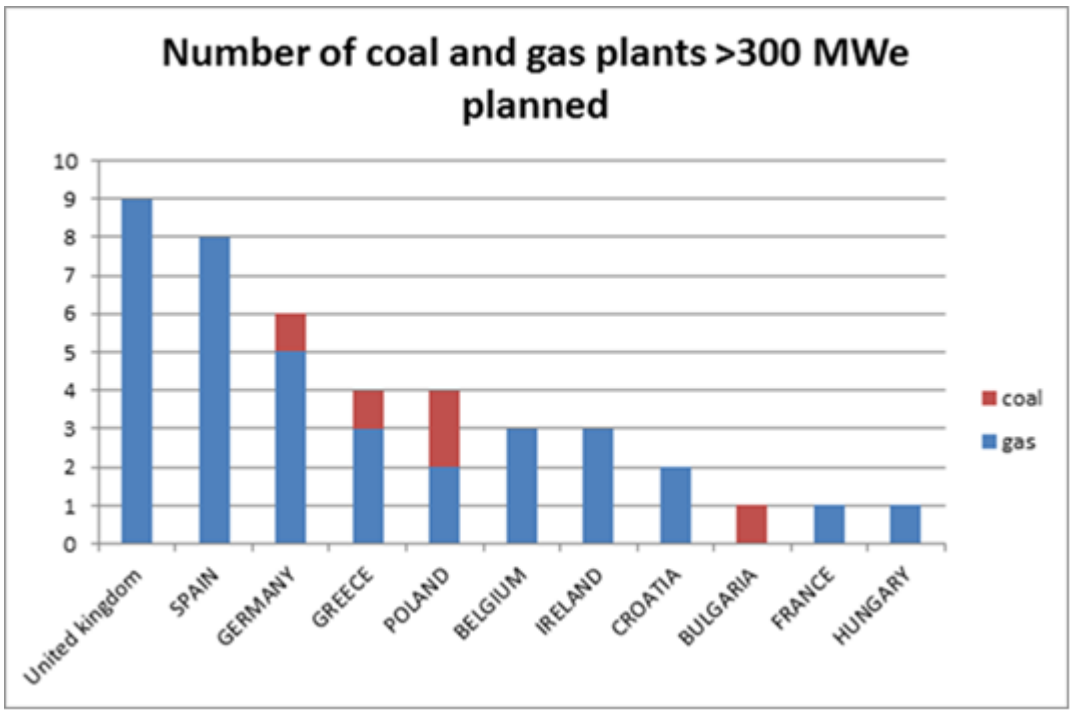
4.16 Q18 – Capture ready plants

18. What is the experience across Europe of the application of the provisions of Article 33 of the CCS Directive? How can we rate the effectiveness of implementation of Article 33 in the national legislation with the view to support the future implementation of "capture ready" plants, e.g. fossil fuel power plants built with the assurance of a future proven CCS retrofit option? Has the practical application of Article 33 showed that it is possible to ensure that adequate conditions for the preparation of CCS implementation for new fossil fuel power plants can be met in a harmonised way across Europe? (for this specific question, the contractor is expected to base its assessments on the concrete list of cases of power plant licensing in Europe and their outcome)

4.16.1 Literature review

While performing the literature review regarding 'carbon capture readiness' (CCR) and consulting representatives from power companies and regulatory agencies it became clear that to date there has been no systematic work done on gathering experiences from permitting CCR for large combustion plants. An exception to this is the UK where substantial information is available on the implementation of CCR requirements in combustion plant permits provided by the competent authority and the permit applicants. A thorough review of the current state-of-the art in the inclusion of the CCR requirements in combustion plant permitting would require a large amount of resources which are beyond the scope of the current assignment. At the moment this section describes experience with the CCR requirements in permitting and illustrative examples, primarily based on information from the UK.

We also asked Member States by contacting members of the Information Exchange Group on the Implementation of the CCS Directive on the CCR aspects of consents based on power stations reported (in the Platt's database) to be 'in planning'. The consent status (including consent date) of these 42 plants is not given in the Platt's database.



Source: Platt's database

It may be the case that these plants were consented before the CCS Directive was enacted, although the CCR clause had immediate effect, so would not have been delayed by transposition issues. The following table lists these plants and the probable start dates, for all those Member States with two or more plants (apart from the UK which is covered in more detail later in this section):

PLANT	COMPANY	Year to start operation	Fuel	TPC, MW	COUNTRY
CATADAU	INTERGEN (UK) LTD	2016	gas	1200	SPAIN
CUBELLES (FOIX)	ENDESA SA	2015	gas	500	SPAIN
PALOS FRONTERA EGH	ENERGIA Y GAS DE HUELVA SAU	2017	gas	1200	SPAIN
ALANGE IBERDROLA	IBERDROLA SA	2017	gas	850	SPAIN
LA PEREDA ENDESA	ENDESA SA	2015	gas	400	SPAIN
LANTARON GN	GAS NATURAL FENOSA	2016	gas	800	SPAIN
LEDESMA	ENDESA SA	2016	gas	800	SPAIN
CUBILLOS DEL SIL	ENDESA SA	2018	gas	824	SPAIN
MARZAHN	VATTENFALL EUROPE AG	2016	gas	300	GERMANY
PROFEN	MITTELDEUT BRAUNKOHL (MIBRAG)	2020	coal	660	GERMANY
KREFELD TRIANEL	TRIANEL GMBH	2016	gas	1000	GERMANY
HAIMING	OMV GAS & POWER	2019	gas	850	GERMANY
BUBESHEIM	SWU STADTWERKE ULM/NEU-ULM	2018	gas	1200	GERMANY
KARLSRUHE MIRO	TRIANEL GMBH	2012	gas	800	GERMANY

VOLOS	MYTILINEOS HOLDINGS SA	2015	gas	440	GREECE
PTOLEMAIS-V	PUBLIC POWER CORP (DEI)	2019	coal	660	GREECE
KORAKIA	PUBLIC POWER CORP (DEI)	2015	gas	500	GREECE
MANTOUDI	GEK TERNA	2016	gas	1160	GREECE
BYDGOSZCZ-IV	ZESPOL ELEK BYDGOSZCZ SA	2018	gas	430	POLAND
POLNOC	KULCZYK POLENERGIA	2018	coal	2000	POLAND
GRUDZIADZ	ENERGA SA	2017	gas	600	POLAND
KWSA SLASKIE	KOMPANIA WEGLOWA SA	2020	coal	900	POLAND
NAVAGNE	EDF LUMINUS	2016	gas	920	BELGIUM
EVERGEM	NEST-ENERGIE	2016	gas	920	BELGIUM
DILS-ENERGIE	ADVANCED POWER AG	2017	gas	920	BELGIUM
TOOMES	QUINN ENERGY	2015	gas	450	IRELAND
DERRYGREENAGH	BORD NA MONA GROUP	2016	gas	600	IRELAND
LUMCLOON	LUMCLOON ENERGY LTD	2015	gas	350	IRELAND

The MS contacts were asked to answer the following questions on these installations:

- The date (if any) on which these plants were consented.
- Was the plant required to demonstrate CCR? If not, why?
- If yes, what requirements were placed on it? Is this information available in English?

The following responses have been received

Belgium:

CCR Article 33 transposed into legislation:

Regional Flanders: Article 30ter of 'Vlarem I' (the Flemish Government implementing order of 6 February 1991 on environmental permits, as modified)

Federal government: In 'Royal Decree of OKTOBER 2000 regarding awarding individual permits for the construction of power installations '**.** (CCR obligations added 1 September 2011). Art. 4 § 2 5 and Art. 3 12.

Current status:

EDF Luminus Navagne: federal production license expired.

Nest-Energie, Evergem: federal production license expired.

The following proposals for new generating plant have valid Federal production licenses:

- Eneco Meerhout Beringen 1000 MW, 2 STEG + GT, building not started, license expires August 2016
- Dils Energie Dilsen 920 MW, 2 STEG, building not started, license expires July 2015
- Electrabel Amercoeur (2) 420 MW, 1 STEG, building not started, license expires September 2016
- EDF Luminus Everghem 920 MW, 2 STEG, building not started, license expires July 2016
- ENI Power Generation SA Manage 450 MW, 1 STEG, planned around 2018-2019, building not started, license expires mid 2019

The ENI Power Generation SA Manage is the only plant which had to comply with the CCR Federal rules, the other 4 power plants applied before it was in force. The ENI plant has demonstrated that all conditions of Art. 4 § 2 5 have not been fulfilled. Therefore Art.3 12 was not a license condition.

Evidence of CCR Application:

The only CCR application received from the Belgium government relates to the Dils-Energie gas plant.

Poland

CCR Article 33 transposed into legislation:

Poland implemented the EU CCS Directive in October 2013 by an amendment to the Polish *Mining and Geological law* and updates to other legal acts. CCS readiness is covered by Art. 66, 82 and 88 of the *Act on access to information about environment and its protection, on participation of society in environmental protection and on assessment of impact on environment.* The Act requires combustion installations of greater than 300 MW, to include of an assessment of CCS readiness on the basis of possible access to underground CO_2 storages and technical & economic feasibility of CO_2 transportation grids in their environmental impact report. The CA then decides on the required CCS readiness mode.

Current status:

There are currently power plants with a total capacity over 5,200 MW under construction in Poland. The breakdown is as follows:

Stalowa Wola - 400 MW (gas),
Włocławek - 463 MW (gas),
Kozienice - 1 000 MW (hard coal),
Opole - 2 x 900 MW (hard coal),
Jaworzno - 910 MW (hard coal)

and six units with a capacity of more than 50MW each (their total capacity amounts to almost 700 MW, all will be fossil fuel fired). There are plans under preparation for generation units with a total capacity of 13,600 MW.

NB The names given here do not match (very well) with those used in the Platt's database, although the total capacity and mix is similar.

Evidence of CCR Application:

CCR assessments are not publicly available. An application for this information can be submitted to the CA during their consideration process.

Spain

CCR Article 33 transposed into legislation:

The requirements on future power plants, in relation to CCS, are established in the Spanish law 40/2010 and royal decree 815/2013. They are fundamentally the same as in Directive 2009/31.

Current status:

The official view is that the plant listed in the Platts database are unlikely to be built, especially to the suggested timescales. It is estimated that 6,000 MW of CCGT installed capacity is currently mothballed in Spain.

Evidence of CCR Application:

No known practical application to date.

No responses have been received from the other MSs contacted.

Prior to the approval of the EU CCS Directive in 2009, 'capture ready' existed as a concept, rather than a legal requirement. During 2007 and 2008, EU ETS prices were relatively high at between €25 to €30 per EUA, and therefore the economic risks of building an unabated coal-fired power plant in Europe provided potential operators with an incentive to consider options for CO_2 capture. A review of the 'carbon capture readiness' of existing and planned gas and coal-fired power plants up to 2008 was conducted by Graus *et al*., 2011. From an industry questionnaire of 20 planned coal-fired power plants and 32 gas-fired power plants, 65% of coal-fired power plants and just 2% of gas-fired power plants were considered 'capture ready'. It could be derived from this assessment that the majority of gas-fired power plant developers did not consider it necessary to ensure a plant was CCR.

According to Article 33 of the EU CCS Directive, from April 23rd 2009, all combustion plants with a rated electrical output of 300 megawatts to be granted an operational license can be retrofitted for CO_2 capture (or 'carbon capture ready' abbreviated as CCR). Although the term CCR is not specifically used in the Directive, it is defined in the following way:

1. Operators of power plant have to assess whether a) suitable storage areas are available, b) transport facilities are technically and economically feasible, and, c) it is technically and economically feasible to retrofit for CO_2 capture.
2. If these 3 conditions are met the competent authority must ascertain that suitable space for the capture and compression installations has been reserved.

All Member States that confirmed transposition of the CCS Directive into national law implemented the 'CCR provisions' in Article 33[41]. Germany, France, Hungary, Poland, Romania, Slovenia and United Kingdom reported to the Commission that they have practically applied these provisions to new combustion plants.

The EC did not define additional guidelines for CCR in their Guidance Documents. In the UK additional guidance on CCR was defined saying that new combustion plants with a capacity of 300 MWe or more can only be built if they comply with the EU CCR provisions. Regulation in France states that space reservation is compulsory and is not dependent on the outcome of the CCR assessment[42]. Furthermore, coal-fired power plants need to be subjected to the CCR rules without limitations on their capacity.

The UK government can be considered to have taken the most rigorous approach of all Member States in implementing Article 33 of the Directive. The requirements of the Directive, are transposed into Article 36 of the Electricity Act 1989. Although slightly more detailed, the key features of Article 33 of Directive remain consistent in the transposition to the Electricity Act. The Act requires that the CCR feasibility assessment needs to be positive in order for planning consent to be provided, and if consent is granted, the operator must continue to provide updates of the CCR assessment every 2 years until retrofit takes place. The DECC guidance note on Carbon Capture Readiness specifies more detail than Article 36 on what should be included in a CCR feasibility assessment. The important features of the guidance note include:

- Minimum land footprints for a range of capture installations, specifically CCGT with post, pre- and oxy- combustion capture, ultra-supercritical pulverised coal with post and oxy-combustion capture, and IGCC with capture.
- A series of checklists concerning the technical aspects to be included for the technical feasibility of the post-combustion amine scrubbing capture system for gas and coal plants, and pre-combustion on natural gas combined cycle plants.
- Identification of a pipeline route with a 1km corridor, with potential obstacles identified.
- A table of realistic and viable fields which could be selected for CO_2 storage, including the expected CO_2 to be stored during the plants operation.
- Information on the parameters, methodology and scenarios to be used for the assessment of the economic feasibility.

Since the enactment of the Directive in 2009, in the UK a number of large combustion plants, primarily combined cycle gas turbine (CCGT) power stations, have been granted planning consent under Article

[41] EC (2014). Report from the Commission to the European Parliament and the Council on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide, COM(2014) 99 final, 8p.
[42] GCCSI (2012). CCS Ready policy and regulations – The state of play, Progress towards the implementation of CCS Ready policy and regulatory frameworks, 81 p.

36 of The Electricity Act 1989[43], and have passed the requirements for CCR. An overview of these plants is provided in **Table 1**.

Table 1: Large combustion plants which have received planning consent in the UK since including CCR approval in the UK

Date of Decision	Company / Location in the UK	Type of power plant	Maximum Output
11.09.14	C.GEN Killingholme Ltd/ North Killingholme, Lincolnshire	Thermal Generating Station (either CCGT or IGCC) - Planning Act 2008	Up to 470MW
28.07.14	ScottishPower (DCL) Limited – Damhead Creek II, Isle of Grain, Kent	CCGT/S36C Electricity Act 1989	n/a
31.10.2011	Thorpe Marsh Ltd (Acorn Power Developments) Thorpe Marsh Doncaster	CCGT, Section 36	1500 MW
04.08.2011	Gateway Energy Centre Ltd, Manorway, Stanford-Le-Hope, Essex	CCGT - section 36	900 MW
04.03.11	RWE Npower, Willington C, Derbyshire	CCGT/OCGT - Section 36	2400MW
23.02.2011	Abernedd Power Co Ltd Abernedd Power Plant Baglan Bay	CCGT - Section 36	870MW
25.01.11	Scottish Power Damhead Creek Isle of Grain	CCGT - Section 36	1,000 MW
11.11.10	Spalding Energy Expansion Ltd West Marsh Road Spalding Lincolnshire	CCGT - Section 36	900MW
01.04.10	Wainstones Energy Ltd Carrington Greater Manchester	CCGT Section 36	1,520MW

The Crown Estate, who are responsible for providing the lease agreements for potential CO_2 storage sites, have produced a map (**Figure 1**), which highlights the locations of the CCGT power stations which have passed the CCR requirements under Article 36, and their chosen storage locations as submitted for consent applications. According to The Crown Estate, the map highlights some of the highly challenging routes selected by power plant operators, which puts some doubt on the value / quality of the CCR feasibility assessments for certain sites. For example, according to consent applications, the Abernedd CCGT Power Plant in south Wales would produce 2.4MtCO_2 per annum, and would need a considerable pipeline to reach the selected storage sites in South Morecambe Bay. The project did however pass the economic feasibility assessment, that CCS could be applied within the lifetime (assumed 30-35 years).

[43] This information is drawn from https://www.og.decc.gov.uk/EIP/pages/recent.htm

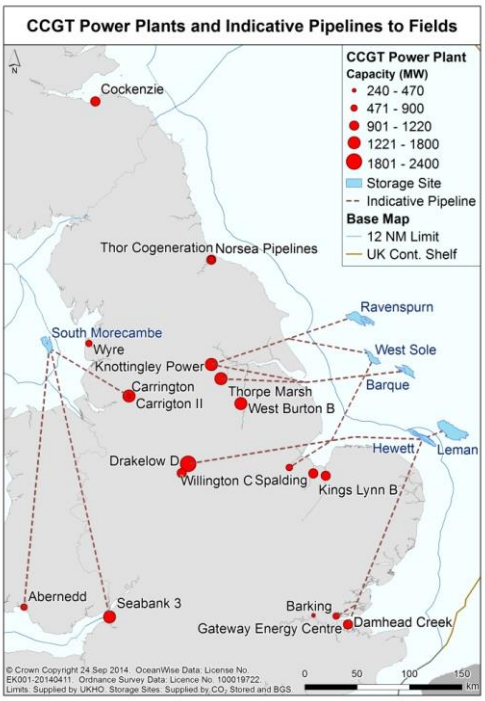


Figure 1: CCGT power plants and indicative pipelines to fields (The Crown Estate, 2014[44])

The MPP3 power plant in Maasvlakte (Netherlands) linked to the ROAD CCS project, was permitted before the CCS Directive was published and transposed. This explains why it was not required to comply with the CCR requirements. Nevertheless the plant owner decided to acquire a certificate for the capture readiness of the MPP3 plant. The certificate was issued by Tüv Nord and includes requirements for reservation of space, cooling water, utilities, steam turbine design and availability of CO_2 storage sites[45].

4.16.2 On line survey

QD3. Do you think the Directive (Article 33) adequately supports the future implementation of "capture ready" plants in a harmonised way across Europe, e.g. fossil fuel power plants built with the assurance of a future proven CCS retrofit option?

Yes	No	Don't Know	Comments
28	44	33	45

Most respondents stated that Article 33 is not strict enough and that the only obligation in is the obligation to make an assessment, and if positive, to ensure suitable space for capture. Respondents agreed that there is a need to strengthen the CCS-readiness provisions and make them more specific as it is clear that large numbers of fossil fuel power plants are being built that will never fit CCS. It was stated that Article 33 provides no guidance on what capture ready should represent and "capture ready" is thus interpreted very differently across Europe. The specifications for being "capture-ready" are relatively weak and allow plants to be constructed that are not "capture ready." Unlike in some other countries, there is no need to certify that the plant remains capture ready on an ongoing basis or work towards retrofit of CCS. It was also recommended by some respondents that provisions should be strengthened to allow the Competent Authority to refuse the granting of an operating licence, if the 'readiness' conditions are not met. It was also highlighted that CCS-readiness should apply to both fossil fuel power plants and carbon-intensive industrial installations.

[44] Permission to use provided by The Crown Estate (26.09.2014)
[45] Guido Magneschi, Hette Hylkema, Gerard Stienstra. Integration of the 250 MWe demo post-combustion CO2 capture plant at MPP3. POWER-GEN Europe, 12-14 June 2012, Cologne

One respondent stated that capture ready' has blocked progress on CCS and that it needs to be replaced with a clear compulsion for either early closure or CCS. In addition, respondents stated that new gas plant should be appropriately sited near CO_2 infrastructure.

In spite of the above, some respondents believed that existing provisions are a proportionate means of avoiding long-term potential “lock-in” of carbon emissions and they do not see the need to strengthen these requirements, given that, despite the technical progress made, CCS is not yet commercially viable.

Additional comments

- Article 33 provides a minimum approach. The obligation ends as soon as a feasibility study has shown that it is not feasible.
- Authorities need further clarity on what is required to fulfil the conditions set to availability of storage, the feasibility to establish transport and the requirements to capture readiness. If the conditions for CCS readiness are not met, it should be clarified that the competent authority shall not grant the power plant an operating license.
- Criteria are hard to fulfil, e.g. proof of storage site availability. An open definition of "capture ready" should be retained since it is impossible to foresee exactly what type of capture system might subsequently be retrofitted.
- Capture readiness does not provide any certainty of CCS deployment. In the UK, gas generators, continue to propose new plants in areas away from potential CCS clusters.
- Acceptance in society and improving public perception should be done before building capture-ready plants.
- In principle, it is difficult to say upfront if a plant would be technically and economically ready to retrofit as it depends very much on the type of capture technology and its size. Different technologies have different integration requirements and “technically” feasible might be interpreted very differently in practice. CCS Ready is not a mitigation activity in itself; it requires a further ‘trigger’ for emitting facilities to actually implement CCS solutions. Such a ‘trigger’ is currently missing.

4.16.3 Interviews

A question in the interview asking for views on article 33, ‘capture ready’ fossil fuel power plants provides some input to this question.

Industry

- Not supported as it currently stands, as it won’t promote CCS and there is no binding requirement.
- Some would like to see clarification to strengthen the case (and requirement) for capture readiness and to exclude peak lopping generation.
- Some ask if CCR should also apply to industrial installations.
- Suggestion (see next question) that this should be covered by the large combustion plant directive.

Environmental NGOs

- Supportive, as a step towards EPS.

4.16.4 Written submissions

Alstom is in favour of reopening the Directive as some elements urgently need to be changed. In their eyes, the capture readiness criteria in art. 33 are particularly insufficient and risk leading to stranded assets. This needs to be strengthened and expanded to industry as well. The new regulation should make capture readiness an obligation, for both power and industry, with the exception of typical peak-shaving power plants if agreed with competent authorities.

CCSA - CCS readiness should be strengthened to genuine CCS readiness and extended to carbon-intensive industry.

E-ON are happy with the current formulation on capture readiness.

EURELECTRIC supports the capture-readiness requirements in the Directive which apply to new fossil-fired plants; these ensure that capture facilities can be retrofitted if CCS becomes commercially available.

International Association of Oil & Gas Producers (OGP) think the current wording in art. 33 (on capture readiness) is sufficient.

The IEA Greenhouse Gas R&D Programme (IEAGHG) provide options for revisions based upon its work in the areas of capture readiness and monitoring. If Article 33 is revised, an option would be to include text to ensure that suitable space be left to build capture plant whether the conditions in Article 33 are met or not, to allow for the uncertainty in predicting future technological developments, economic conditions and regulatory drivers.

WWF and other NGOs state - CO_2 capture readiness requirements are a cosmetic measure that will not prevent coal emissions.

4.16.5 Stakeholder meeting

- A discussion of Article 33 of the Directive indicated the opinion that it lacks clarity on the permitting process for power plants and that this is resulting in plants being able to get consent without Carbon Capture Readiness (CCR). The point was also raised that CCR should also include industrial emission sources.

4.16.6 Summary and Conclusions

The Platt's database indicates that there are some 42 coal and gas-fired generating plants, with an output capacity of over 300 MWe, planned to start operating in Europe after 2012. Data from the MS consenting process relating to Carbon Capture Readiness (CCR) is only readily-available for the UK but not for other countries. In the UK, combined cycle gas turbine (CCGT) plants which applied for Section 36 consents in recent years had to submit a CCR study on the technical and economic feasibility of retrofitting CCS. Applicants had to demonstrate that there is sufficient space left onsite such that they will be able to retrofit carbon capture equipment in the future.

Requests for information to the six MSs with two or more new plants in this list have indicated that the database is not particularly reliable, that capacity growth is low in Spain, that the only application covered by the Directive in Belgium avoided CCR on the basis of it being not being commercially viable and that data on CCR in Polish power plants is not publically available. Data from prior to the CCS Directive indicated that 65% of coal fired plants planned in Europe were considering CCR but only 2% of planned gas fired plants were doing so. Several Member States have reported cases of practical application of article 33 on CCR to the Commission. The UK has produced a guidance note which gives more detail on what plant developers should consider and demonstrate in their CCR checks. The assumptions that some developers have made with regard to feasible CO_2 transport pipe routes in the UK place some doubt on the realism of any future CO_2 capture for some of the plants.

The CCR assessment requirements required by the Directive do not appear to be effectively obliging the developers of new generators to leave the space required for future CO_2 capture. The extra guidance (and the policy commitment) in the UK appear to be much more effective at provoking a much more detailed and realistic CCR assessment and commitment – although this is not perfect. The text in the Directive relating to the 'commercial viability' of CCS being required as part of the CCR assessment is likely to be the main reason why CCR is not being fully investigated or required. Further clarification (and explanation) is required. The situation is complicated by the fact that those MSs with

a practical and realistic alternative to CCS (in terms of meeting their contribution to the scale and speed of CO_2 reductions required for Europe) should be allowed to avoid the cost implications of CCR. There are also important questions outstanding as to whether or not the CCR requirements should apply to plants with low running hours and to industrial installations. The conclusion of this report is that the effectiveness of the Directive could be improved. The recommendations section suggests the drafting of a guidance Document giving extra detail and suggestions on what the developers of new generating plant (including large industrial installations) should consider.

4.17 Q19 – Enhanced hydrocarbon recovery

19. The CCS Directive (recital 20) defines Enhanced Hydrocarbon Recovery (EHR) as the recovery of hydrocarbons in addition to those extracted by water injection or other means. Where EHR is combined with geological storage of CO_2, the provisions of the CCS Directive apply. How can we rate the ease of application of the Directive's requirements concerning EHR projects combined with geological storage of CO_2? Are there any challenges which have been identified for CCS projects under development, and if so, how could these be overcome?

4.17.1 On line survey

QB1. Do you think that the EU regulatory framework for CCS adequately takes the following issues into account?

	Yes	No	Don't Know
The combination of Enhanced Hydrocarbon Recovery (EHR) with CCS	35	37	33

There were mixed responses to the question of EHR. One respondent noted that '*the EU regulatory framework for CCS adequately addresses EHR with CCS on the basis that it permits it as an activity and does not introduce any barriers to the development of projects*'.

Three respondents noted that the Directive is not consistent on the approach to treatment of CO_2 stored as a consequence of EHR. The respondents felt that this severely restricts the Directive's usefulness for EHR projects. *'A consistent approach to treatment of CO_2 trapped as a consequence of EHR would help give confidence to investors in an EHR scheme, as well as those investing in capture and transport.'* One respondent felt that EHR should require additional regulation compared with pure storage, as there are concerns regarding safety that are unique to EHR.

One respondent felt that EHR should be viewed as an opportunity for Europe to increase the security of Energy supply while also stimulating a CCS industry. Another respondent commented that EHR is an enabler of CCS due to the generation of extra oil revenues.

In opposition of the addition of EHR, three respondents felt that the primary function of the Directive in relation to EHR should not be to promote the development or implementation of EHR projects as this should be facilitated at the Member State level, and it is important that the Directive does not prevent or complicate EHR with CCS through additional requirements. Three respondents pointed out that EHR is not CCS and that it should not be covered by the Directive. '*EHR activities are solely under the purview of the MS in terms of the design of tax gathering and incentive systems completely independent of any amendment to the CCS Directive.'*

Two respondents felt that there were complex regulatory issues in regulating EHR with CCS, with additional technical issues relating to additional greenhouse gas emissions from the combustion of extracted hydrocarbons. One respondent went further, suggesting that EHR with CCS should be '*forced to produce enhanced life-cycle emissions accounting that includes the effects of increased oil production and the effects of realistic and relevant baseline alternatives'.*

QB5.2 Are there any challenges which have been identified for CCS and Enhanced Hydrocarbon Recovery (EHR) projects under development?

If yes, how could these be overcome?

Yes	No	Don't Know	Comments
43	8	54	44

44 respondents gave additional qualitative detail in response to this question, noting a range of challenges for CCS and EHR projects under development and how these can be overcome. Issues noted with projects included:

- Lack of evidence around the technical and economic potential of EHR and regulatory frameworks under which these could work.
- Ambiguity around whether CO_2-EOR is in scope of CCS Directive.
- Higher cost of offshore compared to onshore EHR and scale of investment.
- Problems around the quantification, classification and certification of CO_2 captured.
- Ambiguity around ownership of CO_2 and liability status.
- Wellbore integrity uncertainty.
- Lack of reliable supply of CO_2.
- High cost of CO_2 transportation.

A range of solutions were proposed across the various issues, these included:

- Extra funding for initial projects and changes to the tax regime to incentivise EHR.
- Emphasis that any regulatory framework must play an enabling role.
- Investment in CO_2 transport infrastructure.
- Demonstration projects.

4.17.2 Interviews

Input for this question came from an interview question asking what challenges have been identified for CCS and enhanced hydrocarbon recovery projects under development.

Industry

- Position of CO_2 used in EHR with regard to ETS and meeting definition of 'successfully stored' was raised – in the US the EPA have used different criteria.
- The differences between CO_2 used for EHR and just injected were highlighted. Storage of CO_2 is more a side effect than a primary aim of EHR. Moreover, CO_2 is initially recirculated in EHR, rather than stored. The legislation, specifically focused on storage, does not therefore always match EHR.
- Some feel that the oil industry is (or could be) making money from this which should be regulated by DG COMP.

Environmental NGOs

- It appears that UK and Norwegian policy has been developed to account for / deal with EHR (see literature review).
- Pointed out the contradiction that EHR is actually bringing out more carbon – though acceptable in the short term.

4.17.3 Written submissions

International Association of Oil & Gas Producers (OGP) supports the current wording for EOR in the Directive and urges not to include issues in the Directive that are already well regulated in oil and gas regulation.

CO2GeoNet supports the view that it is important to focus the Storage Directive on storage projects, and that EOR and CCUS projects are perhaps better regulated elsewhere.

4.17.4 Stakeholder meeting

- The point was made that EHR is critical for enabling CCS projects (especially now - in the early stages). Some felt that the regulatory framework for EHR needs to be improved/ clarified, particularly with regard to the reward of ETS credits.

4.17.5 Summary and conclusions

The CCS Directive does not appear to do anything to specifically limit or prevent EHR and CCS. EHR is a very useful way (where it is possible) of improving the economics of CCS. There does not appear to be a strong case for adding EHR specific requirements to the Directive. This conclusion is based on the fact that existing oil and gas regulation appears adequate to regulate the health and safety and the fiscal aspects. There does appear to be some clarification required in ETS regulation as to the storage status of CO_2 that might be circulated (i.e, pumped in, then extracted, then re-injected) as part of EHR.

4.18 Q20 – Financial security provisions

20. On the basis of the gathered experience, including on CCS projects development, how effective has been the implementation of the CCS Directive provisions on the financial security and financial mechanism for the storage sites (Articles 19 and 20 of the CCS Directive)? How can we rate the ease of application of those provisions for both storage operators as well as for competent authorities? Are there any challenges with regard to determination of the amounts of the financial security and financial mechanism, and if so, how could these be overcome? Is there evidence that the obligation under Article 19 of the CCS Directive related to the surrender of allowances in the event of CO_2 leakage presents a significant obstacle to the CCS development in Europe?

4.18.1 Literature review

According to the Directive, liability for environmental damage due to leakage from CO_2 storage sites is regulated under an existing regulation (Environmental liability Directive[46]). Liability to climate damage is dealt with by including storage sites in Directive 2003/87/EC[47] (Emissions trading), which requires surrender of emission trading allowances for any leaked emissions.

Liabilities other than those related to the phases of injection, closure and the period after transfer of responsibility should be dealt with at national level. After transfer of liability, monitoring should be reduced but should include leakage detection and should be intensified if leakage is detected. In this phase no recovery of cost from the previous operator can be obtained, on top of the previously established financial contribution.

There has been some criticism of the Directive regarding a lack of clear arrangements as to how liability issues should be handled. The UK Department of Energy and Climate Change (DECC) concludes that “there is currently no accepted basis for estimating the true exposure to these potential liabilities [as referred to in the CCS Directive] and this is proving to be a major obstacle for prospective storage site developers”.[48]

Responsibility will be transferred from operator to authority when evidence is shown that all CO_2 will permanently and completely remain contained. Operators should submit a report to the relevant authority for approval of the transfer. In the early phase, all such reports must be made available to the Commission after receipt by the responsible authority.

[46] Directive 2004/35/EC of the European Parliament . http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:143:0056:0075:en:PDF
[47] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:275:0032:0046:en:PDF
[48] DECC, 2012, 'CCS Roadmap: Supporting Deployment of Carbon Capture and Storage in the UK', London: Department for Energy and Climate Change, p.40

4.18.1.1 Financial obligations

The CCS Directive includes two financial security requirements for CCS project operators: Articles 19 and 20. The Commission provides additional guidance on the implementation of these requirements in Guidance Document 4: financial security.

Article 19 stipulates that throughout their period of responsibility, the operator should prove that he has established adequate monetary provisions to meet all financial obligations arising under the permit and under the EU ETS Directive. After a storage site has been closed (and a list of conditions are met), the responsibility is transferred to the competent authority (Art. 18). At this point the financial security obligation for the operator ends, and is replaced by a financial mechanism (Article 20) to ensure sufficient funds to cover at least the anticipated cost of monitoring the site for 30 years after transfer, but also to potentially cover other post-transfer costs. Just before the transfer of responsibility, the operator makes a financial contribution available to the competent authority to cover these costs.

There is no cap on the amount of the financial contribution after the transfer of responsibility such that project developers may remain liable for all costs after the transfer of liability[49]. This uncertainty over the extent and scope of the financial security provisions in the CCS Directive means that project developers cannot accurately quantify their risk exposure before having entered into negotiations with the Competent Authority.

4.18.2 On line survey

QE10. What is your view on the following statements relating to the provisions on the financial security and financial mechanism for the storage sites (Articles 19 and 20 of the CCS Directive)?

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
The provisions are not strict enough and should be tightened.	5	6	7	25	23	39
The provisions strike a good balance and are ok.	1	11	8	30	16	39
The provisions are too rigid and could be an important constraint on CCS take-up.	15	23	13	10	1	43
The provisions need to be adjusted to allow for them to be practically enforceable.	14	28	12	8	0	43

Some comments were provided under "other" for this question. The respondents tend to indicate that the provisions on financial security and financial mechanism (Articles 19 and 20) are adequate. Most of the respondents however noted that the highly liquid Financial Security requirements outlined in GD4 raise concerns as the requirements could significantly increase the costs of storage operations, and no commercial organisation can accept the unquantifiable and unlimited liability associated with a large geological leak of CO_2 (as evidenced by ROAD project). It was agreed that the cost of the Financial Security and the uncertainty over the size of the liability acts as a disincentive to investing in CO_2 storage facilities and hinders the development of CCS in Europe.

The respondents refer to several reports published by ROAD, GCCSI and the CCS Network on the topics. As highlighted in the case study on the ROAD project, there are a number of provisions that decrease the take up of CCS demonstration projects:

[49] Authorities in the Netherlands and Norway have agreed on capping the financial contribution.

- On Financial security: the most citied barrier is the uncertainty over the long term price evolution of the ETS. Since the EU-ETS allowances must be handed over in the year that the leakage occurs, the operator would need to pay the price at that time, which is subject to a lot of uncertainty.
- On Financial mechanism: transfer of responsibility to the competent authority after closure of the storage site lead to critical issues on the handover criteria - the CCS Directive leaves too much room in interpretation to Member States to reject permits based on the handover criteria. Therefore, the competent authority could reject the closure in order to keep monitoring possibilities open. This would create an unlimited liability for the proponents of demonstration project. (*Although this hypothetical situation may not arise*),

A few respondents mentioned that Member States should be allowed enough flexibility to decide on the modalities for financial security and financial mechanism also in close cooperation with early projects' operators. It was however noted by another respondent that a balance needs to be found so that the competent authority does not take on large financial risks which would then need to be paid from public money. Another responded explored this point further, stating that an in-depth assessment of the impacts of liability transfer clauses on operators and Member States should be considered, particularly with regards to leakage of CO_2 which could lead to changes in financial security requirements.

4.18.3 Interviews

This question was covered by asking interviewees for their views on financial security and financial mechanisms for storage sites (Articles 19 and 20).

Industry

- Clear view that the financial requirements as formulated in the GDs are too rigid and demanding, and MSs seem to take the GDs sometimes as prescriptive. The majority want to see more flexibility in the GDs for the MSs defining the requirements (NB respondents do not make the distinction as to whether the Directive itself is too binding or the implementation of the GDs by the MSs is not flexible enough).
- Seen as a barrier to entry for anyone but very large companies (i.e. the oil and gas industry).
- Guidance document four criticised for being over demanding and prescriptive – it adds liabilities that are not in the Directive.
- The issue of the value of CO_2 that leaks from storage was raised – should it be 'paid back' at the market price when it leaks or from when it was stored? Or are other arrangements better?

Environmental NGOs

- Recognise that developers may need some limit to their liability.
- Feel that the wording of the Directive does give MSs flexibility, though Guidance Document four may be restricting this (though it is not mandatory).

Public actors

- Policy makers agree that more clarity and guidance is needed on this point.

4.18.4 Written submissions

CCSA - The financial security requirements (as in GD4) places onerous requirements which should be revisited to more enable CCS rather than making it look like a high risk activity.

CCSA -The liabilities for seepage linked to ETS are a major barrier for CCS. It is unquantifiable and potentially very large relative to the value of storage. They suggest this should be handled between the storage operator and the MS's competent authorities.

Eurelectric - The seepage liability and the EUA surrender is a major barrier. Risks should be shared by operator and competent authority.

The Crown Estate (UK) state

- It is good that the Commission made it clear that the liability can be independently managed at MS level.

- A probability based approach for leakage and financial security would be welcomed.
- The contents of GD4 relating to financial security are an obstacle:
- The potential cost for leakage can far outweigh the received income for a storage operator. Making it unattractive.
- The very long financial reserve for something that may or may not occur in the far future creates a barrier to CCS deployment. Especially in this early stage this should be removed, best industrial practice can be established later.
- There is a difference between the polluter (CO_2 emitter) and the party helping with the solution (Storage operator); the latter now has to provide all the financial securities. That is not the right balance.

4.18.5 Case studies

Lessons from ROAD Financial security and financial instrument

Issue

The CCS Directive requires Member States to ensure that "*prove that adequate provisions can be established, by way of financial security or any other equivalent, on the basis of arrangements to be decided by the Member States, is presented by the potential operator as part of the application for a storage permit*".[50] Those provisions must be adequate to ensure that all legal obligations arising under the permit, including closure and post-closure requirements, as well as any obligations arising from inclusion of the storage site under the EU ETS Directive, can be met.

The ROAD project faced three important questions regarding financial security:

1. What are the exact activities that must be covered by the financial security?
2. What is the amount of money that should guarantee these activities?
3. What kind of financial instrument is accepted by the competent authority?

Solution and way forward

Question 1: ROAD concluded that the most important activities are:

- Monitoring;
- Contingency monitoring;
- Abandonment;
- Financial contribution;
- EU emission allowances in case of leakage.

Question 2: The costs of these five activities have been assessed. A very large uncertainty in this assessment is connected to the costs of the EU-ETS allowances. Since those must be surrendered in the year that the leakage occurs, ROAD would need to pay the price at that time, which is highly uncertain. It must be noted that the financial security must be adjusted yearly. This means that increases or reductions in the EU-ETS price will impact upon the amount of financial security over time.

[50] Article 19 CCS Directive

Table: Activities and assigned budgets for the ROAD project financial security

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 - 29
Monitoring	12	10	9	8	7	6	5	4	3	0,1
Contingency monitoring	10	10	10	10	10	10	10	10	10	10
Abandonment	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5	0
FC	2	2	2	2	2	2	2	2	2	2
EU-ETS	0	1	2	3	4	5	6	7	8	8
Sub Total	***47***	***46***	***46***	***46***	***46***	***46***	***46***	***46***	***46***	***39,5***
Contingency 20%	9,4	9,2	9,2	9,2	9,2	9,2	9,2	9,2	9,2	7,9
Total	**56,4**	**55,2**	**55,2**	**55,2**	**55,2**	**55,2**	**55,2**	**55,2**	**55,2**	**47,4**

Question 3: With a view to the activities described in the paragraph above, the CCS Directive requires that the operator must provide proof that adequate provisions can be established *"….by way of financial security or any other equivalent*".[51] The CCS Directive does not specify what this security should look like. However, the Guidance Documents provide a summary and assessment of potential financial instruments to cover the financial security these instruments.

ROAD described in the storage permit application several financial instruments that could be used to provide the financial security. ROAD elaborated one specific instrument that proves that a valid and effective financial security can be given before injection. The balance sheet of the operator is strong and can easily cover the financial security as assessed in the storage permit application. The permit conditions secure that injection can only start if the Competent Authority is satisfied with the financial security in 2014, (according to the draft storage permit):

- Operator sets financial security preferably by bank guarantee or escrow;
- Minister approves the financial security instrument selected by operator;
- Operator sets financial security three months before start of injection.

At this moment the Dutch Government accepts a balance sheet, but prefers a bank or parental guarantee. This is also explicitly noted in the storage permit.

The financial security shall be periodically adjusted to take account of changes to the assessed risk of leakage and the estimated costs of all obligations arising under the permit but also to assess whether the provided instrument is still providing sufficient security to the competent authority.

Lessons from ROAD Financial contribution

Member States must ensure that the operator makes a financial contribution available to the competent authority before the transfer of responsibilities to the competent authority takes place.[52] The contribution should cover at least the anticipated cost of monitoring for a period of 30 years, but it also "*may be used to cover the costs borne by the competent authority after the transfer of*

[51] Article 19 (1) CCS Directive
[52] Article 20 CCS Directive

responsibility to ensure that the CO_2 *is completely and permanently contained in geological storage sites after the transfer of responsibility*".[53]

In theory, this means that the competent authority can demand a financial contribution that is almost unlimited, while the competent authority will be responsible in perpetuity for a site after the handover. ROAD discussed this intensively with the competent authority and concluded that if the Government demanded a high financial contribution, there would be no handover. While the competent authority is technically responsible, the former operator will pay the bill. In the opinion of ROAD and the Dutch Government, the financial contribution should only include costs that the competent authority will have after handover and not include contingency costs, i.e. monitoring.

The transfer of responsibilities is subject to strict criteria and will only occur if the leakage risk is limited to an absolute minimum. Therefore, the Dutch competent authority concluded that with regards to the financial contribution:

- It only includes monitoring after the handover for a period limited to 30 years. Only the monitoring instruments will be used as described in the monitoring plan after the well has been abandoned;
- The frequency of monitoring is included in the monitoring plan. This means that once every five years a sub seabed inspection will take place. ROAD requested several market orders for this 30 years of monitoring. On basis of these orders, a provisional amount of EUR 2M will be included in the financial security;
- No contribution will be charged for other possible costs after handover (for example in case of leakage).

4.18.6 Summary and conclusions

There are some serious concerns among developers regarding the levels and procedures for handover from developers to the MS competent authorities and the financial securities related to future monitoring and leakage from storage sites. These concerns relate to articles 19 and 20 but also Guidance Document four. It appears that articles 19 and 20 were written in such a way as to give a relatively high level of flexibility to the MS CAs in deciding when handover should occur and what financial security site operators should provide in order to give sufficient confidence in their ability to safely operate and monitor the storage site up to the point of transfer. Guidance Document four is intended to help provide some further guidance on these issues. It appears that GD4 is being used as more than guidance, which is leading to calls that the more detailed procedures it suggests will impose high costs on projects. This makes CCS projects more difficult to progress.

There are also concerns on the requirement that CO_2 leakage is paid for at the value of CO_2 on the ETS market at the time it leaks, rather than at the time it was captured. This makes it impossible for a site operator to accurately know the potential costs of future leakage. This uncertainty (and the financial guarantee that operators have to provide to illustrate they can meet it, along with other costs such as monitoring) appears to be a factor which makes CCS project less likely to occur. There are some claims that the scale of financial guarantee required is so large that it puts off all but oil and gas companies, who, by nature of their large size, are able to comply.

The only European CCS project with practical experience of going through the permitting process is ROAD. They have agreed workable solutions with the Dutch CA that both parties appear to accept. This single example suggests that even with GD4 there is still enough flexibility to allow procedures to be agreed and projects to be advanced. Given the high level of concern expressed regarding GD4 there appears to be a good case for reviewing any phrases within it that cause most concern for potential storage site developers.

[53] Article 20 CCS Directive

Section 5 Evaluation answers - Relevance

Relevance looks at the relationship between the needs and problems in society and the objectives of the intervention. As such it considers how the situation has changed over time and what the current needs are. Questions under this heading tend to focus on the problems and market failures that the policy is intended to address, and ask if these still exist and if the policy is capable of addressing them.

5.1 Q21 – Do the objectives still respond to the needs

21. To what extent do the objectives of the Directive still respond to the needs?

5.1.1 Interviews

This question overlaps with Question 1, but the answers reported below are focussed on responses to an interview questions which asked for opinions on new issues or issues that have become more important (or apparent though the projects developed) that are not covered by the Directive.

Industry

- The Directive does nothing to speed the uptake of CCS – though its intended central role as an 'enabler' is recognised.
- There are new issues that have emerged but the Directive is not necessarily the best mechanism for addressing these. Other Directives and/or policies are more suitable. For example biomass plus CCS should be covered in the ETS.
- Not enough practical experience to justify changing the Directive yet.
- Suggestion that industrial CCS should be added to the directive (as it doesn't mention it).
- EOR is primarily motivated by non CCS drivers – so if it is to be included as a storage approach, the Directive needs to be adjusted to reflect the technical differences. Hydrocarbon taxes and regulations should deal with the majority of EOR issues.

Environmental NGOs

- Recognise that biomass and EOR are not covered – but that ETS and oil and gas regulations should be sufficient to deal with these.

5.1.2 Summary and conclusions

The important conclusion here is that the CCS Directive is seen as an enabling mechanism for CCS, rather than the main mechanism to make it happen. It is clear that a number of issues related to CCS have increased in importance and/or visibility since the Directive was drafted, for example EHR, biomass and CCS the use of CCS for industrial installations. Most of these issues relate to ways in which the business case for CCS can be improved and the Directive does not appear to actively constrain any of these issues. The issues appear to already be adequately regulated by other legislation, although some adjustments of the ETS regulations may be required.

5.2 Q22 – CCS Enabling policies

22. The Impact Assessment accompanying the CCS Directive concluded that, in order to internalise climate change externalities, ETS would be the right enabling policy for CCS, as the costs of meeting substantial reductions in EU emissions of CO_2 are significantly lower with CCS enabled under ETS than without, but that there was little evidence for additional policy measures going beyond the carbon market in order to address additional externalities. The situation as described in the Impact Assessment has substantially changed given the slow pace of progress of CCS demonstration programme, and the low carbon price. In consideration of the state of play of CCS in Europe and its

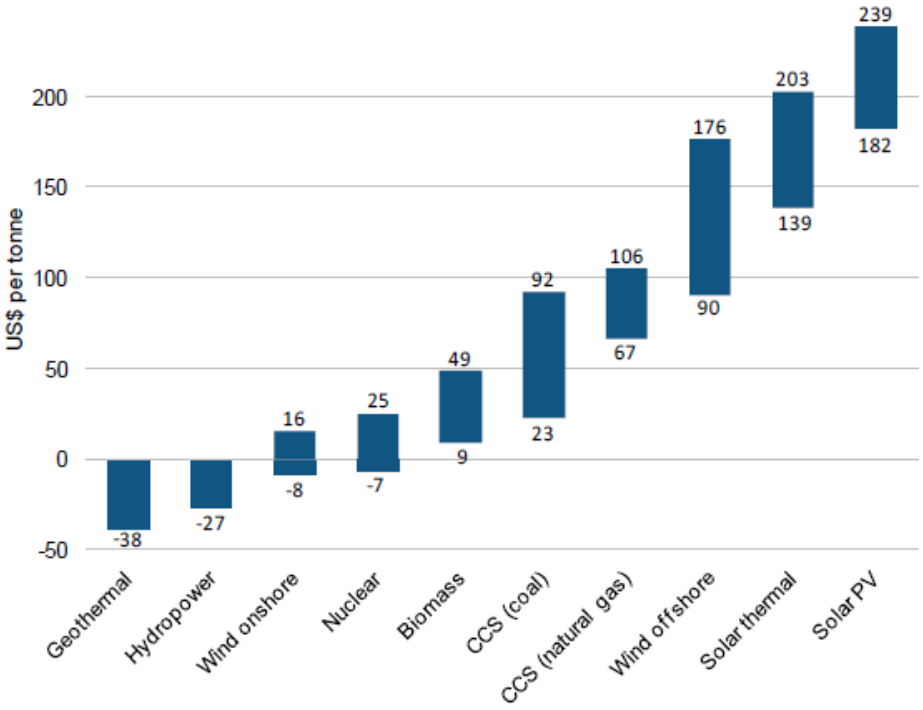
deployment prospects towards 2030 and 2050, how can the appropriateness of the EU regulatory framework for CCS be evaluated? How could the policy framework at European level incorporate additional transitional enabling policy measures, including, if appropriate, other instruments or subsidies to complement the EU ETS system, at least cost and in an effective way?

5.2.1 Literature review

5.2.1.1 CCS economics and financing

CCS, especially if it is applied on coal power plants, is an economically viable mitigation option for CO_2 emissions, as can be seen in the cost comparison of low-carbon technologies in Figure 2.

Figure 2: Cost of CO_2 avoided in US$ per tonne[54]



The cost estimates presented are for first-of-a-kind CCS plants. These costs are likely to decrease significantly in the future. McKinsey & Co believe that the likely learning rate (i.e. the cost reductions that occur via learning from experience) for CCS would be 12%[55]. Currently, however, CCS is still in its early stage and cannot attract sufficient commercial financing as depicted in Figure 3.

As Figure 3 demonstrates, there is an important role for the public sector in financing this development phase. The main problem for CCS economics is that CCS project operators face high upfront costs and uncertain revenues.

CCS is potentially an economically attractive CO_2 mitigation option. Yet the current incentives for financing CCS projects are not sufficient since the price of European Union (Emission) Allowances (EUA) is too low to incentivise CCS projects. With a current EUA price of less than €10/t, investors will need, approximately an additional €40/t to recover capital and operating costs, profit margin and project risk in order to meet their required Internal Rate of Return (IRR).

[54] Source: GCI, 2011, The Costs of CCS and Other Low Carbon Technologies, Chester Abellera and Christopher Short, Global CCS Institute Issues. Brief 2011, No. 2

[55] McKinsey, 2008, Carbon Capture & Storage: Assessing the Economics
The technology learning rate is defined as the unit cost reduction due to a doubling in the worldwide installed capacity. I.e. at a 12% learning rate, if worldwide there is a CO2 capture capacity of 100 Mt/yr, and the capture cost is €100/t, then one may expect this cost to have decreased to €88/t after having increased the worldwide capacity to 200 Mt/yr.

High upfront costs and uncertain revenues are inherent to new and innovative technologies. The upfront costs are likely to decrease through technological learning; the revenues are highly dependent on the carbon price which will remain the most uncertain element in the whole business case.

The UK government published a report[56] from its CCS Cost Reduction Taskforce in May 2013. Their key conclusion was that "UK gas and coal power stations equipped with carbon capture, transport and storage have clear potential to be cost competitive with other forms of low-carbon power generation, delivering electricity at a levelised cost approaching £100/MWh by the early 2020s, and at a cost significantly below £100/MWh soon thereafter."

The report states that the UK government are intending to help support two CCS demonstration projects and describes seven key steps it feels will be required if follow-on and future UK CCS projects are to be developed which deliver the identified cost reductions. These steps are:

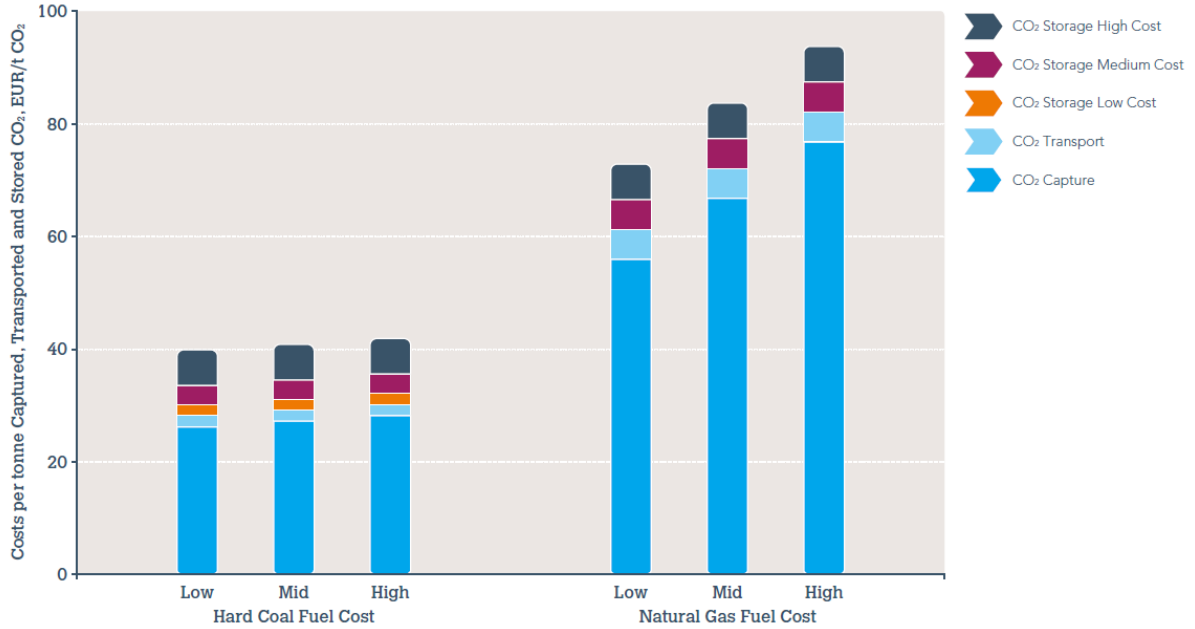
1. Ensure optimal UK CCS transport and storage network configuration.
2. Incentivise CO_2 EOR to limit emissions and maximise UK hydrocarbon production.
3. Ensure funding mechanisms are fit-for-purpose.
4. Create bankable contracts.
5. Create a vision for development of CCS Projects in the UK from follow-on projects through to widespread adoption.
6. Promote characterisation of CO_2 storage locations to create maximum benefit from the UK storage resource.
7. Create policy and financing regimes for CCS from industrial CO_2.

5.2.1.2 EU ETS and the carbon price

The revised EU Emissions Trading System (ETS) Directive 2009/29/EC includes CCS within its scope. The stored CO_2 is seen as not emitted so the operators do not have to buy emission allowances and thus save money. This ETS is seen as the most effective long-term incentive for operators to invest in CCS. However, the global economic crisis and the introduction of many so-called non-ETS parallel measures, both by the EU Commission and the Member States, has prevented a scarcity of emission rights from developing in the EU ETS. Nor is there confidence that this scarcity will develop in the foreseeable future, with the result that the price of CO_2 emissions have tumbled. The current carbon price of around 5-7 euro/tonne CO_2 is not high enough to support a CCS business case, and there is too much uncertainty over the price of carbon credits in the long run. Even with a carbon price of 35 euro/tonne, there would still be an economic gap of at least 25-55 euro/tonne CO_2, assuming that CCS demonstration projects with complete integrated capture, transport and storage infrastructure would cost between €60 and €90 per tonne of CO_2 in 2015[57]. According to a 2011 ZEP study, these costs are between €40 (coal) and €60 (gas) per tonne of CO_2[58], leaving a gap of 5-45 euro/tonne of CO_2 with a 35 euro/tonne carbon price.

[56] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/201021/CCS_Cost_Reduction_Taskforce_-_Final_Report_-_May_2013.pdf
[57] McKinsey, 2008, Carbon Capture & Storage: Assessing the Economics
[58] ZEP, 2011. The costs of CO2 capture, transport and storage - Post-demonstration CCS in the EU. European Technology Platform for Zero Emission Fossil Fuel

Figure 3: Costs per tonne of CO_2 for integrated CCS projects (hard coal and natural gas) calculated with Low, Middle and High Fuel costs.[59]



5.2.1.3 EU funding mechanisms

The EU has two main funding mechanisms to support demonstration of CCS technology: The EU Energy Programme for Recovery (EEPR) and the EU ETS New Entrant Reserve (NER300). Small-scale R&D projects also receive support through the Framework Programme for Research and Innovation, and its successor Horizon 2020.

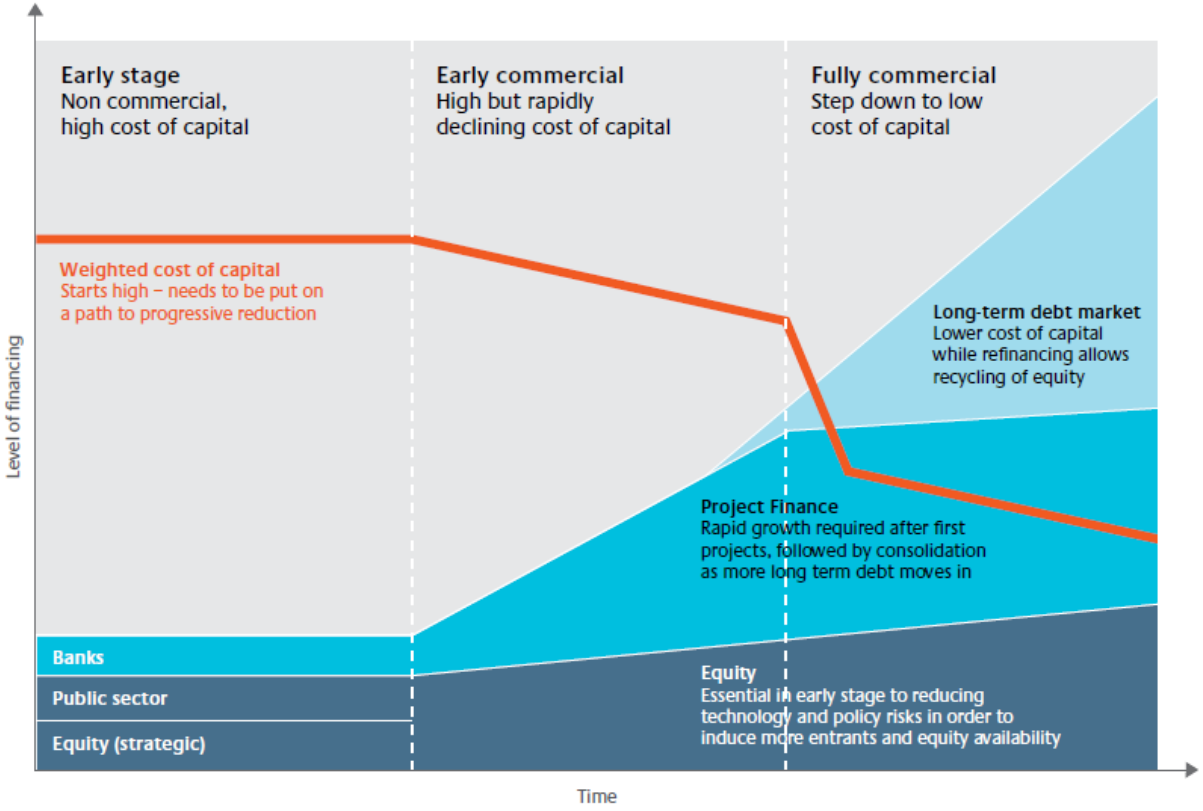
The NER300 programme uses part of the revenues from the sold ETS emission allowances to support CCS projects. The amount of available funds thus depends on the carbon price, which is too low at the moment. The available funds are generally seen as insufficient to provide enough certainty for long-term CCS investments. Thirteen CCS projects were submitted to the EIB for the first round of NER300 funding, but none of them could be awarded funding in December 2012. Most CCS projects were not confirmed by the Member State concerned. Member States were unable to confirm the projects for various reasons: in some cases there were funding gaps, while other CCS projects were not sufficiently mature to allow for such confirmation under the first call for proposals. One further CCS project was confirmed, but then withdrawn after the closure of the confirmation process. In the second round, closed in July 2013, only one CCS project (the UK White Rose project) was approved for funding[60].

The EEPR fund has earmarked 1 billion euros for 6 CCS demonstration projects (with a maximum of €180 million per project and one project per Member State). One project (Compostilla, Spain) provided operational pilot plants for capture, transport and storage, but subsequently took a negative FID. That means that the project developer has decided not to proceed with constructing the demonstration plant (which would not have been covered by the EEPR grant). Two of the projects (Maasvlakte in Rotterdam (the Netherlands) and Don Valley (in the UK) are ongoing. The three others (the Jänschwalde project (Germany), Belchatow (Poland), Porto Tolle (Italy)) were terminated prematurely. The reasons for termination ranged from the lack of a national regulatory framework for CO_2 storage and public acceptance issues (Germany), to rejection of an environmental permit application for a coal-fired power plant (Italy), to lack of funding (the projects in Italy, Spain and Poland).

[59] ZEP, 2011. The costs of CO2 capture, transport and storage - Post-demonstration CCS in the EU. European Technology Platform for Zero Emission Fossil Fuel

[60] http://europa.eu/rapid/press-release_MEMO-14-465_en.htm

Figure 3: Financing CCS - the path to a low cost industry[61]



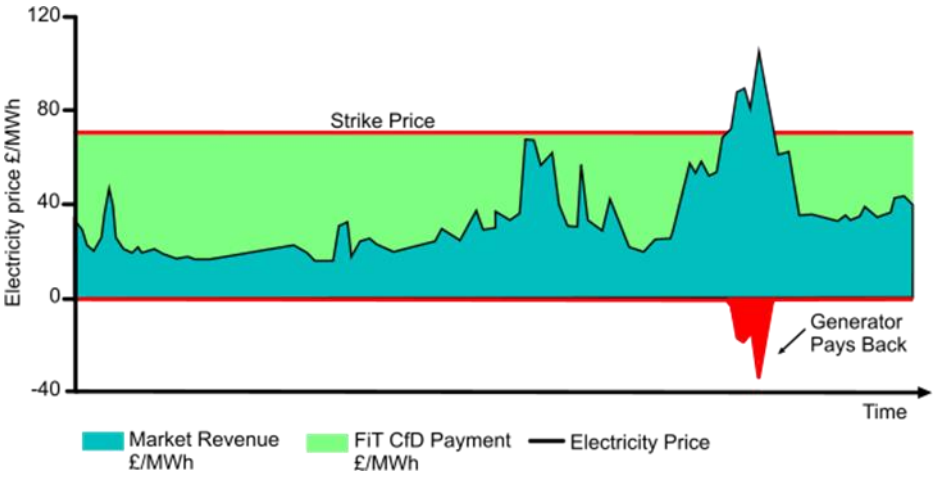
5.2.1.4 Public funding and financial incentives for CCS

Governments have a range of funding mechanisms, tax incentives and subsidies at their disposal to stimulate CCS investments.

Only UK has introduced a substantial specific CCS funding programme. In the UK, £1 billion has been set aside to fund the Carbon Capture Scheme Competition. This funding will be competitively allocated to support project developers with the upfront costs of CCS projects. Additional support for increased operating costs could also potentially be provided in the UK by 'Contracts for Difference' (CfDs), whereby power generated by low carbon technologies can receive a form of feed-in premium to compensate the higher costs[62]. CfDs are part of the UK's Electricity Market Reform (EMR), outlined in 2012 and partly enabled through the Energy Act 2013. CfDs are long-term contracts[63] which set technology specific 'strike prices' which the operator will be guaranteed for producing low-carbon power. Crudely speaking, when the market price for electricity is lower than the strike price, the difference is paid to the operator, and if the market price exceeds the strike price the transaction is reversed.

[61] Source: Ecofin & ETI, 2012, Mobilising private sector finance for CCS in the UK
[62] Mikunda & Haan-Kamminga, 2013, Trans-boundary issues, Tom Mikunda, ECN. Avelien Haan-Kamminga, Presented at 4th IEA CCS Regulatory Network Meeting. Paris, 9-10 May 2012
[63] 15 years maximum for renewable projects, and CCS/nuclear and CCS CfD are not set but expected to be longer.

Figure 4 : Graphical representation of a generic CfD scheme with a strike price[64]



Examples of financial incentives which could shape energy markets in EU Member States include:

- **(i)** grant schemes,
- **(ii)** loan guarantees,
- **(iii)** green certificates,
- **(iv)** purchase contracts,
- **(v)** emissions performance standard
- **(vi)** feed-in-tariffs,
- **(vii)**certificate schemes.

Each of the schemes above may be of potential relevance for CCS projects. Each has its benefits and will be evaluated on a case-by-case basis by policymakers depending on the context. The UK CCS Competition, and the CfD scheme presented above, represents additional financial incentive schemes (additional to the EU ETS) planned for implementation in EU Member States. The Netherlands has made significant grants available[65] for the implementation of two CCS projects; however these have yet to proceed. Other Member States are yet to implement further measures to incentivise CCS. In North America and Canada, emission performance standards for power stations are being introduced which could incentivise CCS on coal-fired power plants.

To date, EU CCS project have relied upon a blend of funding mechanisms. This suggests that the policy measures will almost inevitably overlap with each other.

The European Commission undertook an extensive public consultation on the future of CCS in Europe. The summary report[66] on the analysis of the responses received to this states the following:

"There is wide support for the (continuation of the) EU's CCS demonstration programme, as the best way to demonstrate its technical and economic viability, as well CO_2 storage safety and reliability, and also improve public perceptions. In the opinion of several stakeholders (especially among central governments and industry representatives), achieving a successful demonstration programme should be the key priority for the EU for the near future and public funding is essential to achieve this goal. Additionally, increased efforts into Research & Development (R&D), especially into storage and transport infrastructure aspects and including the exploration of Carbon Capture and Usage (CCU) and Enhanced Oil Recovery (EOR) options, should be made.

There is strong support for the development of national roadmaps for the decarbonisation of Member States' (MS) economies in Europe. The majority of NGOs & associations, a large part of industry

[64] DECC, 2011. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity. UK Department of Energy and Climate Change, July 2011.
[65] Approximately €200 million
[66] http://ec.europa.eu/energy/coal/doc/20130702_ccs_consultation_report.pdf

representatives and some public authorities consider that the national decarbonisation roadmaps should impose no restrictions on the energy mix chosen by MS and that a level playing field for all low-carbon technologies is essential.

A large number of respondents, especially the NGOs & associations and industry, urge the EC to integrate CCS into the 2030 energy and climate policy framework. Complementary to this, the need to treat CCS on a level playing field with other low-carbon technologies, in particular renewables, which have been supported since the 2020 targets have been agreed, is also seen as essential.

The significance of CCS for the industrial sectors, other than power generation, is addressed in two ways. On the one hand, there is quite significant support (among NGOs & associations and some industry representatives – mainly energy utilities and related industries) for the inclusion of industrial facilities in national decarbonisation roadmaps and (CCS) support frameworks. On the other hand, concerns regarding the competitiveness of European industries and a call for moderate ambitions in Europe in the absence of a global climate deal are raised by representatives of the carbon and energy intensive industries. They also call for a detailed impact assessment on implementation costs of CCS before discussing deployment.

A significant number of respondents, from across all categories apart from the citizens, draw attention to the need for a holistic approach which goes beyond CO_2 capture (which is seen as the main focus of the Communication) and also takes transport and storage aspects into account (and incentivises them accordingly). The links between infrastructure development and public opinion and the potential economies of scale associated with the development of shared infrastructure are cited as key arguments.

The interest from and the participation of MS' governments was rather low (four responses from central governments only, besides a few government agencies and regional authorities). The MS that responded generally support the continuation of the EU CCS demonstration programme (i.e. the EEPR and NER300) and national decarbonisation roadmaps, as a prerequisite for further discussions on possible incentives and policies for the medium to long term. Arguments of national sovereignty and the suitability of the EU Emissions Trading System (EU ETS) to drive decarbonisation are invoked.

A significant number of citizens, albeit from one MS [Germany], have mobilised themselves in order to express their opposition to the development of the CCS and to any additional support and/or policy measure to pave the way for deployment. They doubt that CCS can be a tool for mitigating climate change. In their view it is only a ruse in order to keep using fossil fuels and the EU's priority should be renewables, energy storage and adaptation to climate change."

5.2.1.5 State Aid guidelines

New State Aid Guidelines on environmental protection and energy were adopted by the European Commission in April 2014[67]. These guidelines make specific reference to CCS, recognising it as a technology that can contribute to mitigating climate change. The guidelines permit State aid to be provided to CCS installations associated with fossil-fuel and biomass power plants, and also to industrial facilities. The guidelines clearly state that State aid can only be provided in a scenario where the CCS project would not otherwise go ahead, and that the eligible costs to be covered by State aid are those related to the capture, transport and storage of CO_2, and not the emitting installation. Under the updated Block Exemption Regulations (2014)[68], specific reference is made to CCS infrastructure under Article 2 (130(d)) confirming its definition as energy infrastructure. CCS infrastructure is therefore eligible for funding under Article 48 Investment Aid for Energy Infrastructure, allowing up to €50million to be funded per project for infrastructure located in Assisted Areas. Prior to these new State aid guidelines the Commission had also taken a positive attitude towards State aid for CCS projects, approving the provision of €150 million in State aid from the Dutch government to the Maasvlakte CCS Project (The ROAD Project), requested in 2010.[69]

[67] European Commission, 2014. Guidelines on State aid for environmental protection and energy 2014-2020, 2014/C 200/01. Retrieved, 19.08.2014, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014XC0628(01)
[68] European Commission, 2014, Block Exemption Regulations No.651/2014, Retrieved 24.12.2014, http://ec.europa.eu/competition/state_aid/legislation/block.html
[69] European Commission, 2011. Official Journal of the European Union, C149. Retrieved, (19.08.2014) http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2011:149:FULL&from=EN

5.2.1.6 CCS and CDM

Since December 2011, the clean development mechanism (CDM) has been opened up as a potential source of finance for CCS projects. CDM allows companies to offset their carbon emissions through CCS projects outside the EU. Early in the history of the CDM, in 2005, two methodologies for CCS projects were submitted to the CDM executive board. These methodologies were subsequently rejected because of the absence of CCS as a recognised CDM technology. Due to the low price of carbon credits generated from CDM projects (approximately €0.20 euro at time of writing) and a general uncertainty of the continuation of the Kyoto Protocol it is unlikely that any CCS projects will be submitted.

5.2.2 On line survey

QB2. The Impact Assessment completed by the European Commission when the CCS Directive was drafted concluded that the EU Emissions Trading System (ETS) was the right enabling policy for internalising climate change externalities and that there was little evidence of a need for additional measures (going beyond the carbon market). Given the slow rate of progress in CCS to date do you think the European level policy framework needs additional (or less) policy measures to enable the transition to CCS?

Yes - more	No – current measures are sufficient	No - there are already too many measures	Don't Know
71	12	6	16

The majority of respondents felt that there is a need to add new policy measures to the European level policy framework. Clear messages of support were given for additional funding for CCS demonstration and for reform of the EU ETS. Other suggestions included:

- There is a need for matching EU level incentives for negative emissions via bio CCS.
- Additional policies are needed to bring less close-to-market technologies to commercialisation.
- Incentives need to be developed to enable CCS for heavy industry, including metal, cement and chemical production.
- A general European clean energy technology demonstration mechanism that funded demonstration and early deployment based on technical and market attributes would be ideal, but this would extend far beyond CCS and not be easy to implement.
- Specifically for CCS, there remains need for capital grants or loan guarantees for a handful of demonstrations coupled with quantity-specific mechanisms (e.g. the UK CfD FiT approach, payments for CO_2 stored) that would extend to a limited number of projects beyond those receiving capital support.
- Options such as an emissions performance standard for large combustion plant should be considered in more detail.
- Higher price on carbon than the ETS is achieving or a direct, all-industry carbon tax.
- The EU should ask the Member States to develop a national strategy to prepare for the deployment of CCS technology and a related EU CCS roadmap.
- As CCS entails higher costs, its deployment depends on balancing these higher costs with a higher revenue stream for operators for CCS plants, especially in the absence of a strong EU ETS signal. While this could be a feed-in tariff for CCS-equipped plants, it must not necessarily be done in this way; what should be examined is whether any kind of policy measure exists which would be able to balance the added costs and monetise the added climate value for the operator.
- CCS should be eligible for State Aid covering both investment and operating phase as put forward in the recent adopted State Aid guidelines for environment and energy.
- Funding on a pan-European level (extended NER300 or Innovation Fund) but more tailored to the industry's and Member States' requirements.

QB2.1. What is your view of the following potential policy mechanisms to be established at EU level?

	Strongly support	Support	Possible	Don't support	Strongly don't support	Don't know
A CO_2 price ramp – driven by a tighter cap.	38	23	8	5	6	25
Public grants to subsidise capital costs	26	25	15	9	9	21
Public grants to subsidise operating costs of CCS plants	20	19	18	15	10	23
Public grants to subsidise capital and operating costs of CCS plants	28	16	15	12	10	24
CCS certificates	12	18	29	14	12	20
Emission Performance Standards	24	23	20	5	17	16

52 comments were received regarding this question. There was general support for CO_2 price ramps, with an emphasis that they should be market driven by tighter caps and not by fixing a price artificially. '*Clear and predictable price signals have been identified as important drivers for investment in CCS*.'

The majority of respondents expressed support for public grants to subsidise both capital and operating costs. Most respondents commented that feed-in-tariff support and Contracts for Difference for CCS enabled plants are reasonable and desirable approaches.

Seven respondents noted that CCS certificates are a potential option but only if they are carefully designed. Three respondents recommended a ZEP report[70] covering this topic. One respondent commented that '*if you get ETS working then you don't need certificates on top'.*

Regarding Emission Performance Standards, seven respondents advised caution, stating that '*an EPS that is set at a level too low, too early could hinder the development of CCS and shift generation to gas. An EPS set in 2030 once CCS is expected to be mature could advance coal and gas generation with CCS'*.

5.2.3 Interviews

This question was addressed in two parts. The first part asked for views on why progress in CCS has been so much slower than predicted / hoped for. The second part asked for views on policy mechanisms to speed up CCS.

Industry

- The key delay relates to the low C price and the lower than expected value of the NER.
- The appetite for risk among the companies that could be CCS developed has gone down since the financial crisis.
- The commercial case for CCS has not been good enough for companies to pursue it.
- If a comparison is made to renewable energy (where progress has been achieved) the key difference highlighted is that for renewables, targets were set and financial support mechanisms put in place to achieve these targets.
- Progress won't come without demonstration and demonstration won't come without a commercially acceptable risk (either via public subsidy or some other market intervention).
- The Directive is an enabling framework rather than a mechanism to speed up or encourage take up.

[70] http://www.zeroemissionsplatform.eu/downloads/1413.html

Environmental NGOs

- Recognise that public opinion has hindered some projects (especially in Germany).
- One NGO feels that the scientific uncertainty on storage has delayed projects.
- Another NGO feels that the utility companies have been deliberately slow.

Public actors

- Recognise the lack of a commercially viable prospect for developers.

With regard to ways in which CCS could be encouraged / made commercially more attractive:

Industry

- Need a firm GHG emissions cap (for 2030 and 2050) with a defined target / contribution from CCS.
- ETS alone viewed as being insufficient to enable CCS in the mid-term (to 2030). Though it is viewed as the best longer term mechanism.
- Other financial mechanisms / incentives are required.
- The contract for differences approach (as being introduced in the UK) has strong support.
- Mixed views on EPS – some feel that it will not encourage CCS in the medium term.
- Support for another NER300 type scheme – but suggestion is that should be useable for opex as well as capex support. [*Note: The NER 300 programme supports the first 10 years of operational costs*.]
- Any price support mechanism needs to enable development of transport and storage as well as capture.

Environmental NGOs

- Agree with industry points about ETS not being enough and there being a need for additional incentives / mechanisms that support opex and capex and the whole CCS chain.
- Also agree with need for a 2030 target and a 'roadmap' that includes a share for CCS.

5.2.4 Written submissions

Alstom's opinion on enabling CCS policies:

- Immediate funding for demonstration projects is required.
- Using 100% of the auctioning revenues and use of Market Stability Reserve to fuel an expanded NER300 well before 2020.
- Set a CCS target in the 2030 package like EU did for renewables in 2020package. This would help to create a more level playing field. Target should be at least 222Mt in 2030 (in line with 4% GHG reduction and should be divided between power (3/4) and industry (1/4).
- Stronger support at MS level via Feed in or Contracts for Difference like in the UK.
- EU state aid regulation on CCS should be more holistic and not only look at the incremental cost of CCS.
- An urgent reform of the ETS to improve price signal for CO_2 and proposal for market Stability reserve for 2017.

CCSA remarks on the enabling policies:

- New policies must be the key driver for CCS in short and medium term.
    - Level playing field with other low carbon technologies.
    - EU should support more active incentives from MSs, not via costly competition but via feed in tariffs or Contract for Differences.

- CCS should be an explicit part of the 2030 package.
    - They support the Commission's proposal for National Plans, these should include the role for CCS both in power and industry.
    - They suggest an EU milestone for CCS to (in terms of CO_2 avoided of around 222mT by 2030), national plans can be monitored against this milestone.
    - Expand European funding like NER300 or industrial Innovation fund. Regional and Cohesion funds should also be made accessible for CCS.
    - They warn that new energy efficiency policies should NOT go against CCS.

E-ON To speed up CCS developments they see more need to change the ETS directive. This should result in increased ETS incentives for CCS, inclusion of EOR/EGR, inclusion of Bio-CCS and CO_2 shipping.

E-ON feel that EU and MSs need to give additional financial support such as capital grants and feed in tariffs for demonstration projects.

Eurelectric At this stage the policy priority should be to incentivise the construction of CCS demonstration units and reform (strengthen) the EU Emissions Trading System so as to provide a longer- term incentive to implement the technology. No further obligations on market actors should be applied at this stage.

Eurelectric CCS is a technology still to be demonstrated at large scale. It will need public support during the demonstration and early deployment phase; the EU institutions and national governments should work together to develop incentive mechanisms for demonstration (ETS plus complementary innovation policies).

- Eurogas - Long term framework:
    - A long term framework is essential for the development of CCS.
    - Although we are still in research-development and first deployment phase the 2030 framework will be critical for CCS developments.
    - At least minus 40% CO_2 and a well working ETS would give the best signal.
- Eurogas -Economic Incentives:
    - ETS needs to be strengthened as the long term basis for clear market based incentives.
    - ETS is not enough to trigger CCS demonstration in the short term. Temporary and targeted measures are required like feed in premiums or CDFs, assuring an agreed price, to ensure a level playing field with other low carbon technologies.
    - R&D in CDU should also be supported.
    - An instrument like NER 300, well targeted and limited in time and expenditure is required.

European Power Plant Suppliers Association (EPPSA) As CCS entails higher costs, its deployment depends on balancing these higher costs with a higher revenue stream for operators for CCS plants, especially in the absence of a strong EU ETS signal. While this could be a feed-in tariff for CCS-equipped plants, it must not necessarily be done in this way.

Global CCS Institute (GCCSI):- Call for a strong EU CCS policy that:

- Gives a long term, predictable and technology neutral emission reduction signal.
- Short term increased, strong financial support for the early demonstration projects.
- A level playing field between CCS and other low carbon technologies.

Global CCS Institute (GCCSI):- on progress and enabling policy:

- Biggest constraint today for CCS in Europe: there is too much policy uncertainty
- More support needed both in the short term (financial) as well long term (better enabling policies like high CO_2 price).

- Global CCS Institute (GCCSI):- Capture experience around the world shows more and more 'proven technology' and cost is coming down[71].
- For transportation they suggest a European strategy for source clustering and pipeline network to reduce future cost.
- Storage: around the world so much experience that we can call it a proven technology with diverse underground solutions. In Europe enough storage possibilities available at reasonable cost (€6-€20 /ton)

International Association of Oil & Gas Producers (OGP) - In more detail on CCS policy:

- Would prefer worldwide policy mechanism, but if that is not possible EU-wide policy mechanisms.
- These policies should be technology neutral.
- An EU roadmap for CCS would be encouraged.
- They stress that gas in CCS is undervalued, e.g. in the NER 300 criteria.
- They see no role for CCS certificates.
- They do not believe other policies are compatible with a liberalised electricity market *(NB Not clear if they refer here to EPS…?)*
- They suggest concentrating on a single target in climate policy.

The Crown Estate (UK) - on 'enabling policy':

- They suggest distinguishing between a demonstration phase (2013-2017); a mid phase with supported development; and a late phase with commercial deployment.
- They recognise the need to develop CCS mainly for the power industry but that at a later stage industrial CCS also becomes important.
- EOR is recognised as being key to helping speed up the development of CCS.
- Oil and Gas operators should be stimulated to actively engage in characterising the surrounding areas of their production fields.
- The EU could consider capital pre-investment for storage and large scale R&D related to storage, under the condition that results are shared at European scale.
- Both ETS and the UK carbon floor price are too low to drive CCS until mid/late '2020s. Only carbon prices above €58/€59 will force CCS. Therefor other 'realistic' mechanisms are required.
- Good cooperation in the North Sea basin is an opportunity that should be supported.
- The NER 300 process was not fit for purpose. An EEPR type of support could benefit the sector. They mention especially the EU support for Storage characterisation in high grade areas[72] (potentially under Horizon 2020).

Zero Emissions Platform (ZEP) - on the enabling policy:

- New policies for CCS support are needed and should address both Capex and Opex.
- The Commission should support interested MSs and remove legal barriers to CCS deployment at national level.

Euracoal states that:

- The ETS scheme should not be seen as failure since it has been successful in the sense that targets are being met with a low carbon price.

[71] For instance, SaskPower has indicated that should Boundary Dam be replicated, the CAPEX cost could be 30 per cent less (http://www.saskpowerccs.com/symposium/presentations/5%20%20%20Mike%20Monea%20-%20Outro%20-%20May%20%2013%20v5%20-%20F%20I%20N%20A%20L%20%20.pdf)

[72] Consultants take 'high grade areas' to be areas or reservoirs with high potential for CCS

- It is a myth that CCS is not advancing in Europe due to a low ETS allowance price. A higher carbon price in the EU would not, at first, encourage CCS but would result in fuel switching from coal to gas.
- Onshore and offshore wind, nuclear, biomass, solar thermal and PV are all heavily subsidised. CCS will similarly need to be subsidised if it is to have its rightful place among these low-carbon technologies.

National Grid Carbon state:

- CCS needs an effective ETS in the long term and specific incentives in the interim. Incentivising pre-investment in shared-user pipelines or storage site characterisation requires supplementary capital funds well ahead of any support from an ETS instrument; and in the absence of a track record of an appropriate long term CO_2 abatement price, a supplementary policy instrument is necessary to provide confidence in a revenue stream.
- CCS needs to be placed on a level playing field with other renewable energy sources. CCS should be explicitly supported in the 2030 package as an essential part of achieving the European energy and climate change objectives and should also be deemed adequate to meet the requirement in the TEN-E regulation for Projects of Common Interest.

The main messages from Vattenfall's submission are:

- A clearly defined EU long-term roadmap 2050 must be complemented by aligned national roadmaps which include CCS as a low-carbon technology in Europe with more financial support.
- Vattenfall sees a conflict between having parallel EPS and ETS regulation.
- High CO_2-prices generate no business case by themselves. They are first and foremost a cost factor – to be mitigated or avoided. Mitigation/avoidance could come in the shape of CCS or in the shape of moving the business/industry.
- The EU power market is not generating enough revenues to incentivise investments in new capacity. Given the substantial additional upfront and operating costs of CCS, this technology cannot materialise as long as the EU power market is in such a dysfunctional state. Thus, the crisis of CCS mirrors the crisis of the power industry.

The Regulatory Assistance Project (RAP) notes (see related comments under question 37 on EPS):

- Coherent roadmaps and detailed strategies are needed to deliver the EU's energy policy goals. A roadmap needs to be supplemented by detailed and robust decarbonisation strategies that incorporate coherent targets, plans, and roadmaps for particular technologies, including CCS.
- The ETS cannot guarantee the high and stable prices that would be needed to support CCS investment.
- A CCS quota/certificates system is an appropriate instrument for large, infrequent investments such as CCS but it needs to be emphasised that such a scheme should only be introduced to complement an EPS, not as an alternative to it.

5.2.5 Case studies

In the FEED report for the Compostilla project [ENDESA, 2013], it is stated that "[t]he Spanish regulatory market instability is a high risk to face a Final Investment Decision, especially in a project which requires strong institutional support. Regulatory risks are much higher in demonstration phase technologies which are not economically feasible based on the tender market prices. This feature makes decision making and forward planning complicated. Robust regulatory frameworks that support the business case for all investors in the CCS value chain are essential to develop large-scale demonstration projects.

It is therefore essential that CCS should be fully integrated into an EU 2030 Energy and Climate Policy framework. This should be coordinated with structural reform of the ETS in order to strengthen the EUA price and provide a long-term incentive for investment.

From the point of view of regulation as remuneration system, the base load operation should be taken into account. The inertia of the OXYCFB300 Project, associated to the auxiliary equipment, reduces the operational flexibility in secondary regulation (short term supply and demand adjustments generation) and availability premium. It should also be considered that the Spanish market mix is in favour of renewable energies.

Lack of CCS legislation as a global process increases the potential problems in obtaining environmental integrated authorisation.

To sum up, development of a regulatory framework is necessary but not sufficient to catalyse CCS deployment, economic and political barriers would also need to be addressed.

The **White Rose** consortium believes that CCS projects need significant funding at the Commercial Scale Demonstration phase. Support mechanisms are required for both the power / capture side of the CCS chain but also for the transport / storage infrastructure.

It is highlighted by the White Rose CCS Project consortium that the EU ETS should remain the mechanism for electricity and industrial decarbonisation in the EU. However, the current low price of EUAs is clearly insufficient to drive investment in low-carbon plant and technology, so reform of the ETS is needed. The aim of this should be to highlight the benefits of a long term expected revenue stream such as that provided by contracts for difference (CFD) in the UK. Therefore some complementary instrument to support CCS would be necessary.

Requirements for new support policy -Member States have failed to implement appropriate support policies for CCS. Policies such as feed-in premia and contracts for difference should be explicitly encouraged. Any new mechanism to support CCS would need to

- Create a robust and predictable revenue stream ensuring that the developer(s) can recover capital and operating expenditure and achieve an appropriate rate of return which reflects the commercial and technical risks associated with new technology (or scaling up existing technology);
- Recognise the right of individual Member States to determine their own energy mix, but encourage development of a supportive regulatory and incentive environment for CCS where it meets national circumstances;
- Policy should recognise and appropriately reward early investors in CCS to reflect the larger commercial and technical risks of these projects; i.e. developers should not be penalised for being the first mover in the event that the technology underperforms;
- The support should not detract from (and if possible should under-pin) the EU ETS, which we regard as the best instrument to drive long-term de-carbonisation in the EU. However, we recognise that it may be necessary to design a stand-alone support mechanism given the likely timescale necessary to restructure the EU ETS;
- Preferably it should seek to incentivise investment rather than punish noninvestment;
- Support the ability to form intergovernmental agreements between Member States to enable joint investment in CCS.

Renewable energy targets - In addition, it is believed that the renewable targets have slowed down the deployment of CCS. There is a need to establish with policymakers and the public that the place of CCS in the power market is complementary to, and indeed enabling, renewables rather than competing with them. Capture Power Limited believes that an encompassing target which includes both CCS and renewables is required. CCS should be explicitly supported in the 2030 package as an essential part of achieving the European energy and climate change objectives.

Support for transport and storage infrastructure - The consortium believes that direct support is required to the storage and transport elements of the chain. None of the existing support mechanisms addresses this. Investors in transport and storage will need established, and appropriate, long term policy direction to give confidence that a CO_2 abatement market exists combined with specific upfront support for storage and transport pre-investment. Storage operators face a disproportionate upfront

exposure. Emitters expect storage operators to undertake exploration to reduce geological risk, prior to engaging into serious negotiations. In addition, investors in the transport sector are not incentivised to pre-invest in pipeline capacity in a way that realises economies of scale benefits. Financial support to provide this incentive can be delivered through capital grant for pre-investment or a long term contract guaranteed income to cover the cost.

One-off mechanisms (such as the NER300 approach) provide an injection of funding which is appropriate for a transition phase. This kind of unpredictable policy instrument does not give confidence to long term investors and developers of CCS.

CCS competitions - Based on experience, it is believed that support for CCS must move away from "competitions" which are resource intensive and do not provide value for money in the allocation of public funds. Evidence to date of awarding one-off funds to CCS projects clearly shows that care must be taken to avoid introducing obstacles to CCS support by applying legislation developed for more mature markets is applied. The way that State Aid and Procurement legislation has been applied to CCS funding (at least in the UK) has wasted significant amounts of public and industry money in failed competitions and introduced many years of delay to the introduction of CCS. The total amount spent on stopped projects far exceeds any saving that could be achieved through competitive tension. In addition, the competitive environment prevents the few remaining participants in CCS from collaborating in overcoming shared problems.

Given the **Getica Project** forms part of worldwide efforts to demonstrate CCS at a large scale, the investment and O&M costs are relatively high[73]. The assessment of financing sources for the Getica project aimed to maximise the utilisation of sources of direct funding (grants). This would result in lower financial costs to the project and minimise funding risks for the project proponent. It is hoped that 50% of the cost of the Getica project will be financed through the NER300. The European Commission and investors have made it clear that financial support from national governments will be indispensable, in addition to those resources available through EU grant mechanisms and the European Investment Bank (EIB).The funding of the Getica project is highly dependent on the CO_2 price and the support of the Romanian Government by establishing incentive schemes for CCS. Especially in the case of the CO_2 price, the Romanian project has no control over that factor, thus no leverage to minimise the risks.

5.2.6 Stakeholder meeting

- Some stakeholders felt that the best political option to incentivise CCS would be a Carbon tax and that the ETS should be abandoned.

The second session of the workshop focussed on the wider policy framework that is intended to support CCS. Although much of this is outside the control of the Directive it is relevant to the issues raised in the review article (article 38) of the Directive:

- The discussion indicated that there was a strong belief that the broader policy framework does need significant attention if CCS demonstration plants are to become a reality.
- The rationale for the CCS Directive assumed that ETS would have enabled the installation of multiple CCS demonstration plants by now, however this has not happened.
- The discussion included comment on the high level of 'tampering' that has happened to the ETS over the last 10-15 years. However it was also pointed out by some that the ETS has arguably succeeded in encouraging innovation and lowering carbon emissions.
- A number of the stakeholders made the point that whatever EC support can be offered, it should not be regarded as the only relevant incentive. Member State level policy and incentives also need to play a major role in incentivising CCS.

[73] Financial scenarios report to the Global CCS Institute, available at http://decarboni.se/sites/default/files/publications/84536/getica-ccs-demo-project-financial-scenarios-report.pdf

- Some stakeholders voiced the opinion that the level of funding and support for renewable energy needs to be replicated (or partly diverted) towards CCS.
- Some stakeholders made the point that CO_2 reduction targets should be technologically neutral, i.e. the methods of achieving the targets (Res vs. CCS vs. Nuclear vs. energy efficiency etc.) should not be prescribed. Others felt that this would not be possible.
- A number of stakeholders made the point that it is key that the role of CCS (in reducing CO_2 emissions) is clearly mentioned in the 2030 framework. They felt that this should be achieved via the he MS level plans (the national governance plans) for the 2030 framework, which should have a clear role (and share) for CCS.
- There was general agreement that ETS alone won't be enough to incentivise CCS demonstration. A number of stakeholders voiced the perception that subsidies for the capital cost (Capex) of CCS come from EU sources, while support for the operating costs (Opex) comes from MS sources. Although, the NER 300 programme supports the first 10 years of operational costs. Because of this they felt that there was a need for improved policy coherence between EU and MS level support, with a particular need for alignment of Capex and Opex support.
- A discussion was held comparing the support for CCS in Europe with that in other parts of the world – with the conclusion being that funds focussed on research and development have been the main type of funding (i.e. public grants). The point was raised that no region or country has yet answered the question of moving from R&D sourced support for CCS to early deployment support.
- A number of those present voiced the opinion that the EU has lost its lead on CCS demonstrations, with the USA now seen as the leader. This point was somewhat qualified by others who pointed out that the USA projects have been easier to advance because of the financial benefits (and in some cases pre –existence of infrastructure) of using the injected CO_2 in enhanced oil recovery (EOR). The majority of the planned projects in China were also described as being made more viable because of EOR.
- It was suggested that the Commission could help improve the prospects for CCS by developing an 'EU CCS roadmap'– to 2030 and 2050. It was suggested that it was important that this roadmap should include consideration of transport and storage infrastructure and the need for pre-investment in storage and transport. Because large scale capture is not possible without having transport and storage infrastructure in place, and this infrastructure will take much longer to develop than the capture. It was felt that policy may not be giving enough attention to transport and storage infrastructure. A 2050 roadmap for CCS illustrates when work on a storage system needs to be started. This suggests a date of about 2020 – so it is urgent!
- As in the first session there was a clear consensus that the most urgent need is to enable large scale demonstration projects, in order that all concerned can learn from experience.
- There was general support for continuing the NER300 support for CCS, with comments including that it should start as soon as possible as additional delays cannot be afforded (if CCS deployment is to be achieved).
- In a continuation of the theme of slower than expected (and slower than required) progress on CCS one stakeholder described the situation as a 'lost decade' for CCS. They went on to state that another decade could be lost if the political climate is not changed. They expanded upon this point by stating that CCS is only driven by climate change and there is no other reason for utilities to invest in it.
- One stakeholder stated that in their opinion continuing the poorly functioning ETS is what power companies want – as it allows them to continue to operate as they have always done. In this stakeholders opinion this business model is not appropriate to reducing CO_2 emissions and there is a need to urgently address this if CCS is going to succeed.
- Some stakeholders suggested that the UK approach – of 'no new coal without CCS' should be adopted across all of Europe.

- Some stakeholders gave the opinion that if ETS is not enough to encourage CCS, this should not be viewed as an excuse to do nothing. For example the current proposal on the market stability reserve needs to be rapidly adopted.
- There was discussion of EPS with some stakeholders offering the opinion that they don't feel that it would be of significant help in enabling early CCS demos in the EU. Others went further by saying that they feel there is no evidence that EPS works for CCS. Others made the point that ETS is undermined by EPS. One stakeholder raised the point that Article 38.3 of the CCS Directive states that EPS should only be considered when CCS is demonstrated and feasible. Given that neither of these are true yet, EPS should not be considered Other stakeholders supported EPS but felt that it needs to be combined with another financial instrument to help deliver CCS.
- Some stakeholders suggested that a (consistent) EU wide CCS support scheme would avoid the repeat of the wide variation between MS support schemes for renewables.
- One stakeholder raised the point that the cost to the consumer (i.e. higher energy prices because of CCS) should not be forgotten. For example ETS pushes the price up. This impact on energy prices was described as a factor that will limit the level of political support it will ever be possible for CCS to get.
- A number of stakeholders raised the point that there is compelling evidence that CCS is the most cost effective way to decarbonise.
- A number of stakeholders raised the point that CCS certificates are getting attention in non-traditional policy circles. Other stakeholders questioned this approach by saying that a market needs a volume to get working and with no target, would there be enough incentive to get it working? The idea of pursuing a global approach to CCS, utilising the model of the Montreal protocol on CFCs, with a globally reducing (over time) CO_2 allowance, was raised by some stakeholders as being an ideal model.

5.2.7 Summary and conclusions

This question covers a wide variety of issues, with the majority of them going far beyond the objectives of the CCS Directive to encompass energy and climate policy as a whole. A key starting point is that the literature suggests that CCS appears to be cost competitive with other medium to long term options for decarbonising the power supply. It is apparent that, as stated under a number of other questions, the carbon price (via the EU-ETS) has not been high or stable enough to give sufficient confidence to start CCS investments. The low carbon price is mainly a result of the global economic crisis with other energy policy actions also playing a role.

The two EC mechanisms for supporting CCS (the NER300 and the EEPR) have attracted bids, but have not offered high enough levels of support to make up for the funding gap (and general lack of investor confidence) that still exists. All 13 bids to the first round of NER300 stalled and withdrew. One bid has been approved under round two and this continues to move towards Final Investment Decision - with the benefit of additional capital support (and a CCS supportive policy landscape) from the UK government. The EEPR offered funding to six CCS demonstration projects. Two are still being pursued but the other four have been cancelled. The UK and the Netherlands have offered substantial funds of their own to help support CCS demonstrations but no other MSs have done this. There appears to be a good case for addressing some State Aid concerns which remain about the use of MS funds to support the operating phase of early CCS plants (and infrastructure) although the Commission has already adjusted its guidelines to clarify the position of CCS, so this issue may relate more to a lack of willingness by some Member States to support CCS projects.

MS and stakeholder support for EU capital support for CCS (demonstration scale) plants remains high, with calls to ensure that the details of the proposed successor to NER300 are finalised as soon as possible and that the EU's regional and structural funds are made more readily accessible to CCS related projects. Both suggestions appear valid.

There are strong calls for clear signals to be sent regarding the important position of CCS as a way to decarbonise the power supply of Europe. The suggestion that this could be achieved by the specific inclusion of CCS in the EU and MS 2030 low carbon roadmaps, with targets for CCS appears strong and valid. The need to consider transport and storage within this process was also stressed – for example via a process of source clustering and the consideration of pipeline networks. Both of these

points appear valid. Obliging MSs to consider the role of CCS in decarbonising their energy supply would require those MSs who do not wish to purse CCS to indicate how they will achieve the reduction in CO_2 without it. It will also encourage the majority of MSs that have been relatively inactive on the subject to consider if they should be more actively supporting early CCS projects via grants and/or other mechanisms. With regard to the use of competitive processes for awarding grants to CCS projects, the point was made that this process implies extra (at risk) work for applicants and makes cooperation between projects more difficult. Although both of these points are true there is no obvious alternative way in which public subsidy could be transparently allocated. There are a number of active CCS networks and organisations so it appears that a system for information sharing does exist.

The majority of stakeholders think that more support for CCS is needed in the short term. There were a wide variety of suggestions of how this should be achieved. Some of these are CCS specific, such as incentives for CCS in industry and that the EU's Regional and Cohesion funds should be open to CCS projects. The latter of these suggestions appears reasonable. Many of the suggestions go beyond CCS in that they would have significant impacts on energy policy as a whole. This includes the options of EPS and other MS level electricity market mechanisms, such as contracts for difference and the variety of mechanisms used to support renewable sources of energy. There are a number of clear suggestions for changes to the ETS that would benefit CCS. The suggestions are clarification of the treatment of EHR, bioCCS and transport of CO_2 by ship, these suggestions all appear justified and are discussed elsewhere.

There were also suggestions that CCS should ideally be pursued via a global mechanism, with all regions and countries of the world agreeing to a tapering limit for CO_2 emissions, in the same way as CFC emissions were successfully cut via the Montreal protocol. While this suggestion would be ideal in terms of clarity and global commitment the political difficulties and overall aim are very similar (although longer term) to the Kyoto protocol.

Most stakeholders believe that the ETS is the right instrument to support CCS in the long run but it needs to be reformed. Most do not believe that the ETS alone is sufficient to incentivise CCS in the foreseeable future. The expected ETS prices up to 2030 will not trigger CCS developments.

Most industry respondents called for a level-playing field for CCS and other low carbon technologies. The key difference highlighted is that for renewables, targets were set and substantial financial support mechanisms were put in place (mostly at MS level) to achieve these targets. The need for a single target encompassing all low carbon technologies (as suggested above), including CCS, was highlighted.

5.3 Q23 – CCS in Industry

23. The Roadmap for moving to a Low Carbon Economy in 2050 indicates that the CO_2 emissions from industrial sectors need to be reduced by 34% to 40% by 2030 compared to 1990. The potential of CCS in industrial applications can be large. The application of CCS in certain industries, particularly in cement, steel, refining sector, could therefore represent an interesting option for the early deployment of the technology in view of the expected lower costs in comparison to power generation sector. Is the EU legal framework for CCS adequately addressing the prospects of uptake of CCS in the industrial sector? If not, which areas could be improved?

5.3.1 Literature review

Significant attention has recently been placed on the development of CO_2 capture within *industrial processes*[74][75]. Many industrial processes have reached the boundaries of process optimisation, and many energy efficiency measures have already been implemented. CO_2 capture is arguably the only realistic option to significantly decarbonise conventional industrial processes such as the oxygen blast furnace (OBF), the steam cracker and the cement kiln. Decarbonising the industrial sector without CCS would require the development of alternative production processes for important building materials, plastics and transport fuels.

[74] IEA & UNIDO (2011). Technology Roadmap - Carbon Capture and Storage in Industrial Applications, 52 p. http://www.globalccsinstitute.com/publications/technology-roadmap-carbon-capture-and-storage-industrial-applications

[75] ZEP (2013). CO2 Capture and Storage (CCS) in energy-intensive industries - An indispensable route to an EU low-carbon economy,38 p. http://www.zeroemissionsplatform.eu/news/news/1601-zep-publishes-key-report-on-ccs-in-eu-energy-intensive-industries.html

The industrial sector faces many economic challenges to investing in CO_2 capture technology, as summarised in[76]. Furthermore, many industrial stakeholders are not familiar with the concept of CCS, as it has generally emerged as a CO_2 mitigation technology for the power and upstream sectors. Industrial sectors include cement production (0.5 and 1 Mt/a for a typical plant[77]), the chemical industry (ethylene plants have an average output of 0.6 Mt/a[78]), iron and steel furnaces and refineries With regard to the EU CCS Directive, it is possible to highlight two issues that may be of key relevance for industrial stakeholders, as opposed to those in the power sector:

1. CO_2 sources in many industry sectors are far smaller (lower volume) than those in the power sector – therefore one can imagine that investing in pipeline infrastructures and storage sites will be very difficult for industrial firms. The interpretation of Article 21 "Access to transport network and storage sites", and rules around dispute settlement initiated by a particular jurisdiction can have a bearing on industries appetite to invest in CCS, based on access to transport and storage infrastructure.
2. The heterogeneity of industrial processes means that the flue gas compositions are diverse. This would have an impact on what level of impurities may be present in a captured CO_2 stream. Article 12 "CO_2 stream acceptance criteria and procedure", states that a CO_2 stream must overwhelmingly consist of CO_2. The flexibility also leads to uncertainty for industrial stakeholders that are looking for the most cost-effective capture technology. In some sectors, achieving a stream composition of 90% CO_2 could have considerable cost savings, as opposed to aiming for 99% CO_2 purity. Some stakeholders have stressed that a further guidance on stream criteria could be necessary.

5.3.2 On line survey

QB1. Do you think that the EU regulatory framework for CCS adequately takes the following issues into account?

	Yes	No	Don't Know
The uptake of CCS in the industrial sector (non power generation) for example, cement, refining, steel.	24	45	26
The utilisation of CO_2 captured in industrial processes (in combination with CCS) (Carbon Dioxide Utilisation (CDU))	27	51	27

There was much support for additional incentives to support the uptake of CCS in industrial applications. Fifteen respondents felt that specific articles should be added and article 33 regarding CCS readiness should be expanded to industry. One respondent noted that the ETS '*does provide an incentive for CO_2 capture from industrial emitters but, as with power generation, the incentive is insufficient'.* Seven respondents commented that the integration of CCS with industry is crucial for the development of CCS in the long term. '*If sectors such as steel and concrete making were to deploy CCS, it would further accelerate the decarbonisation of electricity generation through RES deployment built using low-carbon construction materials.'*

One respondent commented that while the Directive itself enables storage of CO_2 from any industrial source, there is '*a lack of any focus on capture from industry or supporting its deployment; this is a serious omission in overall EU CCS policy*'.

Comments on CDU

Five respondents felt that the CCS Directive was designed to address the geological storage of CO_2 and not utilisation, meaning that CDU should not be covered by the Directive.

[76] Mikunda T, T Kobera, H de Coninck, M Bazilian, H Rösler & B van der Zwaan (2014). Designing policy for deployment of CCS in industry http://www.tandfonline.com/doi/abs/10.1080/14693062.2014.905441?journalCode=tcpo20#.U9usaqPCRD8
[77] Ecofys. (2009a). Methodology for the free allocation of emission allowances in the EU ETS post 2012 – Sector report for the cement industry. Utrecht, The Netherlands: Ecofys.
[78] Ecofys. (2009b). Methodology for the free allocation of emission allowances in the EU ETS post 2012 – Sector report for the chemical industry. Utrecht, The Netherlands: Ecofys.

5.3.3 Interviews

This question is covered, to a certain extent, under other headings. The key points that emerge are as follows:

- The CO_2 streams in question are high concentration but low volume (in comparison to power stations).
- Given this fact it is felt unlikely that industrial installations will be first movers.
- NGO / public opposition to industrial CO_2 capture is likely to be much less than for power plant projects – due to it being easier to 'sell' in comparison to CCS associated with coal fired power stations.
- The transport and storage issues are all the same as for any other form of CCS.

5.3.4 Written submissions

CO2GeoNet would like to see CCS with industrial sources encouraged through the guidance documents.

5.3.5 Summary and conclusions

Deep decarbonisation of many large industrial processes is only currently possible via CCS. Most industrial sources produce much smaller volumes than powers stations which makes the cost of transport and storage higher (per unit of CO_2 stored). There is also often greater variance in the composition of the CO_2 stream from industrial sources as compared to power stations. The CCS Directive says nothing specific to limit or encourage industrial CCS. Stakeholders argue that CCS is important for industrial installations but given the points raised above many doubt that it will be the first mover. There are calls for industrial CCS to be better addressed in overall EU CCS policy. These calls are reasonable, partly because industrial CCS will make public and NGO acceptance easier for CCS in general.

Section 6 Evaluation answers - Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention. Typical efficiency analysis will include analysis of administrative and regulatory burden and look at aspects of simplification. In many evaluations this is judged by a combination of participant opinion and comparisons, particularly of administrative costs, with other programmes or policies. These comparisons with other policies and programmes are not easy with CCS, as there is no central programme expenditure to consider. The lack of practical experience of CCS projects going through the regulatory process described / regulated by the CCS Directive (only one project – ROAD – has really been any distance through the process) also makes this question particularly difficult to answer.

As discussed in the methodology section Member State representatives (including competent authorities) were invited to respond to the online survey and to attend the stakeholder meetings. However very few Member States took part with contributions only being received from the UK, France and the Netherlands. This has made the assessment of efficiency more difficult, as it has not been possible to identify data on the costs of implementation that have fallen on the Member States.

6.1 Q24 – Are costs proportional to results

24. Are the costs resulting from the implementation of the Directive proportional to the results to be achieved?

6.1.1 Interviews and literature review

This question, despite its normal importance in evaluations, did not receive a great deal of response in the interviews. In summary the response is that it is not possible to tell yet, but there is no reason yet to doubt the initial estimates made in the Impact Assessment[79]. This gave an assessment of cumulative administrative costs (to 2030) for the selected option (CCS enabled via ETS) of €17.8 million, with €12.4 million of this falling on operators, €4.7 on Member States and the rest on the Commission. The impact assessment assesses the costs (of installing capture, transport and storage) and benefits (in terms of CO_2 and other emissions avoided, health and employment etc.) of a number of scenarios related to the ways in which CCS could be enabled, ranging from ETS to varying degrees of mandatory CCS for power stations. The important factor to realise is that the CCS Directive would apply under any of these scenarios, so the overall costs (apart from the administrative costs) and benefits are driven by CCS enabling policy as a whole.

6.1.2 Case studies

The ROAD project - Lessons from ROAD Permit process and timing of Final Investment Decision (FID).

Issue - In ROAD's opinion there is a huge gap between the requirements of the CCS Directive and the feasibility for a concrete project such as ROAD to comply with these requirements. According to ROAD, the permitting process in the CCS Directive is not realistic for a project, because the Directive requires that all the required plans (i.e. monitoring, corrective measures, etc., as described in paragraph 5.3) are fully ready at the moment a project submits its application. In reality, developing all the studies, collecting all necessary information, and issuing reports will only be done after a FID is taken, and in order to take a FID, a granted storage permit is necessary.

Solution - To overcome this issue, ROAD have suggested the following solution: lower the level of details of all plans (i.e. monitoring, corrective measures, financial security etc.) in the application and update these plans prior to injections. The plans (not operational yet) in the permit application provide sufficient information and prove that CO_2 can be stored safely, complying with the CCS Directive requirements, but do not include operational parameters, choices for specific monitoring instruments, all of which will be elaborated in the final plans.

[79] http://ec.europa.eu/clima/policies/lowcarbon/ccs/docs/ccs_ia_jan2008_en.pdf

Way forward - At this time, the competent authorities and the EC have stated that they are satisfied with the current level of detail and have granted the permit. The EC concluded in its opinion that the application ".confirms the suitability of the chosen storage location for the permanent storage of CO_2 as was demonstrated by a detailed characterisation and assessment of the storage site and complex".

It has been agreed that the final plans will be submitted to the competent authority and the EC a year before the injection of CO_2 starts. The competent authorities must give their approval on the final plans and before adjusting the permit the state advisors will give their expert advice. Also in 2014, the EC will be able to give another non-legally binding opinion on the update of the storage permit, when all of the plans have been elaborated.

With this agreement, the draft storage permit has been granted to ROAD (which gives them sufficient confidence to take the final investment decision for the ROAD project) and the competent authorities and the European Commission are able to approve the final plans before injection starts (which complies with the CCS Directive).

For both the Dutch CA and the ROAD operators this was a new exercise, and much time and money was spent in the process. Some of the learnings can be extended to new applications, but due to the nature of CCS the process will probably remain complex and time consuming.

The White Rose Project - Key progress has been made in understanding the risks that industry is willing to take and the premium for accepting other risks. Several of these risks that have resulted in cost premia created by the application of criteria from the Directive, associated legislation including Procurement/ State Aid and Guidance. Significant cost savings could be realised in early projects by the relaxation of these criteria. They could be tightened again if necessary, once economies of scale have driven down.

6.1.3 Summary and conclusions

It is not yet possible to provide an answer on the efficiency of the CCS Directive as there is insufficient evidence. The impact assessment for the CCS Directive estimates the administrative costs to 2030 to be €17.8 million, with 70% of this falling on operators, 26% on Member States and 4% on the Commission. There has not yet been enough experience of CCS regulation to doubt, or suggest adjustments to, the numbers, though the lack of experience also means that they cannot be confirmed.

The overall costs and benefits of CCS depend on CCS (and climate and energy) policy as a whole and the extent to which this drives the uptake of CCS. The CCS Directive is only part of the enabling policy and, as discussed elsewhere, the Directive has not been the main reason why uptake of CCS has so far been lower than predicted.

The ROAD project has been the first (and only) relatively detailed test of the CCS Directive requirements. There are some useful lessons from this project on the procedures and hence administrative cost implications. A useful practical lesson relates to the level of detail required in the plans (covering monitoring, corrective measures, financial security etc.) required when submitting the storage permit application. Given that a final investment decision will not be made until this permit is awarded the ROAD project did not submit highly detailed plans with its application but said these plans would be updated (and expanded) and approval of the CA sought, prior to injection. This approach has been accepted by the CA in the Netherlands and the EC. This appears to be a good model for future applications. The applications should be made public (with any commercial information redacted) and ideally translated into English, so that future applicants can replicate the level of detail.

Section 7 Evaluation answers - Coherence

Coherence considers how well interventions which share common objectives work together. Depending on the scope set, it can look at coherence within the intervention; coherence within interventions of the same policy area (e.g. water policy, health and safety); within a wide area including possibly international agreements/declarations (e.g. all EU environmental activities including international treaties, all EU activities related to consumer protection).

7.1 Q25 – Fit with other EU policy objectives

25. How well does the Directive fit with other EU policy objectives?

7.1.1 On line survey

QB3. The CCS Directive is intended to work alongside a number of other European level policies and programmes. How well do you think the objectives and content of the CCS Directive fit with the following EU policies and tools?

	Good fit	Reasonable fit	Neutral	Some contradictions	Serious contradictions	Don't know
The ETS mechanism (including programmes such as the NER300)	24	32	10	16	7	16
R&D support (FP7 and Horizon 2020)	22	36	15	10	7	15
Support for Renewable Energy Sources	8	8	20	36	15	18
Support for Energy Efficiency	6	14	37	22	5	21
The Waste Directive	9	17	23	5	3	48

There were 126 comments received on this question. The comments are summarised below according to the points that were addressed.

Comments on the ETS mechanism

Respondents felt that clear pricing signals through the ETS could potentially help to drive investment in CCS. ETS is based on a volatile price which is unlikely to reach the levels needed for CCS to contribute to EU 2050 targets. The ETS aims at reducing emissions cost effectively while incentivising development of low carbon technologies including CCS. However, over supply on the market has led to a situation when the carbon price signal is insufficient to trigger these investments.

One respondent commented that it could be possible to '*take storage out of ETS so that leakage (if any ever) is dealt with under a different regime.'*

Comments on support to Research & Development

The majority of respondents showed support for additional R&D and demonstration, although there was some criticism of NER300, Horizon 2020 and FP7 as being '*too short'* to support the development of CCS.

Comments on support for Renewable Energy Sources

Respondents noted that the complementary nature of CCS and renewables should be emphasised, with a number of respondents commenting that a portfolio of technologies will be needed to achieve decarbonisation. Two respondents noted a conflict between CCS and geothermal energy projects, with a further five respondents commenting that funding for RES has diverted funds and development away from other low-carbon technologies such as CCS.

Comments on support for Energy Efficiency

Five respondents called for a level playing field with other low carbon technologies, with two respondents noting that energy efficiency targets should not be designed in such a way that they discourage CCS. However, one respondent also commented that Energy Efficiency should have priority over CCS.

Comments on the Waste Directive

The Waste Directive aims at reducing the use of resources and preventing waste. The additional energy required for CO_2 Capture (and to a lesser extent, transportation), increases the use of resources. One respondent commented that there is a need to clearly state that CO_2 being stored should be classed as a waste. However, three respondents disagreed with this point, and noted that CO_2 is not a waste.

7.1.2 Interviews

Input to this question came from an interview question on the coherence of EU policy related to CCS. This was prompted with mention of a number of key energy policy areas and an enquiry into any contradictions or synergies?

Industry

- CCS directive is internally consistent.
- Overarching energy / CCS policy is complex – with (for example) subsidies for renewable energy arguably dropping the C price, which has made CCS less viable.
- The lack of any target for CCS, when there is a target for renewables, has arguably benefited renewables at the expense of CCS.
- Energy efficiency targets for power plants or Industry could (potentially) be negative for CCS – as CCS will cost more energy as without. EE targets can thus conflict with CO_2 reduction.
- Suggestion that support for CCS projects should be allowable under State Aid.

Environmental NGOs

- Believe that it is possible to promote renewables and CCS at the same time.
- Recognise that ETS is not currently sufficient to enable CCS.

7.1.3 Summary and conclusions

The question of coherence is relatively complex because the CCS Directive is only a part of CCS enabling policy, and CCS enabling policy is in turn part of energy and climate policy. The CCS Directive (and its impact assessment) make it clear that the ETS is seen as the key mechanism for encouraging CCS. The low carbon prices that have characterised the ETS in recent years are recognised as arguably being the main reason why CCS projects have failed to develop in the numbers foreseen when the Directive was enacted. There are a number of other important issues for CCS related to ETS. These are discussed in more detail elsewhere in this report but include the following: the need for additional credit for bioCCS, the treatment of transport of CO_2 by ship, the value of any future leakage of CO_2 from storage facilities and the assignment of ETS income along the chain of capture, transport and storage.

With regard to wider energy and climate policy it is true that renewable energy receives a lot more subsidy than CCS. Some felt that this is harmful for CCS as it reduces the amount of subsidy available for CCS (on the assumption that consumers can also be expected to pay for so much low carbon energy investment) and also because it has the effect of reducing carbon prices, which is also negative for CCS. While both of these points are true it reflects the maturity and relative simplicity of

renewable energy (particularly wind and solar energy) in comparison to CCS. Some of the same comments were also made with regard to energy efficiency in comparison to CCS. The conclusion on this issue appears to be that it is not helpful to think of energy and climate policy in terms of one technology versus another. The best approach, and one that also respects the right of MSs to make their own energy policy decisions, is to agree on (and commit to) long term emission reduction goals and allow each MS to describe how it will achieve these. The literature indicates that CCS will need to play a major role alongside renewables, energy efficiency and other technologies (e.g. nuclear power) but if some MSs can demonstrate an approach that does not require CCS then this should be accepted.

There is support for research and demonstration of CCS via the Horizon 2020 programme, the ETS funded NER300 programme and the EEPR. There was a clear consensus that this should continue. There were some specific suggestions on the NER300 successor, which are discussed elsewhere, but include the need to ensure it is put in place as soon as possible (to avoid funding gaps), to improve clarity over its ability to support operating as well as capital costs and suggestions that the selection criteria should not favour schemes with the largest CO_2 capture but should also consider the ratio between CO_2 captured and 'clean' output.

There are some CCS issues which overlap with the Large Combustion Plant Directive (LCPD). These are discussed in more detail elsewhere but relate to EPS and CCR.

7.2 Q26 – Combination with EIA Directive

26. Has the combination of the Industrial Emissions Directive, EIA Directive and the CCS Directive proven effective to regulate CO_2 capture? Is there a need for different legislative provisions on CO_2 capture at the European / Member States' level? How could the interaction between these Directives be improved?

7.2.1 On line survey

QB4.1 Is the combination of the CCS, Industrial Emissions and EIA Directives sufficient to regulate CO_2 capture?

	Yes	No	Don't Know
At EU level?	58	14	33
At MS level?	49	17	38

The comments received on this question are summarised below according to the points that were addressed.

Comments on EU level

One respondent commented that there are still no CCS projects to regulate, so it is too early to ask this question. Other respondents suggested that stronger climate targets and sectoral targets at EU level, and stricter requirements on power plant emissions (i.e. Emission Performance Standards) could give additional confidence and drive the uptake of CCS. Three respondents felt that the combination of the three existing Directives is sufficient to regulate CO_2 capture.

Comments on Member State level

Four respondents felt that CO_2 capture should be regulated at the EU level, not at the Member State level. One respondent commented that the degree of appropriateness depends strongly on the individual Member States. The UK has implemented an EPS but to be effective this has to be introduced at EU level.

7.2.2 Interviews

In the interviews this question was raised by asking 'Is the CCS directive in combination with EIA and emissions regulations enough regulate the capture part of CCs?

Industry

- Yes, with the possible exception of 'capture readiness'.

7.2.3 Summary and conclusions

The key point here is that there are no operational CCS projects of a scale that brings them within the Directive in Europe yet, so there is no experience with which to answer this question. The industry view is that in general the combination should be sufficient. The two areas where there appears to be some risk of less than ideal coverage are CCR and EPS, these are both discussed elsewhere but it is clear that the coverage of both needs some clarification.

7.3 Q27 – Reporting and monitoring and ETS

27. Concerning reporting and monitoring requirements under the CCS Directive and the ETS Directive, (and the accompanying Commission Regulation 601/2012 on the monitoring and reporting of greenhouse gas emissions pursuant to ETS Directive 2003/87/EC), how has the interaction at the level of competent authorities worked in practice? Are there any legal burdens or uncertainties which have been identified?

7.3.1 Summary and conclusions

As no storage sites have yet become operational for regulation under the CCS Directive there is no experience available to answer this question. There is some discussion of the financial obligations attached to the requirement for future leakages to be paid for the value of CO_2 emissions when they leak (as opposed to when they were captured). This is understandably perceived as an important risk by developers – as the value cannot be accurately estimated in advance. This issue is discussed under question 20 on financial security provisions.

Section 8 Evaluation answers - EU Added value

EU-added value looks for changes which it can reasonably be argued are due to EU intervention, rather than any other influences at work. In many ways, the evaluation of EU added value brings together the findings of the other criteria, presenting the arguments on causality and drawing conclusions, based on the evidence to hand, about the performance of the EU intervention.

The key issue in answering these questions is establishing what the counterfactual would have been, and what the impacts and results of this counterfactual would have been. It is not possible to be certain on what would have happened without EC level action. In combination with the hypothetical approach there is also value in looking at the action of other countries around the world of a similar scale and wealth to individual MSs and looking at the approach they have adopted. If there are no comparable single state actions that can be identified, though other multinational actions can be identified, which in itself helps demonstrate EU added value.

8.1 Q28 – EU added value

28. What is the EU added value of the Directive? To what extent could the changes brought by the Directive have been achieved by national measures only?

8.1.1 On line survey

QA3. Do you think some of the objectives of the CCS Directive would be better addressed by Member States (MSs) at the national level?

	Yes	No	Don't Know
Addressing safety concerns	27	62	16
Addressing environmental concerns	22	69	14
Addressing health concerns	17	59	28
Addressing public acceptance concerns	54	36	15
Helping to create harmonised procedures to ensure a common approach	17	75	13
Helping to increase the speed and scale of CCS uptake	30	53	22

24 respondents provided additional comments on addressing safety concerns. 12 explicitly stated that both EU-wide and national legislation are required, with an overarching Directive setting the minimum standard which is met by the MS taking into account the specificities of the national context. Many noted that MS should have flexibility to introduce their own legislation to meet the objectives. 4 concluded that an EU rather than national vision was more appropriate with 1 believing an EU overlay would deliver no additional value over MS regulation.

18 respondents made notes on addressing environmental concerns. Many (10) agreed with the approach that the Directive sets a minimum standard with MS having flexibility (and being best-placed) to ensure these are met. 4 explicitly believed a common standard of environmental rules are best governed at the EU level with 1 noting that environmental issues are site specific.

14 respondents provided additional comment on the appropriateness of addressing health issues. In common with safety and environmental questions, the majority (8) agreed that common EU standards were an important minimum standard with MS best placed to ensure these are met in their country. In addition, 3 explicitly noted that an EU approach is more appropriate.

With respect to public acceptance, 26 respondents provided additional comments. 13 suggested that concerns need to be addressed through a combined approach at local, national and EU levels; hence the EC has a role to play in maximising acceptance, regardless of where this is 'best' handled. 1 noted

that environmental rules are better addressed at EU level with 5 noting due to the strong local aspect, public attitudes are best managed by MS. Some noted public acceptance requirements would be weaker in MS where public are in favour of offshore storage.

Responses as to whether an EC or national level approach is better to create harmonised procedures, 17 parties provided comment. In similarity to other questions in this section, the many comments suggested that the Directive is useful in steering the creation of a harmonised approach, but that flexibility should be given to MS which are better placed to reflect the individual experience of specific projects (6 comments). However, there was stronger explicit support for harmonisation being best achieved at EU level, with 8 respondents stating this. One suggested that: 'Member States and projects should be allowed to explore/ develop solutions to allow best practices to emerge before any attempts are made at harmonisation'.

26 respondents provided additional comments on the best approach to assisting speed and scale of uptake. Again the majority supported an EU-wide approach but with flexibility provided to MS to support and push-forward CCS whilst reflecting the local specifics (14 respondents). Further, one participant noted: 'EC intervention may be required to prompt action from some Member States' and some suggested: 'Guidance Documents are overly prescriptive'. Only a few participants were of the opinion that either EU or national level action alone is more appropriate to help the speed and scale of deployment. One respondent suggested: 'EU could support collaborative CCS projects to share cost burden'.

QA4. What is your opinion of the following potential benefits of an EU level legislative framework for CCS?

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
Creates a framework to be tested by those MSs that are leading CCS development, that other MSs can adopt in the future (when they become involved).	23	62	6	4	4	6
Creates a common approach to avoid market distortions.	27	42	17	8	4	7
Creates a larger market, giving Europe the potential to become a world leader in CCS.	9	29	36	18	4	9
Creates supra national guidance, which avoids each MS having to develop their own.	18	53	13	11	1	9
Creates guidance which should be less at risk from national politics and therefore should be more technically objective.	19	48	15	11	3	9

20 participants provided additional detail regarding their opinion of the benefits of a legislative framework. Some respondents highlighted the importance of the strategic linkage between setting a legislative framework for CCS and wider decarbonisation policy, in particular focusing on relative affordability between CCS and alternative options.

A key theme of the responses was that a legislative framework at this stage could be premature given the stage of technology development. In fact, some noted that the Directive as it stands had generated overly heavy liabilities and risks for operators, in particular early movers, and in some cases may have presented a barrier to development. However, many agreed that there would be benefits to forming a common framework in the longer run associated with the harmonisation and consistency between projects and potentially supporting EU-wide CCS infrastructure. Some believed that a legislative framework could support R&D, demonstration and early-deployment if appropriately designed.

8.1.2 Interviews

In order to gain views and input on this question the interviews contained a question on 'are these objectives [of the CCS Directive] best addressed by the EU as opposed to MS level action?

Industry

- Support for the EC setting minimum standards and allowing the MSs to apply these.
- Recognise the transnational nature and the need for an international 'voice' for Europe.
- Some feel the EC could do more to place CCS as an option to achieve the 2050 Carbon 'target' – with each MS being required to demonstrate its own roadmap of how it will achieve its share.
- The temptation must be avoided to introduce detailed regulation in anticipation of hypothetical risks.

Environmental NGOs

- Agree with EC competency, and need for MS flexibility.
- Also agree with the idea of MS specific roadmaps.

Public actors

- It is good that the EU takes the lead and sets the basic criteria, then the MSs can tailor it to the national context.

8.1.3 Summary and conclusions

The model of the EC defining a minimum / outline approach and the Member States then developing their own detailed and case / site specific interpretation was described as the best approach by virtually all stakeholders. This is in line with the overarching approach of the Directive and does appear to be the best compromise. This approach also addresses the concerns that attempting to regulate to a very high degree of detail is not appropriate for a sector in which so little experience has been gained. Detailed regulation based on hypothetical risks does bring a risk of over burdensome regulation and should be avoided. Another important benefit of an EU level framework is that it helps create the required large and trans-boundary scale of infrastructure required for European CCS. Another area where EU level action was described as important, though probably not via the CCS Directive, was in the creation of a clear strategic link between CCS and wider low carbon policy. This point is picked up elsewhere in the evaluation.

Areas where the benefits of EU level action are less strong are: Public acceptance, because although the EC can usefully help define structures to promote CCS, public opposition is most likely to occur to specific local installations and here the MS (and the developer) are best placed to respond. The suggestion that EU level action would help create a larger market for CCS and hence help future export potential was also not strongly supported. Although the CCS Directive (and other relevant policies) are designed to help enable CCS it is easy to understand some scepticism on future prospects for EU export, given the lack of experience gained to date and the multinational nature of some of the lead participants, i.e. oil and gas companies.

8.2 Q29 – Lessons from regulators outside the EU

29. What can be learnt from the regulatory experience of other jurisdictions? How does the regulatory framework in the EU compare with the performance of the regulatory framework in other jurisdictions outside the EU? What are the main differences? What explains these differences?

8.2.1 On line survey

QC9. Are you aware of the regulatory approach to CCS in other parts of the world?

Yes	No	Don't Know	Comments
69	12	24	56

The majority of respondents confirmed that they have knowledge of CCS regulation in non-EU countries, and many comments indicated lessons that could be learnt, such as:

- Permitting, particularly for early projects, is a much more complex and time consuming process than initially envisioned and that the interactions between CO_2-EOR and geological storage permitting schemes are particularly important to consider,
- Considerations of what 'capture ready' means could benefit from looking at the Boundary Dam example where the operator of the plant was obliged to ensure that CO_2 storage did go ahead. H&S standards and best practices can be adapted for CO_2 transport and storage,
- The USA and Canada have a less complex regulatory framework, with more alignment with oil and gas regulation, generally not treating CO_2 as "waste" but as "product",
- Legal and regulatory issues remain a priority issue for governments and industry around the world. These issues include, amongst others; the liabilities attaching to storage operations, the trans-boundary movement of CO_2 and possible inconsistencies between various Provincial or State regimes,
- Canadian regulators took a less prescriptive approach which allowed projects to progress faster,
- The industry in Canada sees a market for CCS emerging and they believe that CCS will be a necessity in order to be able to continue with fossil fuelled industry. The situation in Europe is the other way around. The European industry do not see a market for CCS, because of the low price of emission allowances at the EU ETS and no signals that it will be high enough in the coming years to facilitate CCS development,
- The EPA in the US is also giving states the option to introduce an EPS or ETS helps push CCS,
- It is difficult to compare the EU to other countries due to differences in land access, ownership rights and approaches to waste disposal. The Australian approach of avoiding hydrocarbon provinces is not appropriate to EU as these are proposed EU storage areas,
- Australian special measures for early projects may be beneficial,
- Liability issues are handled less strictly in the US and Canada. EU rules on liability (unquantifiable EU ETS liabilities) are significantly stricter,
- There is a difference in public acceptance and the philosophical view that society wants CO_2 out of the atmosphere so society (i.e. the state) will take on storage liabilities.

8.2.2 Interviews

This question was covered by asking the interviewees to comment on what can be learnt from the approach to CCs in other parts of the world?

Industry

- Canada was mentioned as an example of greater flexibility in regulation being an enabler in quicker project realisation.
- Progress in the US has been quicker – this is driven by more existing CO_2 transport networks and a greater existing use of EOR (which is a major help in creating commercial case for CCS).
- The US acceptance of public liability for long terms storage (as a 'common good') has also avoided the issues of long term liability that are occurring in the EU.
- Specific CO_2 taxes are seen to be a success in for instance Norway.

Environmental NGOs

- Agree with greater flexibility and EOR helping progress elsewhere.
- Suggest that commercial appetite for risk may be higher than in Europe.

8.2.3 Case studies

Quest Project *(Canada)* As in Europe, CCS regulation in Alberta is developing alongside the first projects. This brings uncertainty for any upcoming regulatory changes. Addressing these uncertainties is a challenge and this has been mitigated by Shell in Alberta by offering and obtaining involvement in the development of the updated protocols and regulatory framework. Also, both in Europe and in Alberta, permitting processes are not streamlined yet due to the novelty of the regulation[80].

Shell identified the following key enablers in the process with respect to regulation[81]:

- Clear, agreed, site specific definitions for containment and conformance early in the site characterisation phase to inform the risk assessment and associated appraisal strategy appropriately to ensure fit for purpose MMV plan.
- Project Transparency has been an enabler on multiple fronts:
  - Project acceptance from Internal and External stakeholders.
  - Provided guidance to researchers on existing technology gaps.
  - Dialogue between industry and Government for policy discussions.
- Agreement that MMV is performance driven, risk based and adaptive allows for program change over time as both regulatory and subsurface uncertainties are reduced.

In addition, the following success factors were identified with respect to the CCS Regulation[82]:

Regulatory issue	Success factor
Regulatory Framework	specific to the technology
Regulatory Process	clarity on roles, responsibilities, process
Assumption of Liability	appropriate; “carrot” for good operations
Handover Criteria/ Time Period	clarity guides design, MMV, and investment
Pore Space Ownership	less freehold is better
Climate Liability	handover with other liability
Post-Closure Stewardship Funds	appropriate; specific to project risks
Pore Space Tenure Application	demonstration of site suitability
MMV Program	addresses technical and stakeholder
MMV Plan	iterative; updated with time/need
Closure Plan	clarity on transfer information/assets

[80] Shell, 2012, QUEST CARBON CAPTURE AND STORAGE PROJECT, Annual Summary Report - Alberta Department of Energy: 2012, Shell Canada Limited, March 2012

[81] Shell, 2012, QUEST Carbon Capture and Storage - Risk-Based Measurement, Monitoring & Verification, MVA/MMV Knowledge Sharing Workshop, Mobile Alabama, May 16-17, 2012

[82] Jepp, P., 2013, QUEST Carbon Capture & Storage Project, CCS Regulatory Process- Lessons Learned, J.P. Jepp- Regulatory Policy Advisor, Shell Canada, IEA International CCS Regulatory Network Meeting, June 18-19, 2013

Storage Scheme Application	apply for greatest project description
Emergency Response Planning	for stakeholder concern and safety
Stakeholder Engagement	comprehensive, inclusive, responsive

The **Port Arthur Air Product's project** (USA) was facilitated by several factors. Some of these are discussed below.

The project received funding through the American Recovery and Reinvestment Act (AARA). In February 2009, the AARA designated $3.4 billion for CCS programs. This funding was broken down into three major sources; $1.52 billion for a competitive bidding for industrial CCS projects, $800 million for the Clean Coal Power Initiative (CCPI), and $1billion for FutureGen. The Port Arthur CCS project was funded under the industrial CCS project category. This project was selected as one of three projects in October 2009. Phase 1 focussed on research and development and included $21.6 million in Recovery Act funding and $22.5 million in private funding for a total initial investment of $44.1M (for all three projects). Following successful completion of their Phase 1 activities, the three projects have entered into Phase 2 for design, construction, and operation. Port Arthur was selected for Phase 2.

Focus on industrial CCS projects in the initial stages of demonstrating CCS is an attractive option as in many industries (as in the hydrogen industry) it is easier to capture CO_2 than it is from flue gas from power plants. In this case, the plant captures CO_2 from a hydrogen production process. Syngas is produced with high CO concentrations. The water gas shift of CO to CO_2 increases the concentration of CO_2 and so facilitates its capture through physical absorption.

The project was made easier by the fact that EOR has been in place in Texas for over 40 years. Oil and gas companies have the required expertise and in many cases the infrastructure is already established. The naturally-produced CO_2 does not satisfy demand and so there is a need for additional CO_2 which can be satisfied through CCS projects such as the Port Arthur project.

Legislation in Texas had been adapted (the Senate Bill 1387 held in 2009) to provide a framework for the rules for the injection and storage of anthropogenic CO_2 in oil and gas reservoirs, depleted reservoirs, potentially productive reservoirs and certain saline formations.

According to these rules, anthropogenic CO_2 is defined as "carbon dioxide that would otherwise be released into the atmosphere that has been: separated from any other fluid stream; or captured from an emission source including an advanced clean energy project or industrial source of emission; and any incidental associated substance derived from capture of CO_2, and any substance added to CO_2 to enable or improve the process of injecting CO_2".

The access to existing transport pipeline was also facilitated through existing legislation.

The **Boundary Dam project** in Canada has become operational in a very short space of time. There are some interesting lessons from this project for CCS in Europe.

Environment Canada announced final regulations on emissions standards for coal-fired electricity generation plants in September 2012[83]. This applies a performance standard of 420 g/kWh to new coal-fired electricity generation units, and units that have reached the end of their useful life, through regulations under the Canadian Environmental Protection Act, 1999. Temporary exceptions will be made for plants that incorporate CCS, until 2025, and there are incentives for existing plants incorporating CCS earlier than necessary. The EPS is equivalent to a combined cycle natural gas plant. It is due to come into effect on July 1, 2015.

At a provincial level, Alberta is conducting a CCS Regulatory Framework Assessment (RFA). Saskatchewan is a participant in the Alberta RFA. In Saskatchewan, CO_2 transportation by pipeline, injection and storage are regulated under the Oil and Gas Conservation Act (the Act) and the Pipelines Act, 1998, administered by the Ministry of Energy and Resources. An amendment to the Act was proclaimed on 1 April 2012 to expand and clarify provincial regulatory authority for carbon storage. Amended regulations enable greater oversight for carbon storage and set licencing and technical requirements for construction of wells and facilities for production, and processing of

[83] Reduction of CO_2 Emissions from Coal-Fired Generation of Electricity Regulations in Canada

substances that are produced from or injected into a well, also licencing, reporting, liability and penalties for non-compliance.

According to section 20(1) of the Oil and Gas Conservation Regulations (2012) [84], the costs of abandonment and reclamation of a well, facility or associated flow line are the responsibility of a licensee. According to Article 56(1), on completion of abandonment of a well, the licensee or the operator shall: (a) conduct an environmental site assessment; (b) decommission the well site to standards specified by the minister; (c) reclaim the well site to standards specified by the minister; and (d) reclaim any area that is beyond the boundaries of the well site and that has been damaged, contaminated or otherwise adversely affected by the operations of the well. This does not however release the licensee from any past, present or future environmental liability associated with the well or facility site.

The total cost of the project is estimated to be Canadian $1.24 billion (of which $600 million is for CCS and the rest is for modernising the existing plant). The Boundary Dam project received $240 million from the federal government in 2011. The provincial government has also supported the project. The remainder of the budget has come from SaskPower, which made a final investment decision in April 2011. Saskpower announced in October 2013 that the project was $115 million over budget, but it is important to note that this was for renovating the existing plant and not just for the CCS project itself.

A $5.2 million, pre-commercial-scale chemical absorption technology demonstration pilot plant has already been operating at Boundary Dam as part of the International Test Centre for CO_2 Capture. Part-funding of $1.2 million came from the Canada/Saskatchewan Western Economic Partnership Agreement.

Business model

SaskPower is the principal electric utility in Saskatchewan, Canada - the Saskatchewan Government is the sole owner.

Revenue from the sale of CO_2 and other products is expected to offset the project costs of $1,24 billion:

- The majority of the captured gas will be sold to Cenovus for enhanced oil recovery (EOR) at its Weyburn oilfield.
- Technology Research Center (PTRC) has a deal to store CO_2 from the facility's hot test at PTRC's Aquistore CO_2 storage project.
- Sulphur dioxide (SO_2) will be captured, converted to sulphuric acid and sold for industrial use.
- Fly ash, a byproduct of coal combustion, will also be sold for use in ready-mix concrete, pre-cast structures and concrete products.

SaskPower plans to run the CCS plant at Unit 3 for about two years to about 2016. They will then review the technology and the economics, and decide on the plan for Units 4 and 5 at Boundary Dam.

Critics of the project have published a review of the 20-year cash flow of the project85. The Leader-Post article claims that the coal-fired power station will make a net profit of $130-million, while the CCS facility will generate a loss of $1.17 billion over 20 years. The article also claims that Alberta-based Cenovus Energy will make a gross profit of more than $3-billion, arising from the sale of increased amounts of crude oil obtained from enhanced oil recovery.

The provincial government approved the proposals in April 2011, which cleared the way for construction to begin immediately.

Regarding the CO_2 pipeline, in Saskatchewan, CO_2 pipelines are regulated by the Energy Resources Conservation Board (ERCB) under the Pipeline Act. Pipelines that cross provincial or national borders are regulated by the National Energy Board (NEB). Regulatory requirements for CO_2 pipelines generally cover important design elements such as: size, materials selection, design, pressure, resistance to degradation, protection from damage, appropriate monitoring facilities, safety systems and siting considerations.

[84] http://www.qp.gov.sk.ca/documents/English/Regulations/Regulations/O2R6.pdf

[85] http://www.leaderpost.com/technology/project+sequesters+dollars/10261713/story.html

Under ERCB Directive 056, an application for a CO_2 pipeline is considered non-routine. Such a designation triggers an in-depth review of the application. The review also considers the anticipated concentrations of impurities in the CO_2 stream, and limits may be placed on impurities based on project-specific criteria. Details of the technical requirements and permitting requirements for the Cenovus pipeline are not in the public domain.

For CO_2 storage, the permitting process is clear for a new CO_2 injection site. What is not clear, is whether the process differs when injecting into an existing oil field for EOR. Following the initial acquisitions stage, a review is completed to determine whether a project requires a provincial Environmental Impact Assessment. CCS projects are not specifically listed in the regulation as requiring EIAs. However, an assessment may be triggered through a review of the project as a discretionary activity. A well licence application can be completed while the project is in the initial acquisitions stage. Under the ERCB Directive 056, any petroleum industry development that includes wells, pipelines or other structures requires a licence from the ERCB to construct and operate. After drilling, completion and testing of an injection well, proponents can apply for an injection scheme approval under ERCB Directive 065. Directive 065 currently requires an applicant to have all proposed injection wells completed and test results available prior to scheme approval. Applications under this directive provide information necessary for the ERCB to determine that there will be containment of the disposal fluid.

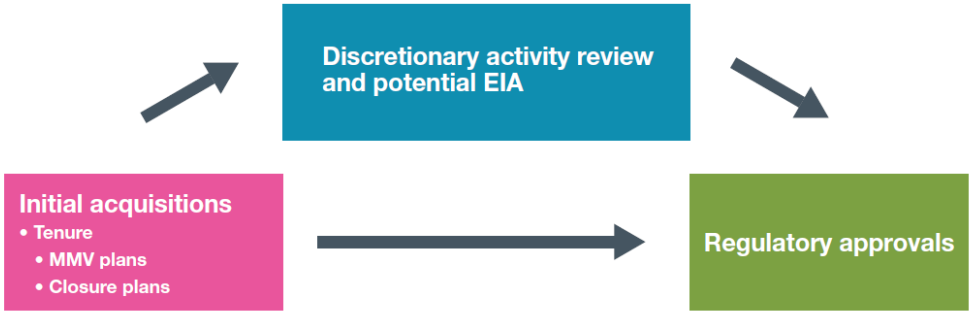


Diagram of Initial Application and Permitting Processes for a CO_2 Sequestration Site[86]

Lessons Learnt

Record speed

The decision to invest was made in April 2011 – the building started a month later. The plant is now operational (as of October 2014).

Low cost

The total cost of the project is estimated to be $1.24 billion (of which $600 million is for CCS and the rest is for modernising the existing plant). Support of $240 million was provided by the provincial Government. In addition, experience gained from the pilot plant as part of the International Test Centre for CO_2 Capture played a role in reducing the costs. The CO_2 transport pipeline was funded and constructed by Cenovus while storage was in the existing Weyburn filed and so storage investment costs were minimal. For comparison purposes, the Mongstad plant had an estimated total capital cost of 3 and 4 billion US dollars for the full chain, partly because, even though the proposed post-combustion technology is the same as that proposed for Boundary Dam, storage was proposed in saline aquifers.

If SaskPower go ahead with converting Units 4 and 5 to CCS this will be in advance of regulatory requirements, as the new Canadian federal emissions regulations for coal-fired generating stations do not require them to be in CCS operation until 2025. Robert Watson, SaskPower CEO said of this action: "It was a bold decision by cabinet to start the project ahead of the regulations... but we worked directly with industry and government and we've got pretty good regulations."

Criteria for success

According to SaskPower, the criteria for success are as follows:

[86] http://www.energy.alberta.ca/CCS/pdfs/CCSrfaNoAppD.pdf

- Chose the right technology at an early stage (based on pilot demonstrations).
- Tight project management.
- The demand for profitability led to a strong focus on keeping the costs low.
- National policies that limit emissions. Coal power plants in Saskatchewan will have to close within 10-20 years if they do not comply with the new regulations.

From the critics' perspective, Boundary Dam Unit #3 is a relatively small power plant, and retrofitting it with a CCS system has cost a lot of money. First-of-a-kind (FOAK) systems are always expensive, but widespread commercial deployment will depend on getting CCS costs down by harnessing what is learned from such projects.

Saskatchewan has unique circumstances that make it favourable for CCS, which will not be easy to replicate elsewhere, including an oil field in the vicinity that is at a stage favourable for EOR. "Experience from this plant will be critically important," the IEA observed. SaskPower claims its next carbon capture project will cost 30 percent less because of what it learned from Boundary Dam.

Composition of CO_2

Currently there is no single, definitive classification for CO_2 in Saskatchewan and in Canada. How CO_2 is classified depends on how it is produced, its concentration, what it is used for and what legislation it falls under. When transporting CO_2 by pipeline, the Pipeline Act would apply. Currently the Pipeline Act has no explicit classification for CO_2, although it would fall under the definition of a gas. The composition of the CO_2 stream is affected by many factors, including feedstock composition, capture technologies and operating conditions. Although there are no prescribed limits for impurities in CO_2 streams used for CCS, for the Boundary Dam project, the purity of the CO_2 prior to transport is 95%.

Liability and transfer of responsibility

According to Section 15(1) of the Oil and Gas Conservation Act, the Minister may request a letter of credit from the developer. The amount is determined by the Minister on a case-by-case basis. This letter of credit ensures that the person's obligations with respect to the suspension, abandonment, restoration, remediation or reclamation of wells, facilities and the sites of wells and facilities are satisfied. The Minister may also require a licensee to submit a security deposit before issuing a licence and may return this deposit if he is satisfied that the licensee has met all of its obligations.

8.2.4 Summary and conclusions

An important point which has emerged from the opinions and evidence is that elsewhere in the world (the US and Canada) the approach to regulating the health and safety and environmental issues of CCS has relied more on adapting existing oil and gas regulation. This is arguably not surprising because virtually all of the projects in these two countries are associated with EHR. This approach has contributed to projects appearing to come on line quicker. Although the projects have become operational quicker it appears that this is driven more by economic factors, especially EHR. It is highly likely that when more CCS projects come to the detailed design and installation stage in Europe that oil and gas standards and practices will be the default option (For detailed design and installation issues).

It appears that the transfer of liability on storage sites is also an issue outside Europe. There are some important differences in the fundamental nature of the approach. The approach in the US and Canada does not appear to be fully formalised yet, but comments from the survey and interviews imply that the approach in the US differs from that in Europe in that liability is transferred to the state with less conditions, described as a US acceptance of public liability for long term storage (as a 'common good'). The question of trans-boundary CO_2 transport is also live in other parts of the world, but no clear approach appears to have emerged yet.

The Canadian Boundary Dam project offers a very positive combination of factors for CCS to work – a nearby oil well at a stage where EOR is highly profitable, a need to reduce CO_2 emissions from a coal fired generating plant and existing expertise in CCS in a nearby test facility. They have made use of existing oil and gas and legislation to regulate the activities, which has helped speed the process up. It appears that there are some areas where existing legislation worked well and others where it needed

to be developed. It is also important to remember the differences in geography i.e. much lower population density than Europe so public concern / opposition to CO_2 storage is less likely.

The Quest project, also in Canada, but a different province to Boundary Dam, also made use of existing regulations. The Developers were positive with regards to the regulator's willingness to develop site specific definitions and to develop the approach in close cooperation. The approach to storage site liability transfer here appears to be close to the European model.

The Port Arthur project in the USA is interesting because it captures CO_2 from an industrial process. As with the Canadian examples EOR is central to the economics of the project, with the pre-existence of naturally sourced CO_2 EOR helping to reduce / remove some infrastructure costs (and provide an income stream). As in Canada the regulatory approach has been to adapt oil and gas legislation.

8.3 Q30 – Commission review of draft storage permits

30. Has the Commission's review of draft storage permit (Article 10) been effective in fostering a uniform implementation of the requirements of the Directive across the Community, and helped to enhance public confidence in CCS? To what extent has the Commission's review been relevant for the competent authorities to take a decision on the permit?

8.3.1 Interviews

This question was also addressed in other responses regarding permitting procedures in general. The clear consensus is that industry and government stakeholders are not convinced that the EC add any value by reviewing applications (in addition to MS review). However NGOs responded more positively to the EC role in permitting.

8.3.2 Written submissions

International Association of Oil & Gas Producers (OGP) see no role for the EC in the permitting process ('unnecessary complication and delay').

8.3.3 Stakeholder meeting

In the view of the ROAD project (arguably the only project which has been through the whole CCS Directive process), the Directive didn't present any barriers to getting the ROAD permit which could not be overcome. The process was smooth, but took a long time. The EC review added months to the whole process. This delay and work load would become more of a problem with multiple applications.

8.3.4 Summary and conclusions

Given that the Commission have only reviewed one permit application so far (for the ROAD project) there is very little evidence to answer this question. It appears that the involvement of the Commission added some delay to the permitting process, although given that this was the first example it is perhaps not surprising that the process was not rapid. It appears reasonable to assume that the process will speed up in the future, especially if, as suggested elsewhere, the level of detail provided by the ROAD project (and accepted) is made public.

The weight of opinion supports the point that the Commission review would help with public confidence for the earliest applications and in those MSs where confidence in the CA might not be as high as in others. The Impact Assessment of the CCS Directive assumed that the review process would not carry on indefinitely and it appears that this assumption remains true.

Section 9 Evaluation answers - Other questions

The remainder of the questions were described in the TOR as 'prospective questions'. Many of the these questions are looking to future options to improve the legislative framework – which could be considered 'sustainability' as they are designed to improve the relevance and effectiveness of the Directive, which should in turn enable it to have longer lasting results and impacts. Many of the questions could be placed under the following two headings (although these are not retained in the draft updated Evaluation Guidelines[87]):

Utility: How do the effects of an intervention compare with the wider needs of the target populations/geographical zones? Over and above those effects that correspond with the stated objectives of an intervention, other effects may occur that may be either negative or positive (i.e. unplanned or unexpected effects). An assessment of these provides the basis of a broader assessment of performance on the basis of an intervention's utility.

Sustainability: To what extent can any positive changes resulting from the intervention be expected to last after it has been terminated or when beneficiaries are no longer supported? While some interventions merely support certain activities that would otherwise not occur, others may be designed to bring about lasting changes within a target public, geographical zone, etc. An assessment of the latter provides the basis of the sustainability of an intervention's effects.

A number of these questions overlap with those already answered. Where this occurs the overlap is pointed out.

9.1 Q31 – ETS benefits for transport and storage

31. Pursuant to the ETS Directive 2009/29/EC amending Directive 2003/87/EC, CO_2 emissions captured, transported and stored according to the revised Directive are to be considered as not emitted. Under the current framework, it is in effect the operator of the capture installation that secures the main financial benefit from not having to surrender allowances in relation to the captured CO_2 which is then transported to a CO_2 storage site in accordance with the CCS Directive provisions. In light of the experience gathered with demonstration projects in Europe, how effective has this approach been in practice for the development of business cases of CCS projects, which is characterised by different operators for the different parts of the chain (capture/transport/storage)? Is it necessary to consider/develop options that reward the downstream CO_2 storage operator? If yes, what possible schemes could be put in place to reward the downstream CO_2 storage operator? What would be the costs and benefits of this approach?

9.1.1 On line survey

QD2. Under the current CCS framework, the operator of the capture installation gains the emissions trading benefit (by not having to surrender emission allowances). This means there is no direct emissions trading benefit to the CO_2 transporter and storage operators. Is this arrangement causing (or could it cause in the future) problems for developing CCS project business cases?

Yes	No	Don't Know	Comments
31	34	40	34

If yes what schemes could be put in place to reward the CO_2 transport and storage operators? What are the potential pros and cons of this approach?

The main issue highlighted repeatedly by many respondents is the liability for storage a site operator which is uncapped and related to unpredictable future carbon price.

[87] http://ec.europa.eu/smart-regulation/evaluation/docs/20131111_guidelines_pc_part_i_ii_clean.pdf

Some respondents stated that transport and storage infrastructure needs to be developed in Europe ahead of establishing capture projects and incentives need to be put in place to encourage development of this infrastructure. Other respondents see that transport and storage infrastructure should be supported through commercial fees. Others thought that it does not matter which part of the chain gets the benefit but it should be the full CCS chain which gets the benefit. It was also stated that this is an issue which can be dealt with in an agreement between the storage operator CO_2 suppliers. Some respondents were against granting allowances to storage site operators as it the ETS is based on the principle of granting these to emitters. Others believed that CO_2 transport and storage prices charged to the capturer can be adjusted to capture their share of the emissions trading benefit.

NGOs were opposed to any scheme that would lead to double counting of emission reductions.

Additional comments are as follows

- The costs and liabilities for transport and storage are passed through to the emitter through transport and storage tariff (ROAD). In a well function carbon market lack of direct benefit to the transporter and storage operator would not be a problem. However, the issue is that the benefits to the capture operator are too low and unpredictable and so transport and storage operators cannot support the required investments. The issue is distribution of risk and reward along the value-chain (emitter, capture installation, transporter, and storage provider).
- Some respondents recommended direct grants for investment in storage and pipeline capacity, and long term contracts (with the UK's CfD as an example) to provide long term revenue assurance.
- If the cost for CO_2 storage is lower than the cost for emissions than transport and storage operators will be able to recover their CapEx and OpEx with an acceptable rate-of-return. At present Europe contains little CCS infrastructure. CCS operators will be required to commit large upfront investment in order to roll-out the transport and storage facilities for emitters to use.
- It is a CCS chain - inject money in at one end and it has to pass along the chain to make each link happen. However, governments have a role to play in establishing a CCS transport and storage infrastructure, being the first crucial links in the chain.
- Create a tradable certificate for every tonne stored. This creates an incentive for a new form of CO_2 storage business to seek out CO_2 emitters and pay for the CO_2.
- ETS for capture side only. For transport and storage, CCS certificates can be applied.
- Get the ETS working. It should be enough.
- A high carbon tax should be applied.
- Storage operator gets the benefits via the storage tariff. Allocating to storage would be counterproductive for development.
- Both the transport and storage operator provide a service that results in the emitter not having to hand over emission allowances. The emitter should at least share some of the responsibility (liability) for the permanent storage of CO_2.

9.1.2 Interviews

This question was raised as 'Do you think the CO_2 transport and storage operators should be entitled to the emission trading benefits that currently only go the capture installation?'

Industry

- The simple answer is yes, but the issue does not appear to be one which needs regulation, as in order for a capture installation to receive credits the transport and storage needs to be in place. A business model to create, operate and maintain transport and storage is therefore required – the capture cannot happen in isolation.
- The storage site operators face high upfront costs and potentially high liabilities, so they will need to have agreed deals that compensate them for this.

9.1.3 Written submissions

Eurelectric - They do not agree with the suggestion that CO_2 allowances could be granted to storage facilities.

9.1.4 Case studies

The White Rose project - The issue of the very large liabilities that are generated by the inclusion of storage sites under the EU Emissions Trading System (EU ETS) has become a major barrier to CCS and a practical solution needs to be found. Under the EU ETS, in the event of any leakage, the storage site operator would be liable to purchase EU Emissions Trading Allowances to offset the CO_2 released. The Operator is thus exposed to a potentially huge liability depending on the price of carbon at the time of leakage which is unknown. This is regardless of the provision of a Financial Security.

9.1.5 Summary and conclusions

The clear view that emerged from industry stakeholders on this issue was that it is something to be agreed upon between capture, transport and storage operators and is not something where regulation is required. The ROAD project confirmed that the costs and liabilities for transport and storage are passed through to the emitter in an agreed tariff. This approach appears suitable to the evaluators.

There was some discussion under this point of the high costs of establishing large scale transport and storage infrastructure in advance of CCS capture projects (and the ETS income these will bring). This led some to suggest that direct grants should be supplied to support the creation of this infrastructure with its operating costs being met by future revenue streams. Possible future revenue streams suggested include income via a Contracts for Difference approach, tradeable certificates in stored CO_2 and a price linked to the value of the emissions avoided. All of these options appear plausible. An in depth analysis of their pros and cons is beyond the scope of this work, but it is an issue that the Commission (and/or others) could usefully investigate.

The issue of the unknown cost to the storage operator of possible future liability for leakage is also of relevance to this question. This point comes up elsewhere in questions 9, 11 and 20.

9.2 Q32 – Uptake of CCS technology outside Europe

32. What has been the progress of uptake of CCS technology outside Europe? What are the prospects for uptake of geological storage of CO_2 in third countries? How does this influence the European situation, for example in terms of potential export of CCS technologies?

9.2.1 Literature review

See question two and section 2.2 – for a review of EU CCS projects vs. global progress.

9.2.2 On line survey

QC10. How do you think progress on the uptake of CCS technology in Europe compares with the rest of the world?

Similar progress	Europe is leading	Europe is a little behind	Europe is well behind	Don't know
14	6	25	46	14

QC11. Do you think this position will influence the ability of Europe to export CCS technology in the future?

Improves prospect	No influence	Reduces prospect	Don't know	Comment
10	8	66	21	26

The majority of respondents felt that the current position (Europe lagging behind) reduces the prospects of Europe exporting CCS technology in the future. Of the 26 comments received for this question, 8 respondents agreed that at the level of CCS R&D, Europe is on a par with the rest of the world, although there is much variability between member states. Most comments highlighted the potentially increasing problem of a lack of demonstration plants in Europe leaving the EU well behind other countries when it comes to exporting technology that has been demonstrated. China has promised commercial CCS before 2020, and the USA and Canada have commercial CCS plants in operation. The Middle East has the world's first large-scale CCS project in the iron and steel sector moving into construction. The UAE continues to develop, through Masdar, a CCS network linking CO_2 emitters to users, for enhanced oil recovery (EOR).

European technology providers (e.g. Alstom, Air Liquide, Linde, Schlumberger, Shell, and Total) are involved in demonstration projects elsewhere, so they are getting experience. However, European electric utilities are not gaining experience and this will impact their future ability to implement CCS in Europe and elsewhere. This also limits the opportunities for European society to engage with and see successful implementation of projects. Non EU countries will tend to buy at home where they can (e.g. Cansolv for Saskpower), particularly if substantial public money is needed to help get early projects going. In addition, capture technology developed by European companies may be taken forward but elsewhere (e.g. China) rather than in Europe. This may limit the ability of European technology companies to fully exploit the benefits of their efforts.

9.2.3 Case studies

The Shell-led Quest project in Alberta, Canada, is the first commercial-scale CCS project to tackle emissions from oil sands extraction. It aims to capture and store up to 1.2 million tonnes of CO_2 per year from the Scotford Upgrader, the facility at Fort Saskatchewan which produces synthetic crude oil from bitumen derived from the Athabasca Oil Sands extraction project. Quest is a fully-integrated CCS project that will capture, transport, inject and store CO_2.

Alberta was seen by Shell as a suitable location due to its[88]:

- Rapidly growing heavy oil sector.
- Ideal geology for CCS.
- Visionary government.
- Forward-thinking proponents.
- Excellent regulatory base (O&G).
- A "learn by doing" approach.

9.2.4 Summary and conclusions

It is clear from the literature review and the survey that Europe is being overtaken by the rest of the world, particularly North America, in terms of operational CCS plants. Some of these plants are relatively large scale and could be described as commercial – though their incomes largely derive from EOR. With regard to research and development Europe is still largely seen as competing with North America, but this parity could be lost given the lessons available from the North American demonstration plants. It appears that projects are also being developed in other parts of the world, including China and the Middle East. European technology partners are described as being active in projects throughout the world, so the prospects for their ability to export in future appear relatively undamaged by the slow progress on demonstration plants in Europe. However European utility companies are not gaining any practical experience in CCS so it is reasonable to assume that their future ability to export their skills is being diminished.

[88] Jepp, P., 2013, QUEST Carbon Capture & Storage Project, CCS Regulatory Process- Lessons Learned, J.P. Jepp- Regulatory Policy Advisor, Shell Canada, IEA International CCS Regulatory Network Meeting, June 18-19, 2013

9.3 Q33 – Carbon capture and utilisation

33. In the last years, technologies for reutilisation of CO_2 from industrial emissions have emerged that could play an important role for the decarbonisation of industrial processes. Potentially, when combined with CO_2 storage, and although none of them seem comparable to CCS in terms of potential for CO_2 abatement capacity, these technologies could play a role to incentivise the business cases of CCS, in addition to fostering additional environmental and climate benefits. Should additional regulatory measures and/or incentives be introduced at European level in support of the (most promising) CO_2 reutilisation technologies in combination with CCS? If yes, which potential measures could be introduced? What would be the pros and cons of this approach?

9.3.1 On line survey

Are the following issues adequately taken into account in CCS policy and legislation?

	Yes	No	Don't Know
The utilisation of CO_2 captured in industrial processes (in combination with CCS) (Carbon Dioxide Utilisation (CDU))	27	51	27

Five respondents felt that the CCS Directive was designed to address the geological storage of CO_2 and not utilisation, meaning that CDU should not be covered by the Directive.

QB5. Should additional regulatory measures and/ or incentives be considered to support Carbon Dioxide Utilisation (CDU) technologies in combination with CCS?

Yes	No	Don't Know
68	14	23

QB5.1 If yes, what is your opinion of the following measures:

	Strongly support	Support	Possible	Don't support	Strongly don't support	Don't know
Targeted R&D grants, e.g. a Horizon 2020 call, and NER300 type programmes	30	32	11	4	4	24
Incentives via emissions trading	17	26	20	9	7	26
Extend / adjust CCS Directive to include EHR and CDU	25	19	12	12	6	31

28 respondents commented on this question. Of those, a number of respondents (7) used the commentary to give further detail on their 'no' answer to question B5, with responses such as '*CDU is not the solution'* and '*CDU only has the potential to mitigate a tiny proportion of EU emissions'*. One respondent commented further on EHR: '*EHR should be actively dis-incentivised as a priority: the EU needs to focus on decarbonisation'.* One respondent commented that EHR is currently allowed under the Directive.

A further 6 respondents commented on the inclusion of CDU in the EU ETS, stating that the monitoring guidelines do not currently allow CDU as an ETS measure, and all 6 respondents supported a change in the guidelines.

Only one respondent commented on targeted grants, to say that CDU should be supported, but using NER300 funding to do so did not make sense. Two respondents commented on an issue linked to CDU and EHR, stating that support should only be given to EHR and CDU only where it leads to

'*permanent storage of effective amounts of CO_2*'. This is an issue that needs to be addressed according to the respondents.

QB6. What is your opinion of the following statements on why additional regulatory measures to support CDU should not be supported?

	Agree	Disagree	Don't Know	Comment
Low CO_2 abatement potential in comparison to CCS on electricity generation	40	29	36	34
High cost of abatement	22	32	50	24

There were 58 comments received on this question.

In terms of abatement potential, the qualitative responses of survey participants highlight a much more mixed picture than the summary results suggest. Some respondents back up the overall finding that there is a belief that CDU abatement opportunities are relatively small and may pose a distraction to the core objectives of the CCS Directive. However, some believe this could be a regionally important source of abatement and there could be significant individual opportunities in the near future. Further, several respondents questioned the definition of CDU implied, highlighting the difficulty of forming generalisations, for example: 'CDU encompasses a vast array of technologies and applications, each with different costs, applicability and environmental suitability. As such it is impossible to treat such a diverse collection of CO_2 management methods as a single or even similar entity'. Some suggest that the situation could change with proper incentives and that CDU could aid the development of CCS.

With respect to costs, few respondents believed that a perception of high-cost should exclude regulatory support for CDU. Instead, two key themes emerged. First, many suggested that the costs of CDU will be determined by a number of factors specific to the abatement opportunity and it is difficult to generalise given CDU represents a diverse group of technologies. Secondly, many believe that further R&D is required to develop a better understanding of the costs of CDU opportunities.

9.3.2 Interviews

Industry:

- The main regulatory issues with CCU are with the ETS Directive, not the CCS Directive

9.3.3 Written submissions

Alstom see no need to regulate CCUS *(NB we believe they refer only to the Carbon Dioxide Utilisation, CDU part)* nor Bio CCS in the CCS directive. In their view this is a better fit in the ETS directive.

Eurelectric - Carbon dioxide utilisation (CDU) could be a useful means of optimising the technology and EURELECTRIC therefore recommends amending the EU ETS Monitoring Guidelines to make CDU eligible.

DNV GL stresses the importance of CCUS. DNV GL believes:

- CCUS is key for the oil, gas and utility industries to manage risks of stranded assets.
- CCUS is already happening, but needs regulations that provide stimulate investment.
- CCUS is critical to secure low-carbon energy in local markets dependent on fossil fuels.
- CCUS is on a cost-race with different applications driving down relative and absolute costs.
- CCUS is an enabling technology for the ongoing energy transition to more renewables.

9.3.4 Stakeholder meeting

- The opinion was raised by some stakeholders that Carbon Dioxide Utilisation (CDU) should always be seen as a 'side benefit' to storage. The discussion suggested that stakeholders felt

that the Directive does enough on utilisation and that the detail of CDU is better addressed via ETS regulation.

9.3.5 Summary and conclusions

It appears that CDU is outside the scope of the CCS Directive and there were no substantive suggestions to change this. There was some criticism of the attention being paid to CDU given its low mitigation potential in comparison to the power sector. Others say that CDU is important for some regions of the Europe (with concentrations of particular industries) and that it in the right circumstances it can provide a very useful boost to the economics of carbon capture. The heterogeneity of the techniques described as CDU was also highlighted, suggesting that it might be difficult to design incentives to specifically promote it. The clearest message on CDU, which appears valid, was that the ETS regulations should be adjusted to recognise its benefits (where permanent containment can be demonstrated).

9.4 Q34 – Need for revision in the environmental risk framework for storage

34. On the basis of the latest scientific knowledge, and taking into account experiences from pilot and demonstration projects in Europe and beyond, are there any potential areas of revisions of the environmental risk management framework for CO_2 storage as set out by the CCS Directive (e.g. with regard to the threshold of 100 kilotons for exclusion of R&D projects from the scope of the CCS Directive)? What would be the pros and cons of such revisions?

9.4.1 Literature review

Storage technology is strongly based on current / known practice in oil and gas exploration, production and storage. Existing storage demonstrations and pilots, along with field tests of monitoring methods, provide critical information about the behaviour of subsurface CO_2. It appears that some good progress has made, for example the EU research projects SiteChar and CO_2CARE, in developing the the knowledge base regarding CO_2 storage on issues such as data collection, three-dimensional static geological earth models, characterisation of the storage dynamic behaviour, and risk assessment methodologies for CO_2 storage.

The commissioning and decommissioning of injection installations are issues that need further attention from the engineering point of view. For example the possibility of mothballing existing offshore oil and gas platforms for future re-use in CO_2 storage operations has been raised.[89]

9.4.2 On line survey

QE11. Which areas of the environmental risk management framework for CO_2 storage as set out in the CCS Directive do you think need to be revised?

	Yes	No	Don't know	Comment
The threshold of 100kT for R&D projects	20	47	38	14
Risk assessment provisions	13	47	45	9
Monitoring provisions	24	42	39	11
Corrective measure provisions	18	39	48	10
Transfer criteria	40	20	45	25
Reporting provisions	10	45	50	5

[89] Filip Neele, Johan ten Veen, Frank Wilschut & Cor Hofstee (2012). Independent assessment of high-capacity offshore CO_2 storage options, TNO report no TNO-060-UT-2012-00414 / B, 93 p.

Post closure provisions	37	26	42	22

The majority of comments received on the threshold suggested that it should be increased. Other parties noted that the threshold could be flexible based on the R&D project or and could be considered alongside other criteria to give MS greater scope in defining project scale, such as injection rate.

Several specific comments were made upon reflection of potential revisions to the risk assessment provisions, including: making an allowance for the probability of the hazard (in particular in the financial security requirements), reducing requirement for modelling, expanding to wider risk-management practices and allowing more flexibility. Two respondents suggested that risk processes should be applied explicitly in the site characterisation processes.

For those that thought monitoring provisions could be revised, several provided specific comments on how this could be done, for example: to take into account different sectors, injection and storage methods, allow permit performance conditions established early in the project to become measures of stability for site closure and giving more discretion to monitoring programmes.

A minority of respondents highlighted that corrective measures could be revised to provide more tangible evidence for different measures and provide a clearer balance between cost and practicality. Some thought it was too early to know whether revision is required.

Three key themes emerge from survey comments regarding potential revision of transfer criteria. First, a number of participants raised concerns regarding the Financial Security requirements outlined in Guidance Document 4. These parties highlight: necessary updates to the financial security increase operational costs, it is challenging to fund this over a long-period due to limited revenue streams and no commercial organisation is able to accept unquantifiable and unlimited liability. 'The cost of the financial security and the uncertainty over the size of the liability act as a disincentive to prospective CO_2 storage operators to invest in CO_2 storage facilities and represents a significant barrier to the deployment of CCS in Europe'. Second, a number of respondents suggest that the 20 year default minimum period is unnecessary and arbitrary and should be removed in place of more project-specific performance criteria. Finally, respondents suggest more clarification, in particular around key terms such as 'stable', would be worthwhile. Another party suggests greater release of data would be welcome to support knowledge sharing and research.

Participants suggested reporting provisions could be improved through closer interactions between operators and regulators.

The majority of survey respondents believe that revisions to post-closure provisions could be beneficial, in particular regarding the minimum period. Several participants suggest this represents an unnecessary burden on the industry which is not based on scientific substantiation and should be removed. Instead, this would be replaced with a negotiable period based on performance-based test of permanent storage. Some note that ''performance permit indicators' agreed between operator and regulator during the planning and progress of the storage project that become the measures of site stability for post-closure conditions'. A couple of parties suggest that this is not the proper time to revisit the Directive as no more is known since its original drafting.

9.4.3 Interviews

Input for this question was sought by asking for views on the environmental risk framework (the 100kt threshold for R+D projects, risk assessment provisions, monitoring provisions, corrective measure provisions, transfer criteria, and reporting and post closure provisions) for CO_2 storage.

Industry

- The 100kt threshold for R+D could be higher – to help enable projects.

Public actors

- Not sure if any benefit in changing the 100kt R+D threshold.

9.4.4 Summary and conclusions

The literature review suggests that there has been some good progress made via EU research projects on storage issues. Although some felt there was a lack of experience to consider changing yet there were a number of suggestions on possible changes to the risk framework for storage, as follows:

There was some support for increasing the R+D project threshold (below which the CCS Directive requirements do not apply) from 100kt of CO_2 stored. No specific higher figures were suggested and no clear evidence was presented on why this should be considered (other than the claim that it would help enable CCS projects). Given the lack of evidence the threshold should be left the same until sufficient evidence on the R+D benefits from storing >100kt is provided.

A number of suggestions for more flexibility were made, for example to allow better recognition of the type of injection and storage method and to allow less modelling. These suggestions for more flexibility are in line with other suggestions on other aspects. Given the lack of experience it is not possible to comment on whether such flexibility will, or will not materialise in practice. It appears premature to suggest additional (or less) flexibility before the current approach has been tested, therefore the Directive should be left as it is until further experience has been gained.

The concerns on the site transfer criteria, specifically the financial security requirements (Guidance Document four) and the 20 year default period were also criticised here. These issues are covered in questions 9, 11 and 20.

9.5 Q 35 – Need for an EU storage atlas

35. Capacity estimates for CO_2 storage have been developed across Europe at the European level (e.g. Geocapacity project); this exercise is also ongoing at Member States level, pursuant to Article 4 of the CCS Directive. In light of the latest available knowledge, is there a need to establish an improved EU atlas of storage capacity of CO_2 across Europe? If so, what would be the estimated costs of such an assessment?

9.5.1 Literature review

Future up-scaling of CCS will only be possible if storage capacity is available. The first step in this is to begin regional site characterisation programmes. The Geocapacity project has made a conservative estimate[90] of storage capacity in selected MS of 117 Gt CO_2. This is equal to 62 years of storage of the 1.9 Gt annual emissions of CO_2 from point sources emitting more than 0.1 Mt/year. This estimate of storage capacity is distributed as follows: 96 Gt CO_2 in deep saline aquifers, 20 Gt in depleted hydrocarbon fields and 1 Gt in unmineable coal beds. The table below gives an indication of CO_2 storage capacities in different Member States for these three types.

[90] Geocapacity (2009). Assessing European Capacity for Geological Storage of Carbon Dioxide, Publishable Final Activity Report, 37 p.

Table 1 Specification of annual emissions and storage capacities for selected MS

Country	Annual total emissions of CO_2 (Mt)	Annual CO_2 emissions from large point sources (Mt)	CO_2 storage capacity in deep saline aquifers (Mt)	CO_2 storage capacity in hydrocarbon fields (Mt)	CO_2 storage capacity in coal fields (Mt)
Slovakia	46	23	1716	-	-
Estonia	21	12	-	-	-
Latvia	4	2	404	-	-
Lithuania	18	6	30	7	-
Poland	325	188	1761	764	415
Czech Republic	128	78	766	33	54
Hungary	79	23	140	389	87
Romania	74	67	7500	1500	-
Bulgaria	52	42	2100	3	17
Albania	0	0	20	111	-
FYROM	6	4	390	-	-
Croatia	23	5	2710	189	-
Spain	423	158	14000	34	145
Italy	212	140	4669	1810	71
Slovenia	20	7	92	2	-
Bosnia-Herzegovina	-	9	197	-	-
Germany	864	465	14900	2180	-
Luxemburg	-	-	-	-	-
The Netherlands	180	92	340	1700	300
France	-	131	7922	770	-
Greece	110	69	184	70	-
United Kingdom	555	258	7100	7300	-
Denmark	52	28	2553	203	-
Norway	-	28	26031	3157	-
Belgium	-	58	199	-	-
Total	-	**1893**	**95724**	**20222**	**1089**

Source: Geocapacity (2009)

There is a JRC report from the 'CO2Stop' project due out in October which could be linked to a map of CO_2 sources. There has also been a project in Australia to prepare a storage atlas, which had problems due to the atlas being based on static analysis. In order for any project to realistically consider an area for CO_2 storage injection tests are required. Injections costs are quickly several millions of Euros per site and thus much more expensive than static analysis.

9.5.2 On line survey

QE12. In light of the growing amount of knowledge and data on capacity estimates for CO_2 storage in Europe and need for understanding the CCS upscaling potential, do you think there is a need to establish an improved EU atlas of storage capacity of CO_2 across Europe?

Yes	No	Don't Know	Comments
66	16	23	41

Several respondents provided comments to this question. The views differed on whether there is a need to establish an improved EU atlas of storage capacity. The respondents supporting the atlas identified different benefits that it helps to deliver - drives data collection and the results can inform policy decisions on the suitability of CCS; strengthens Europe's credibility as an active promoter of CCS; facilitates infrastructure planning; reduces the cost of developing storage sites by identifying the most suitable sites to be developed; reduces uncertainty for future CCS investments and helps making storage opportunities accessible for new entrants provided that the tool would be public and easily accessible.

While the respondents noted the need for the EU atlas, the need for assessing/ updating sound estimation methodologies for such an atlas was also highlighted. One respondent noted that it is critically important to understand the assumptions that lie at the basis of the storage capacity estimates entered in the database. These are especially relevant for saline formations, the capacities of which were derived without taking into account regulatory or economic limitations. The work required to prepare the atlas is however variable by Member States, in some cases, new methodologies could be applied to existing data, in other cases new data would be required to advance knowledge as use of existing data has already been maximised. It was noted that the UK Storage Appraisal Project used a detailed repeatable methodology based on static and dynamic considerations. Capacity mapping elsewhere is however mostly not so robust.

Further ideas were provided on the content of such an atlas – while one respondent was clear that areas that should be reserved for other subsurface uses must not figure in the atlas, the other respondent however thought that the atlas could include all underground resources such as potential storage sites, geothermal resources, etc. and identify possible conflicts in the use of these resources. It was added that the atlas should contain effective storage capacity, rather than theoretical or technical capacity.

Some respondent also argued against the atlas, the most common reasoning being that it should be defined at Member State level as Member states already have the maps and experts they need. Especially on the continental shelf (North Sea) there is sufficient knowledge of possible storage locations (due to the work of professor Hazeldine (University of Edinburgh) and others). While one respondent admitted that the EU atlas would be useful, it does not substitute the very detailed characterisation efforts that are required to select a storage site, to prove the capacity, infectivity, and containment and to design operations. What is required is the detailed appraisal and drilling work which better characterises storage sites and increases confidence and thus decreases investment risk.

9.5.3 Interviews

The interview question – do you think there a need to establish an improved EU atlas of storage capacity of CO_2 across Europe, gave the following responses:

Industry

- Could be useful, but should not be a priority.
- Not sure if it would be better to do from the top down or amalgamate MS.

Environmental NGOs

- Agree that it is not a priority.
- Geological survey – think it could stimulate the market.

9.5.4 Written submissions

CO2GeoNet supports a CO_2 Storage Atlas for Europe, through cooperation of Member States.

9.5.5 Summary and conclusions

It is clear that storage needs to be available for future upscaling of CCS to happen. The CO2Geonet project has estimated that there is sufficient storage in Europe for 60 years of European CO_2 point source emissions. There are some benefits associated with preparing a storage atlas such as that it would help enable better informed policy decisions, help early infrastructure planning and help to

maintain EC credibility as a CCS leader. However there are some important provisos to bear in mind. These include the need for a consistent methodology which will not be easy given the wide variation between Member States in data quality and availability. The point was also made that some Member States (e.g. the UK) already have good quality information available and that the information would be better gathered by Member States rather than in a top down way. The value of an atlas based on static modelling (as opposed to much more expensive injection test (drilling)) was also questioned as any developer would require detailed injection test before practically committing to a storage site.

On balance, although there are some concerns over the detailed practical usefulness of an atlas it would be a useful high level tool and would send a positive signal on the EC's commitment to CCS. Therefore it appears that pursuing an atlas is a good idea.

9.6 Q36 – Need for review of article 18?

36. In light of the lack of experience with the procedure regarding the Commission's review on the transfer of responsibility pursuant to Article 18 of the CCS Directive, to which extent is it appropriate to already review the procedures under Article 18?

9.6.1 Summary and conclusions

This question was not directly raised in the survey or interviews. There has been no experience yet of the Commission review of site transfer and it seems unlikely that this will occur for a number of years – given that the Directive suggests a 20 year minimum (although many would like to see this reduced) before this occurs and no site has started storing yet.

It is possible to draw some lessons from the opinions and lessons learnt with regard to the Commission review of the storage permit. This is discussed under questions 7 and 11 but in summary some Commission involvement appears useful (for public credibility purposes) but this should not continue indefinitely and a detailed description of the level of detail and information required by the first projects to pass through the process should be shared in in order to reduce the administrative burden (for site operators, the CA and the Commission).

9.7 Q37 – Need for EPS?

37. Is it needed and practicable to establish a mandatory requirement for Emission Performance Standard (EPS) for new electricity-generating large combustion installations pursuant to Article 9a of Directive 2001/80/EC, where permanent containment of CO_2 in such a way to prevent and, where this is not possible, eliminate as far as possible negative effects and any risks to the environment and human health, and the environmental and human safety of CCS has been sufficiently demonstrated, as well as its economic feasibility? In light of the progress of CCS demonstration in Europe, is it needed, practicable and justifiable to establish EPS mandatory requirements for fossil fuel power plants, and if so, at which level ?

9.7.1 On line survey

QD4. In light of the slow progress of CCS demonstration in Europe, do you think is it needed, practicable and justifiable to establish mandatory Emission Performance Standard (EPS) requirements for fossil fuel power plants?

Yes	No	Don't Know	Comments
44	30	31	48

There was a wide range of opinions on this topic. There was an agreement amongst many respondents, mainly NGOs, that an EU-wide mandatory EPS is necessary. Respondents stated that a level needs to be set to prevent new build (unabated) coal-fired plant.

An EPS on power generators or on suppliers is practicable, using existing information on g/kWh of carbon; and increasingly justifiable, with some Member States implementing their own EPS (e.g. the

UK) and the USA EPA taking a similar route. A separate policy mechanism may however be required for industrial CCS.

While some respondents believed that an EPS is not required as it will undermine the ETS and will stall investment in new power plants, others believed that an EPS is necessary.

Some respondents believed that while an EPS would encourage emissions reductions, given the current stage of technology deployment; it is not likely to encourage demonstration of CCS. Thus, it is not a substitute for more targeted demonstration programs. It was stated by some respondents that an Emission Performance Standard should not be considered, unless coupled with an appropriate mechanism that incentivises CCS. Without financial incentives, an EPS system would only divert or delay investment in CCS and would likely be counterproductive, particular for early deployment. The introduction of fuel-specific CO_2 emission limit values would promote the deployment of BAT, and the associated improvements in average efficiency of the EU power generation fleet would lead to lower CO_2 emissions, more efficient resource use, and would also facilitate deployment of CCS, as the energy demands of CCS are better met by BAT power plants.

Additional comments from respondents are as follows

- EPS may be considered to be a justifiable addition to ensure those new plant which will require to be built over the next 5 - 10 years do not lock the EU into high carbon generation past 2050.
- EPS in short term would deter investment in CCS and lead to a shift to gas instead, with construction of unabated CCGTs.
- Introducing an EPS before CCS has benefited from the cost reductions that come with commercial-scale demonstration could hinder the further deployment of gas and coal fired power plant, with and without CCS.
- If an EPS is set at 450g/kWh in 2030, the effect in 2025 does not advance early CCS, while the effect in 2050 is small. It would also lead to a shift to gas, and not CCS, in the early years. An EPS set at 225g/kWh in 2030, on the other hand, prevents investment in unabated gas and gas with CCS is selected; it then advances lignite, coal and gas CCS and by 2050 increases the total level of CCS deployment. Due to the grandfathering of existing plants, an EPS therefore cannot be expected to have benefited from an extensive demonstration and commercialisation period.
- Depending on the threshold chosen, the EPS is likely to lead governments – or the EU – to pick winners without respecting the principle of technology neutrality, potentially endangering fuel diversity and affordable electricity supply.
- It is not possible to mandate CCS via an EPS until the technology is commercially viable.
- An EPS is designed to prohibit the operation of certain plants under certain conditions and is not a direct CCS support mechanism. Implementing an EPS without addressing direct support to drive CCS deployment will not further CCS demonstration.
- EPS can be implemented in many different ways with flexibilities that allow plant operators to make operational decisions – but the point of an EPS is to guide investment / reinvestment / divestment decisions, which are currently not being influenced via carbon price.

QD5. Do you think that mandatory EPS runs the risk of having conflicting objectives with emissions trading, which could in turn have negative consequences for CCS?

Yes	No	Don't Know	Comments
35	32	38	35

Most respondents thought that setting a mandatory EU-wide EPS will conflict with the ETS. It was stated that an EPS will add to the distortions in the ETS already caused by subsidies provided for other low carbon technologies. Respondents noted that there is the risk of "double regulation" in implementing an EPS alongside the ETS. One respondent thought that this question is difficult to answer as the impact of a mandatory EPS on emissions trading objectives would be entirely dependent on the level at which it was set, the date at which it was introduced and the status of the technology at the point of introduction.

Additional comments as below:

- An EPS can be designed and introduced in a way that there is no conflict between the two policy measures, indeed they can be every bit as complementary as are the ETS and the CCS Directive.
- It is not possible to implement strict standards in the short term on all emitters; the EPS will therefore not lead to immediate investments being made in CCS.
- A market based system such as EU ETS does not work effectively alongside regulation in the form of an EPS
- ETS and EPS are complimentary
- An EPS, like RE support, would be damaging for the future of the ETS.

QD6. When do you think EPS should become mandatory for new large combustion electricity generating plants?

As soon as possible	From 2020	From 2025	From 2030	Should not be mandatory	Don't know	Comments
36	6	3	1	23	36	32

Some respondents said that there is a case for setting an EPS in the near future. While some of the R&D entities would like to see the EPS introduced in short to mid-term; the majority of projects would not want it to become mandatory, at least not before CCS becomes commercially viable and the best available technology for low carbon generation. Many respondents thought an EPS should be set as soon as the technology becomes commercially available. The level of the EPS should then be set at a level below 100-150 g/MWh. Above this level, investments will be directed to unabated gas power plants, not towards power plants equipped with CCS. Some respondents specified the period between 2020 and 2025.

One respondent stated that due to the insufficient price signal from the ETS and a poor outlook due to continued oversupply of allowances, CO_2 intensive generation such as coal and lignite facilities are being planned or refitted around Europe now. The continued operation of such facilities or investment in new plants is not compatible with the EU climate goals. An emissions performance standard (EPS) should therefore apply, with immediate effect to all new generation capacity to ensure that new investment is compatible with medium and long term carbon reduction goals. An EPS should not grandfather existing plants. It is necessary for an EPS to apply to existing plants to avoid perverse incentives that would support the continued operation of old and inefficient plants.

Other respondents stated that the potential impact of an EPS in hindering CCS by being too low too early should be considered.

Respondents stated that evidence suggests that an EPS won't increase the rate and scale of CCS deployment; technology needs to be commercially-deployed first and the success of an EPS will also be dependent on what additional policies and incentives are in place to enable CCS to compete on a level playing field with other low-carbon technologies.

QD6.1. What could be a practical level of EPS (in g CO_2 / kWh)?

<300	300	350	400	450	500	>500
40	5	10	12	8	3	19

Many stakeholders stated that this question is misleading as it is only applicable to those who believe EPS is necessary. Stakeholders opposed to EPS did not want to answer this question but were forced to in order to be able to continue with the questionnaire. The quantitaive results show that most respondents selected a level below 300 g / kWh. Comments from other questions on EPS were reviewed to give a clearer idea on this topic as discussed above. Most respondents believed that a practicable level of EPS is < 300 g/kWh. Comments stated that identifying an EPS level is dependent on the status of the technology at the point of introduction.

9.7.2 Interviews

This question was covered under question 22 on the most appropriate mechanism to support CCS.

9.7.3 Written submissions

Alstom feel that a mandatory EPS will not encourage CCS deployment in the short term, and if wrongly designed could favour gas over coal with CCS. An effective EPS for the medium term should be below 150g/MWh

E-ON do NOT support an EPS as this will not drive investments in CCS. It would increase the risk for secure energy supply in the future.

Euracoal submitted their position paper on EPS under the UK energy Bill. Although this is not stated we presume it is their intention to say that the arguments against EPS in this paper for the UK are also valid for the CCS-EPS discussion in the Directive review.

Euracoal is not in favour of an EPS system and think it is not compatible with current IED and ETS.

An EPS that favours one fuel over another (gas over coal) is particularly inadvisable as it would:

- Reduce fuel diversity;
- Limit competition in the electricity market; and result in fuel switch from coal to gas and hence delay CCS deployment.

Euracoal believes that the EPS discussion should not be part of the CCS Directive Review since the conditions for including it have not been met (only where the permanent safe containment of CO_2 has been sufficiently demonstrated as well as its economic feasibility – Article 38).

EURELECTRIC does not support the introduction of an emissions performance standard (EPS), as this would not incentivise the development of CCS effectively and would cut across the EU ETS. (and art. 38.3 does not allow for an EPS at this stage as CCS is not yet economically feasible).

Eurogas -NO EPS and NO CCS certificates, both would be an incorrect approach to solving the problem. This would undermine the ETS and would create life extensions of inefficient power plants and reduce the chances for gas-fired power plants as back up for renewable energy.

European Power Plant Suppliers Association (EPPSA) - An Emission Performance Standard should not be considered, unless coupled with an appropriate mechanism that incentivises CCS; without financial incentives, an EPS system would only divert or delay investment in CCS and would likely be counterproductive, particular for early deployment.

The Crown Estate (UK) - Think an EPS system on its own is not enough to push CCS forward. The Storage also needs to be incentivised. They think a system of CO_2 storage certificates could be helpful to incentivise storage.

The Regulatory Assistance Project (RAP) notes that:

- Combining the ETS with an emissions performance standard (EPS) could achieve multiple desired outcomes; it would drive CCS deployment, strengthen investor confidence, and keep rate of decarbonisation on track over all timescales. An EPS trajectory would provide investors with much greater market foresight and investor confidence about when carbon intensive generation will need to shut down, reduce operating hours, or be fitted with CCS technology. This greater certainty would not only reduce the risk of stranded assets but also drive the development of CCS supply chains.
- A long term EPS trajectory (to 2050) will give investors more certainty about whether a plant can fully recover fixed costs before CCS is required to be fitted, whether or not it will be economically viable to fit a plant with CCS or whether it will be more profitable to invest in alternatives.
- A well-designed EPS can be compatible with the EU ETS, the internal energy market (IEM), and other carbon reduction policies. It would be necessary to review and adjust the ETS cap, not the ETS price, in order to manage interactions between the ETS and complementary measures such as an EPS.
- Public subsidies to commercialise CCS should be focussed on energy-intensive industry rather than the power sector and not in the absence of an EPS. From the perspective of EU

competiveness, it would be logical to focus subsidies for the commercialisation of CCS in heavy industry applications as the heavy industry sector has limited options for decarbonisation strategies compared with the power sector.

The submission of WWF and other NGOs concerns primarily Emissions Performance Standards (EPS), which they see as key to countering the EU's coal addiction. They further state that:

- The European Union needs an Emissions Performance Standard (EPS) for CO_2 from power plants as it will prevent lock-in to the worst-polluting infrastructure. It will also provide a clear investment signal for the decarbonisation of the sector by complementing the Emission Trading System (ETS), and binding climate, renewable energy and efficiency targets. In this way, the EU 2030 climate & energy framework will provide regulatory certainty for all market actors throughout the EU.
- Non-price measures are required in tandem with a CO_2 price.

9.7.4 Stakeholder meeting

- Some stakeholders felt that Emission Performance Standards (EPS) should not be introduced hastily, and it would not be appropriate to do this before the (CCS) technology is ready.
- A number of stakeholders made the point that the questions on EPS in the on-line survey were poorly worded and as such the results should be treated with care.

9.7.5 Summary and conclusions

There are diverse views on the effectiveness and need for EPS in general and its potential role in promoting CCS. The UK already has an EPS in place that effectively prevents any new unabated coal fired generation and the US is considering a similar approach.

The NGOs who responded feel that an EPS is required in order to prevent new unabated coal generation and to speed to closure (or retrofitting of CCS) to existing coal fired generation.

A number of respondents feel that an EPS would risk undermining / contradicting the ETS as it would be 'double regulation' of the same issue. They predict that the likely impact would be a switch from coal to gas fired generation, with no meaningful impact on the uptake of CCS. Others argue that a carefully designed EPS (with the level reducing over time) would not undermine the ETS and could help encourage CCS.

It is not possible to reach a conclusion as to which argument is most likely to be correct without some consistent modelling of the various options.

9.8 Q38 – Any evidence of need for additional regulation of transport?

38. Is there scientific evidence that environmental risks associated to transport of CO_2 should be further regulated, on top of the existing legislative framework?

9.8.1 Literature review

If early CCS projects are to support the first elements of larger scale CCS, it would be preferable to incorporate transport and storage infrastructure. The design of these early systems should be flexible to allow other projects to join both the transport and storage infrastructure at a later date. It is generally expected that over time, complex networks will develop that join multiple CO_2 suppliers to multiple storage locations[91]. Supporting the development of such networks presents a challenge that requires developments in the areas of international regulations, agreements and governance, as well as the

[91] Element Energy, 2010. One North Sea.

technical development of network management. We did not find any indication in the literature of a need for more regulation on this topic.

9.8.2 On line survey

QB4. Are you aware of any scientific evidence that environmental risks associated with the transport of CO_2 should be further regulated, on top of the existing legislative framework?

Yes	No	Don't Know
9	60	36

10 comments were received for this question mostly indicating that there is no scientific evidence to justify further regulation yet. It was specifically highlighted that the key issue here is not whether there is a need for further regulation but the lack of scientific knowledge and evidence, given the specific behaviour of CO_2 and pipeline impurities, required to fully apply existing regulation with confidence. Several comments recommended the following sources for information on this topic:

- Herold, et. al. (2010), Carbon Capture, Transport and Storage in Europe: A Problematic Energy Bridge to Nowhere? Weblink: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1721484
- Ivan S. COLE, Penny CORRIGAN, Samson SIM, Nick BIRBILIS, « Corrosion of pipelines used for CO_2 transport in CCS: is it a real problem? ». International Journal of Greenhouse Gas Control, Volume 5, Issue 4, July 2011, P. 749-756.
- P.W. PARFOMAK, P. FOLGER, A. VANN, « Carbon Dioxide Pipelines for Carbon Sequestration: Emerging Policy Issues ». Congressional Research Service 2009, p. 15-16. Weblink http://stage.trunitydev.net/files/182901_183000/182932/co2_pipelines_for_carbon_sequestration-emerging-issues.pdf
- Tim HILL, Jeremy J. COLLS, « Assessing the risk for CO_2 transportation within CCS projects, CFD modelling ». International Journal of Greenhouse Gas Control, volume 5, issue 4, July 2011, p. 816–825.

9.8.3 Interviews

There was one specific response to this question from industry: No. There is no additional evidence which shows that there is a need to regulate additional risks from CO_2 transport.

9.8.4 Summary and conclusions

It is clear that a transport network for CO_2 will be required in order for CCS to become a large scale reality, and that this system needs to be in place before multiple large scale capture installations can become operational. There were no additional (newly identified) risks that suggest that the transport of CO_2 needs to be further regulated.

9.9 Q39 – Ship transport of CO_2

39. What has been the practical experience of CO_2 transport by ship so far? In light of this experience, could the EU regulatory framework on CCS better address the issue of ship transport of CO_2?

9.9.1 Literature review

Transport by ship can be an alternative to pipeline transport, with ship transport more cost effective for small volumes over long distances (typically longer than 700 km)[92]. Shipping has been suggested as a suitable transport mode for the early demonstration phase of CCS in Europe, whereby only relatively small amounts of CO_2 are necessary for pilot and demonstration projects. In recent years, the concept

[92] ZEP, 2011. The costs of CO_2 transport.

of large scale CO_2 transportation by ship gained momentum as, under certain conditions, a more cost-effective and flexible alternative for CO_2 pipelines. Transportation of CO_2 already occurs by ship in some European countries.

As CO_2 transport by ship already occurs, no major legal hurdles to the activity are expected. A full legal assessment of CO_2 shipping, both from a legal and safety perspective has been completed in work funded by the CATO Institute[93]. One issue has arisen however, related to the status of a CO_2 carrier under the European Union Emissions Trading Scheme (EU ETS). If a CO_2 carrier transports CO_2 to a storage site for the purposes of storage under the scheme, it would be considered an 'emitter' under the modalities of the regulation. All current emitters under the scheme are fixed installations. According to the Commission[94], should a project involve transport of CO_2 by ship, this activity would have to be opted into the EU-ETS pursuant to Article 24 of the EU Emissions Trading Directive. The opt-in document would have to specify how the CO_2 emissions of the vessel would be calculated. Further analysis is detailed in other CATO literature[95].

9.9.2 On line survey

QB1. Do you think that the EU regulatory framework for CCS adequately takes the following issues into account?

	Yes	No	Don't Know
Transport of captured CO_2 by ship	19	49	37

Nine respondents felt that the CCS Directive was designed to address the geological storage of CO_2 and not transport, meaning that ship transport should not be covered by the Directive. One respondent noted that CO_2 shipping is already practiced on an industrial scale.

Three respondents commented that transportation by ship is currently a grey area under the EU-ETS creating a disincentive.

9.9.3 Interviews

This question was raised by asking: Do you think CO_2 transport by ship needs to be specifically regulated?

The vast majority of stakeholders agreed that:

- The key issue appears to be in the ETS regulations, where ships need to be classified as 'installations' and included in the measuring and reporting guidelines.
- There appears to be a consensus that the technical and health and safety issues are sufficiently covered by existing legislation.

9.9.4 Written submissions

The Bastor 2 project (a two year research project that has investigated the opportunities for CO_2 storage under the Baltic Sea) state: Many stakeholders see ship transports as an important element of the CCS infrastructure. The uncertainty that currently pertains to the potential inclusion of ship transport under the EU ETS as an opt in on a case by case basis (acc. to art. 24 of Directive 2003/87/EC) is not conducive to creating the conditions needed for incentivising long term planning and investments that include CCS. Bastor2 considers the formal inclusion of ship transport, including principles for monitoring and verifications, under the EU ETS a vital component of any package of measures aimed at improving the currently bleak prospect for CCS in the EU.

[93] Boekholt, R (2014). Regulation of liability and safety in ship transport of CO2 – a comparative analysis, CATO2 deliverable CATO2-WP4.1-D11, 58 p. http://www.co2-cato.org/publications/library1/regulation-of-liability-and-safety-in-ship-transport-of-co21

[94] European Commission, 2011. Questions and Answers on the NER 300 Programme and the first Call for Proposals (02/05/2011). Retrieved, (19.09.2014), http://ec.europa.eu/clima/funding/ner300-1/docs/faq_13_en.pdf

[95] De Wolff, J, T Mikunda, R Catau, F Blank & S Z Khawaja (2013) Technical and Legal aspects of CO2 transport by ship and implementation of the CO2 flow monitoring, CATO2 deliverable CATO2-WP4.1-D09, 49 p., http://www.co2-cato.org/publications/library1/technical-and-legal-aspects-of-co2-transport-by-ship-and-implementation-of-the-co2-flow-monitoring

9.9.5 Summary and conclusions

Transport of captured CO_2 by ship is more cost effective than pipeline transport for small volumes and / or large distances. Both scenarios are likely for early demonstration / pilot schemes. The fact that CO_2 is already transported by ship suggests that there are no legal hurdles to expanding this practice. There are no hurdles identified to ship transport of CO_2 in the CCS Directive. There are clear problems under the ETS related to the treatment of CO_2 transported by ship, it appears that these could be addressed by changes to the ETS regulations and this should be addressed at the earliest possible opportunity.

9.10 Q40 – Guidance documents and the need for standards to support CCS development

40. What are the prospects for standards to be developed and applied in a European context to support the objectives of the CCS Directive? Are there any areas in standardisation, which could potentially achieve an important contribution in this respect (e.g. in the areas of risk assessment, CO_2 stream composition)? What are the pros and cons for developing standards for CCS at European level?

9.10.1 On line survey

QA5. A series of four Guidance Documents were developed to support a coherent implementation of the CCS Directive across the EU member States. What is your opinion on the contribution of these guidance documents:

	Agree	They have no impact	Don't Agree	Don't know
They were helpful for the preparation of CCS projects	47	10	11	35
They were helpful for the implementation of CCS legislation in MSs	37	14	8	44
They have increased the impact of the Directive	27	18	17	40

23 respondent provided comments on the helpfulness of the Guidance Documents for the preparation of CCS projects. 10 respondents providing comments agreed that the Guidance has been helpful in general, one noting that this is particularly helpful 'to bring existing participants, Competent Authorities and new entrants to a shared level of understanding.' Another respondent commented that 'Guidance document 2 provides a helpful framework for interpreting Annex I'. 8 out of the 10 respondents however stated that Guidance 4 has not been helpful, the following comments were provided:

'the highly liquid financial security requirements may lead to a high cost of financing CCS and be a barrier to the development of CCS', 'over-restrictive proposals on definitions for financial security and financial contributions', 'self- assurance and corporate guarantees from affiliated companies are rated as the riskiest forms of financial security, despite these being acceptable for oil and operations', 'Guidance Document 4 does not provide for any suggestions of dealing with the uncertainty of EUA prices in the case of a leakage, exposing storage operators to significant future liabilities' , 'need for highly liquid, upfront financial securities under GD4 has been a disincentive for investment', 'there are some particular areas that in my view have hindered progress such as the upfront financial securities'.

In regards to the future actions, some thoughts were provided. One respondent commented that the Guidance has focussed on transport, storage and financial aspects and capture processes might benefit from additional guidance. Another responded noted that 'risk assessment GD1 and the site characterisation GD2 were used by research projects and can now be significantly updated as a result

of the findings'. It was however also suggested that the Guidance Documents have served their purpose and should now be removed as supra-national documents and Member State Competent Authorities should be encouraged to develop their own positions.

15 respondent provided comments on the helpfulness of the Guidance Documents for the implementation of the CCS legislation in the Member States. 3 respondents noted that the Guidance Documents were issued too late; the national law has been largely already implemented before the Guidance was published. 1 respondent noted that the Guidance Documents had no major impact on the translation of the Directive. 3 respondents however agreed that the Guidance Documents have served their purpose of providing a resource for Member States in the process of transposition. 2 of them however further explained that replacement of the Guidance Documents with national-level guidance – based on real experience and local circumstances – should be considered.

16 respondent provided comments on whether the Guidance Documents have increased the impact of the Directive. The opinions on the topic however vary largely. 5 respondents believe that the Guidance Documents had negative impact, one commenting further 'several countries have used the transpositions to make CCS almost impossible'. Further 4 respondents criticised more specifically the Guidance Document 4 that offers a too prescriptive guidance in relation to financial guarantees. 1 respondent believed the Guidance Documents to have insignificant impact and 2 respondents said that the documents clarified many aspects of the Directive and harmonised approaches.

QA6. Do you think that the development of a European standard in line with the CCS Directive objectives, on top of the guidelines, is desirable?

Yes	No	Don't know	Comment
42	42	21	45

27 respondents provided comments for this question. In general, it was agreed that even the existence of standard is desirable, the standards must be introduced at the right time and reflect genuine understanding of technical risks. Almost all of the respondents therefore strongly agreed that it is too early in Europe to assess the required scope of European standards as the experience is yet too limited given that there is no large scale integrated CCS project yet in operation in Europe. The standards cannot be descriptive for technology that is not mature. Premature standardisation could limit flexibility in the development phase of a technology and stifle innovation. Several of the respondents (10) believed that the ISO standard in development should provide sufficient technical detail and need not be replicated by a European effort.

Additional thoughts from the respondents:

- Standards should be developed based on actual project experience rather than on hypotheses and therefore should be developed over time, addressing only 'no regrets' issues initially.
- There is a risk that early standard setting could lock in 'gold-plated' high cost requirements, and stifle innovation necessary in the early development and deployment of technologies.
- We consider that the minimum requirements in relation to health, safety and environment are sufficiently covered in the Directive and CCS standards will rather limit than support CCS development at this stage. We specifically highlight that there is no evidence that lack of a standards is prohibitive to CCS development/deployment.
- In addition as ISO standards are being currently produced for CCS, setting up European standards risk to be obsolete and in the worst case the process could be detrimental to the ISO process.
- It is clear that regions that are progressing more rapidly on CCS such as North America will have more to add to the drafting of international standards.
- Those EU representatives would hopefully consider EC guidance documents while developing the ISO standards. As for all ISO standards, its transposition in a CEN standard will be done when the standard will have been approved at the ISO level.
- EU-funded and member state-funded research activities have included best practice and knowledge capture documents (SiteChar, www.sitechar-co2.eu; CO2Care, www.co2care.org; RISC, www.risc-project.eu; ULTimateCO2, www.ultimateco2.eu; CO2MultiStore, www.sccs.org.uk); these could form the basis of an EC standard.

- There may be scope to develop initial thinking on where and what form standards would be most helpful to build industry and investor confidence. When more practical engineering experience is available, it would then be possible to move more rapidly to an accepted set of standards.
- "A" standard would not be sufficient.
- It would force project developers to collaborate on finding common solutions to particular issues.

QA7. If yes, what is your view on the following statements?

	Agree	Disagree	Don't know
European standards can be best developed by upgrading the existing Guidance Documents	28	27	49
A dedicated European CEN standard for CCS should be developed	17	36	51
European standard should be based on/fully linked with the ISO CCS standard, which is currently being developed	50	10	45
No further standards are necessary	13	45	46
Independent industrial standards, like ISO, are sufficient	24	26	52

20 respondents provided additional qualitative thoughts on the statements. The majority of respondents believe that any standards should be developed in-line with the ISO standards when these have been fully developed and adapted to the EU where appropriate. Many also suggested therefore that the EC should focus on helping shape the global CCS standard, drawing on review of existing projects. A second key theme was that it may be too early at this stage to adopt a standard given the first CCS plants have not been commissioned resulting in no project population against which standards can be benchmarked.

QA8. How important do you think developing common EU standards is to achieving the following?

	Vital	Very important	Useful	Neutral	Not important	Don't know
Risk assessment – evaluation processes	24	31	14	9	16	11
Risk management protocol (how risk is assigned / treated)	24	24	18	11	17	11
CO_2 stream composition	16	19	28	13	15	14
Environmental impact assessment	17	31	19	9	17	12

31 participants provided additional views on this question. The majority of respondents believed that developing a standard at this stage would be premature and not-needed in the absence of commercial scale CCS-experience and before a global ISO standard has been agreed. However, many also noted the potential benefits of a standard in achieving standardisation of aspects of the CCS chain once large-scale projects were in operation, including regarding specific issues such as site selection, transportation of CO_2 and stream composition. Some respondents highlighted the importance of site-specific elements in processes such as risk assessment, underlining that any standard will need to be flexible and applicable across projects and one suggests existing EIA processes are sufficient, making it unnecessary to include this within any CCS standard.

9.10.2 Interviews

The answers related to this question can be split into two sections. The first section relates to the concept of standards in general, and the ISO CCS work. The second section relates to the Guidance Documents recently produced by the Commission.

The concept of standards in general, and the ISO CCS work:

Industry

- Too early to develop detailed standards yet – not practical or useful with such a low level of experience.
- The ISO standards should be used / linked to – though many feel that it is premature to have begun to develop these.

Environmental NGOs

- Too early and highly unlikely to be acceptable to all.

Public actors

- Inconclusive: some believe standards are necessary, others disagree. Some think developing standards now is premature, others don't.

With regard to the Guidance documents:

- General concept is helpful and useful.
- Don't need any more yet – premature to have them before experience is gained.
- Guidance document four is over prescriptive and implies major financial liabilities – that introduce uncertainty and barriers to CCS.

9.10.3 Written submissions

CCSA general remark is on the questions of standards for CCS. They feel it is too early for European standards due to a lack of best practice so far.

Eurelectric Some of the potential obstacles to developing CCS are found in the Commission's Guidance documents, notably the provisions on financial security, and in Member State implementation of the Directive; these issues could be handled without a revision of the text.

Eurelectric - GD4 financial security places onerous requirements on financial securities. Needs probability approach.

Eurelectric - It is too early to prepare further standards for CCS now.

International Association of Oil & Gas Producers (OGP) concentrate on the Guidance Documents in their contribution:

- Make it more clear that the GD are non-binding for MSs; and
- Make better use of the existing knowledge on risk-management in the Oil and Gas industry.
- The general tone of the GDs suggest a high degree of uncertainty on knowledge and safety for CCS. This is not true, with over 13.000 wells injected with CO_2 and CO_2 fields being drilled and closed already for decades and thousands of miles of CO_2 transport pipes it is a well understood issue in the industry. The fact that it is now, newly, used for climate reasons does not change the required technical knowledge much. The uncertain tone is negative for public perception.
- The GDs should be written to promote the use of industries best practice in managing risk and uncertainty.

- GD1: GD1 is not clear in scope and language. Make more use of established standards and practice in industry.
- GD2:
    - We have a lot of experience with CO_2, the text does not reflect this well.
    - Focus should not be on depleted oil/gas fields only; saline also offers reliable storage options.
    - Don't be too prescriptive with technology, as this might turn counter-productive.
    - More flexibility is needed in storage permitting to make it 'fit for purpose'
- GD 3:
    - CCS demonstration sometimes needs more flexibility to stimulate investors, current text is written very much with mature technology in mind.
    - Due to the extensive experience with CO_2 in the industry the need for extensive and elaborate abandonment, monitoring and transfer criteria is not clear. Concentrate on what is most new/required: the need for good monitoring for CO_2 /ETS accounting purpose.
    - The criteria for transfer should be performance based and not time based, in this perspective the automatic penalty in the 10-year period after minor leakage is neither desirable nor necessary.
- GD 4:
    - GD4 may create significant financial hurdles for CCS developers.
    - GD4 does not reflect existing experience / knowledge with CCS, it assumes no relevant experience, no idea on probabilities etc. This is not the case and leads to unnecessary cost increases.
    - It also leads to unnecessary negative public perception of CCS.

Zero Emissions Platform (ZEP) - GD4 requirements for financial securities should be revised and be made more practical.

National Grid Carbon state:

- Existing Guidance Documents at supra-national level should be removed. No new guidance should be created at supra-national level until an agreed number of commercial scale full/ part chain projects have been progressed to operation.

E-ON see no current need to change the Directive. However the review of Guidance Documents could be supportive for CCS developments. "The largest and unquantifiable risk for CCS is related to the requirement to surrender CCS certificates in case of leakage (NB we assume they refer to EUA's), whereas the price of the certificate in the future is unknown. Sharing the risk between member states and the investors or linking the price to the cost at the moment of injection would be potential approaches to removing this barrier. However instead of changing the directive it seems to be more appropriate to address these issues by modifying Guidance Document 4 on financial security.

9.10.4 Case studies

The White Rose Project - Guidance has been useful in developing the applications. It is thought that Guidance Documents 1 – 3 were useful and helpful. However, Guidance Note 4 on liability and financial security is thought to be counter-productive and does not encourage investment in CCS as discussed below.

CCS Standards are thought to be useful for developing CCS projects but in the long-term after enough experience is gained. It is believed that standards should be developed at a global rather than European level. In the near term, standards would be premature and counterproductive as they will hinder innovation and development and will miss out on the benefit of experience from what are expected to be early projects addressing a range of issues. It would also restrict Member State abilities to regulate early projects in a tailored manner. Standards should be developed based on

actual project experience such as the White Rose project rather than on hypotheses and therefore should be developed over time. There should also be a minimal number of standards globally on the same subject. There is a risk that introducing a European specific standard where a standard already exists, could add additional constraints without benefit. The EC should help shape and then adopt the ISO CCS standard for definition of storage capacity rather than develop a CEN standard. Guidance Documents should not be considered as standards.

9.10.5 Stakeholder meeting

- There is too much regulation for an immature industry, the guidance documents are too detailed – especially GD4. Although the Commission responded that the GDs are not legislation and MSs should know this. However the point was made that often, de-facto, they become treated as such.
- With regard to the developments of detailed standards on CCS, the majority of those who expressed an opinion felt that it is too early to pursue standardisation (due to the lack of practical experience), and as such the ISO process is premature. However, the point was also raised that the ISO process is happening so should not be ignored.

9.10.6 Summary and conclusions

The responses and conclusions regarding this question can be split into two groups - those relating to the Guidance Documents and those relating to the development of operational (ISO type) standards.

With regard to the Guidance Documents, it appears that numbers one to three are generally regarded as helpful. There are clear feelings from developers and potential developers that Guidance Document four is over prescriptive in its suggestions, particularly with regard to the type of financial guarantees that storage site operators need to supply to CAs. Despite the fact that the Guidance Documents have no legislative power (with some under the impression that their main purposes was to help MSs in transposing the CCS Directive) it is clear that MSs are interpreting the Guidance Documents like extensions of the Directive. Other comments on the Guidance Documents include that:

- One and two could be updated as a result of completed research.
- It would be possible to now withdraw the Guidance Documents and allow MSs to develop their own detailed guidance.
- There is no Guidance Document on capture.
- The tone of the Guidance Documents was also felt to lack recognition of the experience gained in CO_2 injection for EHR.

Having reviewed the opinions on this issue the conclusion of this report is that the Guidance Documents should be retained, as they are useful for MSs as they receive their first CCS applications. Guidance Document four should be updated – based on detailed / specific comments from stakeholders, and consideration should be given to creating an additional Guidance Document related to capture – particularly on Carbon capture readiness. Although MSs should know, it would be a good idea to clearly state in the Guidance Documents that they do not have legislative force.

Section 10 Conclusions

This section presents our conclusions against each of the evaluation questions. There is also a short summary of our views on the headline evaluation headline questions.

10.1 Effectiveness

Effectiveness considers how successful an intervention has been in achieving or progressing towards its objectives. Since Smart Regulation normally involves a hierarchy of objectives for a given intervention, analysis of effectiveness should look at changes to outputs, results and impacts as appropriate, separately identifying these elements and clearly stating how each is covered.

The stakeholders recognise and support the objectives of the Directive. As we discuss under 'relevance' the need for the Directive has arguably increased over the last five year. This is because of the increasing evidence of the scale and impacts of climate change and the need to rapidly decarbonise the power supply of Europe and the rest of the world.

The number of CCS installations (referring to capture, transport and storage) achieved to date has been much less than expected when the Directive was passed. No schemes large enough to be regulated by the Directive have yet become operational in Europe, although a number of small 'pilot' / R+D scale installations have been operating. One project (ROAD in the Netherlands) has passed through the early stages of gaining CCS Directive approval but has yet to become operational. . A number of projects have been proposed, with some being approved for EC support, but of these all apart from the UK project White Rose (supported under NER300) all have either stopped or are in significant difficulties. The lack of progress has been driven by the lack of a commercial case for CCS, largely because of the global economic downturn and low carbon prices (via the EU-ETS). This lack of practical experience means that it is not possible to identify many effects induced by the CCS Directive. There is clear stakeholder concern that reopening the Directive now would bring a period of further uncertainty for CCS which would not be helpful in a sector where investor confidence is already low.

There are some issues which have risen up the agenda since the Directive was enacted. Some of the issues are better addressed via other policies or mechanisms. There are also some details of the Directive, e.g. related to the financial securities required for transferring storage sites from operators to the state and carbon capture readiness for new power generating plants where the Directive could be improved in terms of clarity. Of the issues that could be addressed via the CCS Directive it does not appear that any are of sufficient importance to justify the risks associated with reopening the Directive.

10.1.1 Q1 – Effects correspond to objectives

1. How do the effects of the Directive correspond to the objectives?

The evidence and the stakeholder views support the conclusion that the objectives are appropriate.

Looking at the intervention logic – the central problem of the needs to address climate change and to ensure security of energy supply remains in place, with increasing evidence[96] of the need to address climate change. The original IA for the Directive explicitly mentions that a clear benefit of CCS is seen as the ability it offers to use European coal as a fuel for electricity generation as opposed to imported gas – because of the security of supply benefits this brings.

The literature and stakeholder views support the conclusion that the Directive does little to help establish CCS infrastructure (other than first steps in a regulatory framework) or define its role in the EU's climate and energy policy.

The Directive has had some positive effects on addressing health and environmental concerns and harmonising procedures between MSs.

[96] "Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks." IPCC AR 5 October 2014. http://www.ipcc.ch/

The Directive appears to have had very little (or even a slightly negative) impact in terms of public acceptance and increasing uptake of CCS. This is arguably not surprising as the Directive does not have the tools to directly do that. The Directive should have some positive impact on public acceptance but the evidence of this is only likely to become apparent when sites become operational and (if the Directive works) well regulated.

The liability issues raised in the Directive are another barrier to CCS but the assumption that it is legitimate that for storage site operators to bear some responsibility for potential harm to the environment is reasonable. It can also be concluded that, based on the weight of opinion and evidence found, that the liability issues are a much less significant barrier than the general economics of CCS. The major reasons for lack of progress in CCS installation are not related to the Directive. These reasons include the economic downturn and wider energy policy issues such as the ETS.

10.1.2 Q2 – Progress on CCS

2. As recalled in the Consultative Communication on CCS published by the Commission in March 2013, CCS technology demonstration in Europe is not progressing at the pace as envisaged at the time of European Council of March 2007. How can we rate progress on the validation of cost and technical projections for CCS technology in Europe? (Elements of capture-transport-storage to be distinguished).

Only two of 12 current CCs projects in the world are in Europe, both of these are in Norway, where the CCS Directive is applicable, but the projects were permitted before the CCS Directive came into force. One final investment decision appears close in Europe. Activity is focussed on a small number of MSs (UK and NL are most active). There have been more activity in the rest of the world and Europe is falling behind.

There has been good quality research work done in Europe, but this is desk based work on feasibility and regulation. There is more information on practical experience coming from outside the EU. The non EU knowledge gained on capture is more transferable (to the EU) than the knowledge gained on storage.

The European Council of June 2008 called on the Commission to bring forward as soon as possible a mechanism to incentivise Member State and private sector investments to ensure the construction and operation by 2015 of up to 12 CCS demonstration plants. This has not occurred, as discussed elsewhere this lack of progress has very little to do with the Directive As also discussed elsewhere if the EU (and the rest of the world) is to address climate change this need remains valid. Future progress needs large scale demonstration projects. It appears that the most pressing need is for steps towards developing transport networks and storage complexes – as these are the first stage in creating a CCS system..

10.1.3 Q3 – Public acceptance

3. How is the CCS Directive (and its implementation in national legislation) contributing to fostering public acceptance of CCS as a climate change mitigation technology across Europe (e.g. in the process of authorisation of a storage site)? Is the EU regulatory framework for CCS effectively and practically taking into account public safety and environmental concerns which may arise?

It appears that overall opposition to CCS, particularly onshore storage, has increased.

General public awareness (and hence knowledge of) CCS is low. Most Member States have done little or nothing to improve CCS awareness. This needs to be addressed and CCS needs to be placed in a wider context as an important part of climate policy. This evaluation's recommendations for both EU and MS level actions on this point are included in the sections related to CCS enabling policy.

For prospective project sites communication and openness is very important. There are some good examples of successful public education and engagement at sites, with frequent, targeted and honest engagement being very important.

The Directive has not helped to improve public acceptance. In part this relates to the tone (and focus) of the directive on the risks of CCS. This (almost inevitably) gives the impression that CCS is hazardous. The industry view is that the risks involved are not uncommon and are not any higher than many industrial sectors (including energy). This focus on risks appears to be part of the reason why

public perception is to equate CCS more with fracking and nuclear waste than with natural gas transport and use.

Cancellation of CCS projects has not helped confidence (though this is not the fault of the Directive).

10.1.4 Q4 – Legal barriers to CCS

4. One of the main original objectives when setting up the EU legal framework was to ensure that legal barriers for CCS deployment would be removed (recital 8 of the CCS Directive). To which extent is EU regulatory framework on CCS effectively supporting CCS projects under development? In terms of comprehensiveness of the framework, have additional (legal) challenges been identified on the basis of project experience, which are not yet sufficiently addressed by the EU regulatory framework on CCS?

There were legal barriers to CCS and the Directive has defined a common framework designed to help address these. However there has been virtually no practical experience of the detailed implementation of this framework. There are a number of areas where uncertainty remains and the lack of practical experience in Europe means that these are hard to address until this experience has been had. Areas of uncertainty include – trans-boundary transport of CO_2, liability issues, treatment of leakage, access to depleted hydrocarbon fields and conflicting spatial demands for storage sites. The trans-boundary transport is partly an issue which needs to be addressed by existing trans-boundary transport and marine treaties such as the London Protocol. OSPAR and others (see question 39). The EC could help to push the agenda forward in all related international treaties. The issues of access to depleted hydrocarbon fields and conflicting spatial demands are issues for MS spatial planning and mineral access policy. The other areas of uncertainty require practical application (and MS and operator level interpretation) of the Directive before they can be assessed.

10.1.5 Q5 – Definition of 'permanent' storage

5. Among the original objectives when setting up the EU regulatory framework for CCS, was to ensure that this novel technology would be deployed in an environmentally safe way (recital 9 of the CCS Directive). What evidence can be gathered, on the basis of the technical progress and latest scientific knowledge, and including via CCS demonstration projects, that geological storage of CO_2 leads to permanent containment of CO_2 in such a way as to prevent and reduce as far as possible negative effects on environment and human health, and any resulting risks for environmental and human safety? Is there sufficient consensus about the definition of "permanent" containment of CO_2 on the basis of the experiences acquired so far (in Europe and beyond)?

There is not yet sufficient practical experience to answer the question as to whether geological storage of CO_2 is permanent and low risk. The work that has been done to date helps to improve the knowledge required to reduce the risks. Results to date from R&D scale storage sites (e.g. Lacq) indicate that safe and long-term storage is possible. Although there is still lack of consensus on the use of the term 'permanent', it appears to be the best compromise as it helps public confidence and allows enough flexibility in terms of practical implementation. The majority opinion that 'permanent' should not be replaced with a specific number of years appears to be the best solution.

The definition needs to be made workable for EHR – where the CO_2 is initially recirculated (in and out of 'storage'). The US EPA has developed criteria to allow for this (see question 19).

About half of the stakeholders who responded agreed that a distinction needs to be made between minor and major leakage. A minority remarked that the re-start of the 10-year period described in the Guidance Documents should be reworded accordingly and be more dependent on the cause of the problem. It is reasonable to conclude that if a distinction was made between minor and major leakage, the Directive would be improved.

10.1.6 Q6 – Biomass and CCS

6. What has been the experience, in Europe, as well as outside Europe, of application of biomass as a fuel used for CCS (large-scale demonstration) projects? What do these experiences prove in terms of techno-economic feasibility of CCS when biomass is used as a fuel in comparison to CCS in fossil

fuels-based installations? What types of incentives and support measures have been put in place (across Europe and beyond) to realise projects of CCS with biomass? How can we evaluate, if appropriate, the effectiveness and adequacy of the provisions of the CCS Directive for projects for which biomass are used as a fuel?

There is one Bio-CCS project working in the US and there is one plant with some Bio-CCS under development in Europe (the White Rose project in the UK). It appears that there are no apparent barriers to Bio-CCS as a result of the Directive. There is a clear consensus that the ETS regulations need to be adjusted to give full credit to Bio-CCS.

Biomass-CCS is recognised as relevant but more likely to emerge as an issue in the future when coal-fired power plants equipped with CCS start co-firing biomass.

10.1.7 Q7 – Storage permits

7. How many storage permits have been issued in the EU so far? How could the CCS Directive support the increase of the number of storage permits?

From the literature review and interviews it is apparent that only one permit has been awarded (to the ROAD project). There are numerous suggestions for how enabling policy could support an increase in the number of storage permits but it does not appear to be appropriate to expect the CCS Directive to play a direct role in increasing the number of storage permits.

10.1.8 Q8 – Risk management framework

8. How can we evaluate the legal practicality of the risk management framework of the CCS Directive as experienced for CO_2 storage demonstration projects for both storage operators and competent authorities? How has the interaction between competent authorities and operators worked out in practice?

The only example to date of the permitting process being completed is for the ROAD project. Many concerns were highlighted regarding the high level of detail required on future plans before a project starts / receives a final investment decision. Experience from the ROAD project suggests that the level of detail required should be reduced on the understanding that more detail will be provided (for approval) one year prior to injection. A specific point which could be clarified, either via a guidance document or in a future review is the legal aspect in a permit whether an 'Unincorporated Joint Venture' can be the 'operator'.

10.1.9 Q9 – Transfer of responsibility

9. How can we evaluate on the basis of the gathered experience the effectiveness of the criteria established for the transfer of responsibility under Article 18 of the CCS Directive? Are there any risks posed to the CCS project development?

Important concerns exist on the transfer of responsibility. The main concern is that the minimum period (20 years) is too long and/or not justified. There are calls for it to be replaced by site specific performance criteria to be set by the Member State competent authority. This would allow appropriate flexibility based on experience and the nature of the site. The Competent Authorities already have the flexibility to reduce this 20 year period. The future role of ISO standards (under development) was also mentioned. The ROAD project (with practical experience) of the permit process asked for clarity on whether the 20 year period could be reduced, on what evidence and who would decide?

The suggestion that MSs should consider their regulatory processes with regard to the relinquishment of closed hydrocarbon fields (to enable access to new entrants) appears to be a good idea and this should be raised with Member States.

10.1.10 Q10 – Exploration permits

10. How can we rate the ease of application of the procedures of approval of exploration permits of storage sites in the Member States pursuant to Article 5 (Exploration permits) of the CCS Directive,

and how have these procedures worked out in practice? Are there any challenges which have been identified, and how could these be overcome?

It appears that there are examples of sites being explored under other MS controlled (presumably oil and gas) licensing arrangements. Although some concerns that the exploration licence requirements for CCS are overly complex were raised this does not appear to be a significant problem. Given the lack of practical experience there is not sufficient evidence to justify any changes in the Directive with regard to exploration licences.

10.1.11 Q11 – Storage permits

11. Application process. How can we rate the ease of application of the procedures of approval of CO_2 storage permits pursuant to Articles 6 to 11 (storage permits) of the CCS Directive, and how have these procedures worked out in practice? Are there any challenges which have been identified, and how could these be overcome?

There has only been one example to date of the process being completed (ROAD). There are some concerns over Competent Authority (CA) requiring more detail than is available at this stage of a project. There are also concerns over the additional burden of referring the permits to the EC for review (industry stakeholders question the value and purpose of having the EC involved in permit approval, seeing it as superfluous, while some others were happy with the role of the EC as an extra 'safeguard'), the lack of knowledge among CAs and transnational issues. The permitting process requires a multidisciplinary set of skills from the applicant. The EC involvement in the process is discussed elsewhere (question 30).

The relationships between the applicant, CA, MS and EC reviewer are (understandably given the lack of experience) immature. The suggestion made by stakeholders that the information on the applications made should be made publically available (ideally by the Commission) in one language is a strong one. This would be of great use to future applicants (and the CAs in these MSs).

10.1.12 Q 12 – Stream acceptance criteria

12. What has been the practical experience in Europe with the provisions on CO_2 stream acceptance criteria and procedures pursuant to Article 12? Have the provisions of the Directive related to risk assessment proven effective and consistent for the determination of acceptable CO_2 stream compositions by competent authority?

The consensus amongst stakeholders that the wording in Article 12 would benefit from clarification, but should not be tightened and MS flexibility should be retained appears valid. A specific suggestion for clarification is with regard to the word 'overwhelmingly' which some interpret as being higher than 99% - which is considered too high. Another suggestion is that the wording could be adjusted to specifically allow any fluids produced from the reservoir to be re-injected (e.g. to enable EHR), although this activity is not prohibited by the current wording. As mentioned by some stakeholders it is sensible to assume that these details will be clarified in future standards (such as ISO). Given the lack of practical experience to date and the mixed views on the current phrasing the wording should be left as it is until further experience has been gained.

10.1.13 Q13 – Storage site assessment criteria

13. What has been the practical experience, particularly in the development of European CO_2 storage sites and complexes, of using the criteria for the characterisation and assessment of the potential storage complex and surrounding area referred to in Article 4(3) and as outlined in Annex I of the CCS Directive? Has there been sufficient progress in the knowledge basis on issues such as data collection, three dimensional static geological earth models, characterisation of the storage dynamic behaviour, sensitivity characterisation, and risk assessment methodologies for CO_2 storage sites and

The criteria are generally viewed as acceptable by stakeholders. However, stakeholders felt that while some requirements are vague, others are very specific and could potentially limit MS flexibility to take account of site specific issues. Some feel that the use of different injection methods (for example CO_2 dissolved in water (as proposed in Iceland in combination with geothermal energy extraction) should be more clearly permitted by the Directive – however there is no evidence that this approach is prohibited so no change would be recommended. There has been some progress on most issues, but

it is highly varied between MSs and there has been more practical experience gained in North America than in Europe. There has been no experience of corrective measures yet – as no leakage has occurred yet. The published work that has been done on CO_2 storage capacity has used a variety of methodologies, which makes comparison difficult or not possible. Difficulties have been reported in getting geological data from areas explored (and/or used) by oil and gas companies.

From the Ketzin and other storage tests, it appears that storage can be safely achieved, with no leakage and with a good match between reality and modelled expectations. In conclusion there has been some good progress made with regard to knowledge and small scale pilots of site characterisation but more and larger scale tests are still required.

10.1.14 Q14 – Site monitoring plans

14. What has been the experience, in the development of CCS projects and their storage sites and complexes, of using the criteria for establishing and updating the monitoring plan referred to in Article 13(2) and for post-closure monitoring plans pursuant to Annex II? What is the experience in using this Annex for the preparation of the storage permits, and has this proven practically enforceable?

There is general acceptance that the criteria are workable, i.e. fit for purpose. There were a number of comments on areas that could be clarified. For example clarification on which parts of the storage reservoir the monitoring should apply to, e.g. – just the reservoir? The cap rock? The whole aquifer? Despite these questions it is too early (given the lack of practical experience) to more tightly specify technical requirements as it risks being over prescriptive and limiting MS flexibility.

10.1.15 Q15 – 17 Third party access and trans-boundary issues

15. As recalled by recital 38 of the CCS Directive, depending on the carbon price, access to transportation networks and storage operators could become a condition for competitive operation in the EU energy market. What has been the practical experience across Member States of the implementation of the provisions concerning third-party access (Article 21 of the CCS Directive) with the view to ensure that potential users are able to obtain access to transport network and storage sites in a transparent and non-discriminatory manner? How can we rate the procedures implemented by the Member States in terms of adequacy and effectiveness? In general terms, in light of the experiences

16. What has been the practical experience with the settlement of disputes about access to transport networks and storage sites, both within one Member State and across Member States? (Article 22 of the CCS Directive). How can we rate the procedures implemented by the Member States in terms of effectiveness?

17. Pursuant to Article 24 of the CCS Directive, the competent authorities of the Member States shall jointly meet requirements of the CCS Directive and other relevant Community legislation in cases of trans-boundary transport of CO_2, trans-boundary storage sites or trans-boundary storage complexes. Has there been any practical experience of cooperation among Member States, and how effective were those?

There has been no practical experience of articles 21, 22 or 24 yet.

The technology for the pipeline transport of CO_2 is well established and there is experience being gained on the issue in North America. Experience in Europe remains very limited. The industry opinion is that there are no higher risks than for the (very common) transport of natural gas or oil. There is a need for a cross border transport (and storage) network to be available before large CCS is possible, this will require large investment and 'over sizing' to enable future CCS growth.

There are some concerns over the scope of article 21, with regard to allowing third party access to storage capacity. These centre on the inability of the storage operator to refuse access and the arrangements for the sharing of the liability associated with a shared storage site. Suggestions have been made on how these concerns could be addressed. However, there does not appear to be a problem in the short term as developers appear happy to cooperate. The evidence and opinions suggest that the coverage of this issue is left as it is but should be considered in a future review, in the light of experience.

The issues of transboundary transport of CO_2, particularly the London Protocol, are discussed again under questions 38 and 39.

10.1.16 Q18 – Capture ready plants

18. What is the experience across Europe of the application of the provisions of Article 33 of the CCS Directive? How can we rate the effectiveness of implementation of Article 33 in the national legislation with the view to support the future implementation of "capture ready" plants, e.g. fossil fuel power plants built with the assurance of a future proven CCS retrofit option? Has the practical application of Article 33 showed that it is possible to ensure that adequate conditions for the preparation of CCS implementation for new fossil fuel power plants can be met in a harmonised way across Europe? (for this specific question, the contractor is expected to base its assessments on the concrete list of cases of power plant licensing in Europe and their outcome)

The Platt's database indicates that there are some 42 coal and gas-fired generating plants, with an output capacity of over 300 MWe, planned to start operating in Europe after 2012. Data from the MS consenting process relating to Carbon Capture Readiness (CCR) is only readily-available for the UK but not for other countries. In the UK, combined cycle gas turbine (CCGT) plants which applied for Section 36 consents in recent years had to submit a CCR study on the technical and economic feasibility of retrofitting CCS. Applicants had to demonstrate that there is sufficient space left onsite such that they will be able to retrofit carbon capture equipment in the future.

Requests for information to the six MSs with two or more new plants in this list have indicated that the database is not particularly reliable, that capacity growth is low in Spain, that the only application covered by the Directive in Belgium avoided CCR on the basis of it being not being commercially viable and that data on CCR in Polish power plants is not publically available. Data from prior to the CCS Directive indicated that 65% of coal fired plants planned in Europe were considering CCR but only 2% of planned gas fired plants were doing so. Several Member States have reported cases of practical application of article 33 on CCR to the Commission. The UK has produced a guidance note which gives more detail on what plant developers should consider and demonstrate in their CCR checks. The assumptions that some developers have made with regard to feasible CO_2 transport pipe routes in the UK place some doubt on the realism of any future CO_2 capture for some of the plants.

The CCR assessment requirements required by the Directive do not appear to be effectively obliging the developers of new generators to leave the space required for future CO_2 capture. The extra guidance (and the policy commitment) in the UK appear to be much more effective at provoking a much more detailed and realistic CCR assessment and commitment – although this is not perfect. The text in the Directive relating to the 'commercial viability' of CCS being required as part of the CCR assessment is likely to be the main reason why CCR is not being fully investigated or required. Further clarification (and explanation) is required. The situation is complicated by the fact that those MSs with a practical and realistic alternative to CCS (in terms of meeting their contribution to the scale and speed of CO_2 reductions required for Europe) should be allowed to avoid the cost implications of CCR. There are also important questions outstanding as to whether or not the CCR requirements should apply to plants with low running hours and to industrial installations. The conclusion of this report is that the effectiveness of the Directive could be improved. The recommendations section suggests the drafting of a guidance Document giving extra detail and suggestions on what the developers of new generating plant (including large industrial installations) should consider.

10.1.17 Q19 – Enhanced hydrocarbon recovery

19. The CCS Directive (recital 20) defines Enhanced Hydrocarbon Recovery (EHR) as the recovery of hydrocarbons in addition to those extracted by water injection or other means. Where EHR is combined with geological storage of CO_2, the provisions of the CCS Directive apply. How can we rate the ease of application of the Directive's requirements concerning EHR projects combined with geological storage of CO_2? Are there any challenges which have been identified for CCS projects under development, and if so, how could these be overcome?

The CCS Directive does not appear to do anything to specifically limit or prevent EHR and CCS. EHR is a very useful way (where it is possible) of improving the economics of CCS. There does not appear to be a strong case for adding EHR specific requirements to the Directive. This conclusion is based on the fact that existing oil and gas regulation appears adequate to regulate the health and safety and the fiscal aspects. There does appear to be some clarification required in ETS regulation as to the storage status of CO_2 that might be circulated (i.e. pumped in, then extracted, then re-injected) as part of EHR.

10.1.18 Q20 – Financial security provisions

20. On the basis of the gathered experience, including on CCS projects development, how effective has been the implementation of the CCS Directive provisions on the financial security and financial mechanism for the storage sites (Articles 19 and 20 of the CCS Directive)? How can we rate the ease of application of those provisions for both storage operators as well as for competent authorities? Are there any challenges with regard to determination of the amounts of the financial security and financial mechanism, and if so, how could these be overcome? Is there evidence that the obligation under Article 19 of the CCS Directive related to the surrender of allowances in the event of CO_2 leakage presents a significant obstacle to the CCS development in Europe?

There are some serious concerns among developers regarding the levels and procedures for handover from developers to the MS competent authorities and the financial securities related to future monitoring and leakage from storage sites. These concerns relate to articles 19 and 20 but also Guidance Document four. It appears that articles 19 and 20 were written in such a way as to give a relatively high level of flexibility to the MS CAs in deciding when handover should occur and what financial security site operators should provide in order to give sufficient confidence in their ability to safely operate and monitor the storage site up to the point of transfer. Guidance Document four is intended to help provide some further guidance on these issues. It appears that GD4 is being used as more than guidance, which is leading to calls that the more detailed procedures it suggests will impose high costs on projects. This makes CCs project more difficult to progress.

There are also concerns on the requirement that CO_2 leakage is paid for at the value of CO_2 on the ETS market at the time it leaks, rather than at the time it was captured. This makes it impossible for a site operator to accurately know the potential costs of future leakage. This uncertainty (and the financial guarantee that operators have to provide to illustrate they can meet it, along with other costs such as monitoring) appears to be a factor which makes CCS project less likely to occur. There are some claims that the scale of financial guarantee required is so large that it puts off all but oil and gas companies, who, by nature of their large size, are able to comply.

The only European CCS project with practical experience of going through the permitting process is ROAD. They have agreed workable solutions with the Dutch CA that both parties appear to accept. This single example suggests that even with GD4 there is still enough flexibility to allow procedures to be agreed and projects to be advanced. Given the high level of concern expressed regarding GD4 there appears to be a good case for reviewing any phrases within it that cause most concern for potential storage site developers.

10.2 Relevance

Relevance looks at the relationship between the needs and problems in society and the objectives of the intervention. As such it considers how the situation has changed over time and what the current needs are.

As discussed under effectiveness there are some issues that have risen up the agenda since the Directive was passed, for example BioCCS, EHR and CCS in industry. However the majority of these need to be addressed via other legislation (particularly the EU-ETS) or are of insufficient importance (in terms of creating a barrier to CCS) to justify reopening the CCS Directive.

In terms of encouraging CCS and enabling multiple large scale demonstration projects (covering capture, transport and storage) it is apparent that there is much more potential and need for change in other CCS enabling policies than in the CCS Directive. This is not to suggest that the CCS Directive is not an important and useful part of enabling CCS, it provides a useful framework for a common approach to the issues of CCS. The need for action to reduce emissions remains very high and the most recent analysis suggests that this need is even more urgent than previously thought. If CCS is to become a reality on the scale that analysis suggests is required (and feasible) to achieve the emissions reduction targets it needs to be given a higher profile in energy and climate policy as a whole. The ETS appears to be a credible mechanism to support CCS in the long term but in the short term there is a need for additional support. This support needs to subsidise the capital costs of capture, transport and storage infrastructure and also provide support for the ongoing operating costs.

10.2.1 Q21 – Do the objectives still respond to the needs

21. To what extent do the objectives of the Directive still respond to the needs?

The important conclusion here is that the CCS Directive is seen as an enabling mechanism for CCS, rather than the main mechanism to make it happen. It is clear that a number of issues related to CCS have increased in importance and/or visibility since the Directive was drafted, for example EHR, biomass and CCS the use of CCS for industrial installations. Most of these issues relate to ways in which the business case for CCS can be improved and the Directive does not appear to actively constrain any of these issues. The issues appear to already be adequately regulated by other legislation, although some adjustments of the ETS regulations may be required.

Most stakeholders who responded agree that there is no need for the Directive to be revised to directly address new issues (like Enhanced Hydrocarbon Recovery (EHR) or Carbon dioxide use (CDU)) that are already adequately covered under other (e.g. oil & gas) regulation. Some preferred that, where possible, existing regulation (other than the CCS Directive) should be used to address new and emerging issues related to CCS.

The majority of the feedback suggests that the Directive should remain focussed on health, safety and environmental concerns and that public acceptance and enabling policies should not be part of the Directive. This opinion appears valid and matches the intervention logic for the Directive.

The vast majority of the stakeholders who responded, but not all of the stakeholders, are in favour of CCS. The evaluation questions and survey format implicitly assumed that the respondents support further development of CCS, yet opponents also wanted to voice their concerns. Reasons given for opposing CCS include:

- CCS contribution to climate change is too little and too late.
- Actual CO_2 savings are overestimated.
- CCS is used as a way to justify fossil (especially coal) -fired power generation now, on the basis of far from certain future CCS infrastructure being built.
- Adverse environmental effects due to energy penalty and chemicals use.
- CCS would add significantly to both water withdrawal and water consumption.

10.2.2 Q22 – CCS Enabling policies

22. The Impact Assessment accompanying the CCS Directive concluded that, in order to internalise climate change externalities, ETS would be the right enabling policy for CCS, as the costs of meeting substantial reductions in EU emissions of CO_2 are significantly lower with CCS enabled under ETS than without, but that there was little evidence for additional policy measures going beyond the carbon market in order to address additional externalities. The situation as described in the Impact Assessment has substantially changed given the slow pace of progress of CCS demonstration programme, and the low carbon price. In consideration of the state of play of CCS in Europe and its deployment prospects towards 2030 and 2050, how can the appropriateness of the EU regulatory framework for CCS be evaluated? How could the policy framework at European level incorporate additional transitional enabling policy measures, including, if appropriate, other instruments or subsidies to complement the EU ETS system, at least cost and in an effective way?

This question covers a wide variety of issues, with the majority of them going far beyond the objectives of the CCS Directive to encompass energy and climate policy as a whole. A key starting point is that the literature suggests that CCS appears to be cost competitive with other medium to long term options for decarbonising the power supply. It is apparent that, as stated under a number of other questions, the carbon price (via the EU-ETS) has not been high or stable enough to give sufficient confidence to start CCS investments. The low carbon price is mainly a result of the global economic crisis with other energy policy actions also playing a role.

The two EC mechanisms for supporting CCS (the NER300 and the EEPR) have attracted bids, but have not offered high enough levels of support to make up for the funding gap (and general lack of investor confidence) that still exists. All 13 bids to the first round of NER300 stalled and withdrew. One bid has been approved under round two and this continues to move towards Final Investment Decision - with the benefit of additional capital support (and a CCS supportive policy landscape) from the UK government. The EEPR offered funding to six CCS demonstration projects. Two are still being pursued but the other four have been cancelled. The UK and the Netherlands have offered substantial

funds of their own to help support CCS demonstrations but no other MSs have done this. There appears to be a good case for addressing some State Aid concerns which remain about the use of MS funds to support the operating phase of early CCS plants (and infrastructure) although the Commission has already adjusted its guidelines to clarify the position of CCS, so this issue may relate more to a lack of willingness by some Member States to support CCS projects.

MS and stakeholder support for EU capital support for CCS (demonstration scale) plants remains high, with calls to ensure that the details of the proposed successor to NER300 are finalised as soon as possible and that the EU's regional and structural funds are made more readily accessible to CCS related projects. Both suggestions appear valid.

There are strong calls for clear signals to be sent regarding the important position of CCS as a way to decarbonise the power supply of Europe. The suggestion that this could be achieved by the specific inclusion of CCS in the EU and MS 2030 low carbon roadmaps, with targets for CCS appears strong and valid. The need to consider transport and storage within this process was also stressed – for example via a process of source clustering and the consideration of pipeline networks. Both of these points appear valid. Obliging MSs to consider the role of CCS in decarbonising their energy supply would require those MSs who do not wish to purse CCS to indicate how they will achieve the reduction in CO_2 without it. It will also encourage the majority of MSs that have been relatively inactive on the subject to consider if they should be more actively supporting early CCS projects via grants and/or other mechanisms. With regard to the use of competitive processes for awarding grants to CCS projects, the point was made that this process implies extra (at risk) work for applicants and makes cooperation between projects more difficult. Although both of these points are true there is no obvious alternative way in which public subsidy could be transparently allocated. There are a number of active CCS networks and organisations so it appears that a system for information sharing does exist.

The majority of stakeholders think that more support for CCS is needed in the short term. There were a wide variety of suggestions of how this should be achieved. Some of these are CCS specific, such as incentives for CCS in industry and that the EU's Regional and Cohesion funds should be open to CCS projects. The latter of these suggestions appears reasonable. Many of the suggestions go beyond CCS in that they would have significant impacts on energy policy as a whole. This includes the options of EPS and other MS level electricity market mechanisms, such as contracts for difference and the variety of mechanisms used to support renewable sources of energy. There are a number of clear suggestions for changes to the ETS that would benefit CCS. The suggestions are clarification of the treatment of EHR, bioCCS and transport of CO_2 by ship, these suggestions all appear justified and are discussed elsewhere.

There were also suggestions that CCS should ideally be pursued via a global mechanism, with all regions and countries of the world agreeing to a tapering limit for CO_2 emissions, in the same way as CFC emissions were successfully cut via the Montreal protocol. While this suggestion would be ideal in terms of clarity and global commitment the political difficulties and overall aim are very similar (although longer term) to the Kyoto protocol.

Most stakeholders believe that the ETS is the right instrument to support CCS in the long run but it needs to be reformed. Most do not believe that the ETS alone is sufficient to incentivise CCS in the foreseeable future. The expected ETS prices up to 2030 will not trigger CCS developments.

Most industry respondents called for a level-playing field for CCS and other low carbon technologies. The key difference highlighted is that for renewables, targets were set and substantial financial support mechanisms were put in place (mostly at MS level) to achieve these targets. The need for a single target encompassing all low carbon technologies (as suggested above), including CCS, was highlighted.

10.2.3 Q23 – CCS in Industry

23. The Roadmap for moving to a Low Carbon Economy in 2050 indicates that the CO_2 emissions from industrial sectors need to be reduced by 34% to 40% by 2030 compared to 1990. The potential of CCS in industrial applications can be large. The application of CCS in certain industries, particularly in cement, steel, refining sector, could therefore represent an interesting option for the early deployment of the technology in view of the expected lower costs in comparison to power generation sector. Is the EU legal framework for CCS adequately addressing the prospects of uptake of CCS in the industrial sector? If not, which areas could be improved?

Deep decarbonisation of many large industrial processes is only currently possible via CCS. Most industrial sources produce much smaller volumes than powers stations which makes the cost of transport and storage higher (per unit of CO_2 stored). There is also often greater variance in the composition of the CO_2 stream from industrial sources as compared to power stations. The CCS Directive says nothing specific to limit or encourage industrial CCS. Stakeholders argue that CCS is important for industrial installations but given the points raised above many doubt that it will be the first mover. There are calls for industrial CCS to be better addressed in overall EU CCS policy. These calls are reasonable, partly because industrial CCS will make public and NGO acceptance easier for CCS in general.

10.3 Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention. Typical efficiency analysis will include analysis of administrative and regulatory burden and look at aspects of simplification. This is often judged by a combination of participant opinion and comparisons, particularly of administrative costs, with other programmes or policies. These comparisons with other policies and programmes are not easy with CCS, as there is no central programme expenditure to consider. The lack of practical experience of CCS projects going through the regulatory process described / regulated by the CCS Directive (only one project – ROAD – has really been any distance through the process) also makes this question particularly difficult to answer.

As discussed in the methodology section Member State representatives (including competent authorities) were invited to respond to the online survey and to attend the stakeholder meetings. However, very few Member States took part with contributions only being received from the UK, France and the Netherlands. This has made the assessment of efficiency more difficult, as it has not been possible to identify data on the costs of implementation that have fallen on the Member States. The evidence and opinions collected indicate that the administrative costs estimated in the Impact assessment still appear reasonable. A wider cost benefit assessment for CCS as a whole is deemed beyond the scope of this work.

10.3.1 Q24 – Are costs proportional to results

24. Are the costs resulting from the implementation of the Directive proportional to the results to be achieved?

It is not yet possible to provide an answer on the efficiency of the CCS Directive as there is insufficient evidence. The impact assessment for the CCS Directive estimates the administrative costs to 2030 to be €17.8 million, with 70% of this falling on operators, 26% on Member States and 4% on the Commission. There has not yet been enough experience of CCS regulation to doubt, or suggest adjustments to, the numbers, though the lack of experience also means that they cannot be confirmed.

The overall costs and benefits of CCS depend on CCS (and climate and energy) policy as a whole and the extent to which this drives the uptake of CCS. The CCS Directive is only part of the enabling policy and, as discussed elsewhere, the Directive has not been the main reason why uptake of CCS has so far been lower than predicted.

The ROAD project has been the first (and only) relatively detailed test of the CCS Directive requirements. There are some useful lessons from this project on the procedures and hence administrative cost implications. A useful practical lesson relates to the level of detail required in the plans (covering monitoring, corrective measures, financial security etc.) required when submitting the storage permit application. Given that a final investment decision will not be made until this permit is awarded the ROAD project did not submit highly detailed plans with its application but said these plans would be updated (and expanded) and approval of the CA sought, prior to injection. This approach has been accepted by the CA in the Netherlands and the EC. This appears to be a good model for future applications. The applications should be made public (with any commercial information redacted) and ideally translated into English, so that future applicants can replicate the level of detail.

10.4 Coherence

Coherence considers how well interventions which share common objectives work together. Depending on the scope set, it can look at coherence within the intervention; coherence within interventions of the same policy area (e.g. water policy, health and safety); within a wide area including possibly international agreements/declarations (e.g. all EU environmental activities including international treaties, all EU activities related to consumer protection).

It appears that the CCS Directive is internally coherent. As discussed under effectiveness and relevance it is important to realise that the Directive is only one part of the policy framework designed / intended to enable CCS. There do not appear to be any significant problems relating to the CCS Directive and other interventions. There are some issues where changes to other interventions would be mutually beneficial – for example the treatment of CO_2 transport by ship and bioCCS under the ETS regulation. The fact that CCS has not progressed at the expected rate is largely due to the economic downturn and the low carbon price. Wider energy policy, for example the support provided to renewable generation, also appears to have had a negative impact on carbon prices.

10.4.1 Q25 – Fit with other EU policy objectives

25. How well does the Directive fit with other EU policy objectives?

The question of coherence is relatively complex because the CCS Directive is only a part of CCS enabling policy, and CCS enabling policy is in turn part of energy and climate policy. The CCS Directive (and its impact assessment) make it clear that the ETS is seen as the key mechanism for encouraging CCS. The low carbon prices that have characterised the ETS in recent years are recognised as arguably being the main reason why CCS projects have failed to develop in the numbers foreseen when the Directive was enacted. There are a number of other important issues for CCS related to ETS. These are discussed in more detail elsewhere in this report but include the following: the need for additional credit for bioCCS, the treatment of transport of CO_2 by ship, the value of any future leakage of CO_2 from storage facilities and the assignment of ETS income along the chain of capture, transport and storage.

With regard to wider energy and climate policy it is true that renewable energy receives a lot more subsidy than CCS. Some felt that this is harmful for CCS as it reduces the amount of subsidy available for CCS (on the assumption that consumers can also be expected to pay for so much low carbon energy investment) and also because it has the effect of reducing carbon prices, which is also negative for CCS. While both of these points have an impact on CCS it reflects the maturity and relative simplicity of renewable energy (particularly wind and solar energy) in comparison to CCS. Some of the same comments were also made with regard to energy efficiency in comparison to CCS. The conclusion on this issue appears to be that it is not helpful to think of energy and climate policy in terms of one technology versus another. The best approach, and one that also respects the right of MSs to make their own energy policy decisions, is to agree on (and commit to) long term emission reduction goals and allow each MS to describe how it will achieve these. The literature indicates that CCS will need to play a major role alongside renewables, energy efficiency and other technologies (e.g. nuclear power) but if some MSs can demonstrate an approach that does not require CCS then this should be accepted.

There is support for research and demonstration of CCS via the Horizon 2020 programme, the ETS funded NER300 programme and the EEPR. There was a clear consensus that this should continue. There were some specific suggestions on the NER300 successor, which are discussed elsewhere, but include the need to ensure it is put in place as soon as possible (to avoid funding gaps), to improve clarity over its ability to support operating as well as capital costs and suggestions that the selection criteria should not favour schemes with the largest CO_2 capture but should also consider the ratio between CO_2 captured and 'clean' output.

There are some CCS issues which overlap with the Large Combustion Plant Directive (LCPD). These are discussed in more detail elsewhere but relate to EPS and CCR.

10.4.2 Q26 – Combination with EIA Directive

26. Has the combination of the Industrial Emissions Directive, EIA Directive and the CCS Directive proven effective to regulate CO_2 capture? Is there a need for different legislative provisions on CO_2

capture at the European / Member States' level? How could the interaction between these Directives be improved?

The key point here is that there are no operational CCS projects of a scale that brings them within the Directive in Europe yet, so there is no experience with which to answer this question. The industry view is that in general the combination should be sufficient. The two areas where there appears to be some risk of less than ideal coverage are CCR and EPS, these are both discussed elsewhere but it is clear that the coverage of both needs some clarification.

10.4.3 Q27 – Reporting and monitoring and ETS

27. Concerning reporting and monitoring requirements under the CCS Directive and the ETS Directive, (and the accompanying Commission Regulation 601/2012 on the monitoring and reporting of greenhouse gas emissions pursuant to ETS Directive 2003/87/EC), how has the interaction at the level of competent authorities worked in practice? Are there any legal burdens or uncertainties which have been identified?

As no storage sites have yet become operational for regulation under the CCS Directive there is no experience available to answer this question. There is some discussion of the financial obligations attached to the requirement for future leakages to be paid for the value of CO_2 emissions when they leak (as opposed to when they were captured). This is understandably perceived as an important risk by developers – as the value cannot be accurately estimated in advance. This issue is discussed under question 20 on financial security provisions.

10.5 EU Added value

EU-added value looks for changes which it can reasonably be argued are due to EU intervention, rather than any other influences at work. In many ways, the evaluation of EU added value brings together the findings of the other criteria, presenting the arguments on causality and drawing conclusions, based on the evidence to hand, about the performance of the EU intervention. The key issue in answering this group of questions is establishing what the counterfactual would have been, and what the impacts and results of this counterfactual would have been.

It is not possible to be certain on what would have happened without EC level action but support for some EC level action on CCS remains strong. It is clear that for many issues the member state Competent Authority will need to define, agree and implement the site specific details of CCS installations. This approach appears to be the intended (and the appropriate) model for the Directive but care needs to be taken that the Guidance Documents do not become over prescriptive.

It appears that CCS regulation in other parts of the world, particularly the US and Canada, has been more heavily based on existing oil and gas regulation. This seems to have been a factor in enabling somewhat quicker realisation of projects in these countries, but other factors (mainly the existence of attractive EHR opportunities) appear to be more important. Some of the issues that cause concern with regard to the CCS Directive, e.g. the long term transfer of responsibility for storage sites are also problematical in other countries – largely because of the lack of directly comparable experience.

10.5.1 Q28 – EU added value

28. What is the EU added value of the Directive? To what extent could the changes brought by the Directive have been achieved by national measures only?

The model of the EC defining a minimum / outline approach and the Member States then developing their own detailed and case / site specific interpretation was described as the best approach by virtually all stakeholders. This is in line with the overarching approach of the Directive and does appear to be the best compromise. This approach also addresses the concerns that attempting to regulate to a very high degree of detail is not appropriate for a sector in which so little experience has been gained. Detailed regulation based on hypothetical risks does bring a risk of over burdensome regulation and should be avoided. Another important benefit of an EU level framework is that it helps create the required large and trans-boundary scale of infrastructure required for European CCS. Another area where EU level action was described as important, though probably not via the CCS

Directive, was in the creation of a clear strategic link between CCS and wider low carbon policy. This point is picked up elsewhere in the evaluation.

Areas where the benefits of EU level action are less strong are: Public acceptance, because although the EC can usefully help define structures to promote CCS, public opposition is most likely to occur to specific local installations and here the MS (and the developer) are best placed to respond. The suggestion that EU level action would help create a larger market for CCS and hence help future export potential was also not strongly supported. Although the CCS Directive (and other relevant policies) are designed to help enable CCS it is easy to understand some scepticism on future prospects for EU export, given the lack of experience gained to date and the multinational nature of some of the lead participants, i.e. oil and gas companies.

10.5.2 Q29 – Lessons from regulators outside the EU

29. What can be learnt from the regulatory experience of other jurisdictions? How does the regulatory framework in the EU compare with the performance of the regulatory framework in other jurisdictions outside the EU? What are the main differences? What explains these differences?

An important point which has emerged from the opinions and evidence is that elsewhere in the world (the US and Canada) the approach to regulating the health and safety and environmental issues of CCS has relied more on adapting existing oil and gas regulation. This is arguably not surprising because virtually all of the projects in these two countries are associated with EHR. This approach has contributed to projects appearing to come on line quicker. Although the projects have become operational quicker it appears that this is driven more by economic factors, especially EHR. It is highly likely that when more CCS projects come to the detailed design and installation stage in Europe that oil and gas standards and practices will be the default option (For detailed design and installation issues).

It appears that the transfer of liability on storage sites is also an issue outside Europe. There are some important differences in the fundamental nature of the approach. The approach in the US and Canada does not appear to be fully formalised yet, but comments from the survey and interviews imply that the approach in the US differs from that in Europe in that liability is transferred to the state with less conditions, described as a US acceptance of public liability for long term storage (as a 'common good'). The question of trans-boundary CO_2 transport is also live in other parts of the world, but no clear approach appears to have emerged yet.

The Canadian Boundary Dam project offers a very positive combination of factors for CCS to work – a nearby oil well at a stage where EOR is highly profitable, a need to reduce CO_2 emissions from a coal fired generating plant and existing expertise in CCS in a nearby test facility. They have made use of existing oil and gas and legislation to regulate the activities, which has helped speed the process up. It appears that there are some areas where existing legislation worked well and others where it needed to be developed. It is also important to remember the differences in geography i.e. much lower population density than Europe so public concern / opposition to CO_2 storage is less likely.

The Quest project, also in Canada, but a different province to Boundary Dam, also made use of existing regulations. The Developers were positive with regards to the regulator's willingness to develop site specific definitions and to develop the approach in close cooperation. The approach to storage site liability transfer here appears to be close to the European model.

The Port Arthur project in the USA is interesting because it captures CO_2 from an industrial process. As with the Canadian examples EOR is central to the economics of the project, with the pre-existence of naturally sourced CO_2 EOR helping to reduce / remove some infrastructure costs (and provide an income stream). As in Canada the regulatory approach has been to adapt oil and gas legislation.

10.5.3 Q30 – Commission review of draft storage permits

30. Has the Commission's review of draft storage permits (Article 10) been effective in fostering a uniform implementation of the requirements of the Directive across the Community, and helped to enhance public confidence in CCS? To what extent has the Commission's review been relevant for the competent authorities to take a decision on the permit?

Given that the Commission have only reviewed one permit application so far (for the ROAD project) there is very little evidence to answer this question. It appears that the involvement of the Commission

added some delay to the permitting process, although given that this was the first example it is perhaps not surprising that the process was not rapid. It appears reasonable to assume that the process will speed up in the future, especially if, as suggested elsewhere, the level of detail provided by the ROAD project (and accepted) is made public.

The weight of opinion supports the point that the Commission review would help with public confidence for the earliest applications and in those MSs where confidence in the CA might not be as high as in others. The Impact Assessment of the CCS Directive assumed that the review process would not carry on indefinitely and it appears that this assumption remains true.

10.6 Other Questions

The remainder of the questions were described in the TOR as 'prospective questions'. Many of the these questions are looking to future options to improve the legislative framework – which could be considered 'sustainability' as they are designed to improve the relevance and effectiveness of the Directive, which should in turn enable it to have longer lasting results and impacts.

Many of these questions relate to the wider CCS enabling framework, as opposed to the Directive. The important conclusions here reinforce what has been concluded under the other question groups. For example the need to revise the ETS to better enable ship transport of CO_2, the complexities of the EPS as a possible short term measure to encourage CCS, the potential befits of CO_2 storage atlas and the need to ensure that the Guidance Documents are not over prescriptive. For those questions which are more directly relevant to the Directive the conclusions again agree with what has been said under other questions; That there are some areas that could be slightly improved, but none appear pressing enough to justify a full reopening of the Directive.

A number of these questions overlap with those already answered. Where this occurs the overlap is pointed out.

10.6.1 Q31 – ETS benefits for transport and storage

31. Pursuant to the ETS Directive 2009/29/EC amending Directive 2003/87/EC, CO_2 emissions captured, transported and stored according to the revised Directive are to be considered as not emitted. Under the current framework, it is in effect the operator of the capture installation that secures the main financial benefit from not having to surrender allowances in relation to the captured CO_2 which is then transported to a CO_2 storage site in accordance with the CCS Directive provisions. In light of the experience gathered with demonstration projects in Europe, how effective has this approach been in practice for the development of business cases of CCS projects, which is characterised by different operators for the different parts of the chain (capture/transport/storage)? Is it necessary to consider/develop options that reward the downstream CO_2 storage operator? If yes, what possible schemes could be put in place to reward the downstream CO_2 storage operator? What would be the costs and benefits of this approach?

The clear view that emerged from industry stakeholders on this issue was that it is something to be agreed upon between capture, transport and storage operators and is not something where regulation is required. The ROAD project confirmed that the costs and liabilities for transport and storage are passed through to the emitter in an agreed tariff. This approach appears suitable to the evaluators.

There was some discussion under this point of the high costs of establishing large scale transport and storage infrastructure in advance of CCS capture projects (and the ETS income these will bring). This led some to suggest that direct grants should be supplied to support the creation of this infrastructure with its operating costs being met by future revenue streams. Possible future revenue streams suggested include income via a Contracts for Difference approach, tradeable certificates in stored CO_2 and a price linked to the value of the emissions avoided. All of these options appear plausible. An in depth analysis of their pros and cons is beyond the scope of this work, but it is an issue that the Commission (and/or others) could usefully investigate. The issue of the unknown cost to the storage operator of possible future liability for leakage is also of relevance to this question. This point comes up elsewhere in questions 9, 11 and 20.

10.6.2 Q32 – Uptake of CCS technology outside Europe

32. What has been the progress of uptake of CCS technology outside Europe? What are the prospects for uptake of geological storage of CO_2 in third countries? How does this influence the European situation, for example in terms of potential export of CCS technologies?

It is clear from the literature review and the survey that in terms of operational CCS plants Europe is being overtaken by the rest of the world, particularly North America,. Some of these plants are relatively large scale and could be described as commercial – though their incomes largely derive from EOR. With regard to research and development Europe is still largely seen as competing with North America, but this parity could be lost given the lessons available from the North American demonstration plants. It appears that projects are also being developed in other parts of the world, including China and the Middle East. European technology partners are described as being active in projects throughout the world, so the prospects for their ability to export in future appear relatively undamaged by the slow progress on demonstration plants in Europe. However European utility companies are not gaining any practical experience in CCS so it is reasonable to assume that their future ability to export their skills is being diminished.

10.6.3 Q33 – Carbon capture and utilisation

33. In the last years, technologies for reutilisation of CO_2 from industrial emissions have emerged that could play an important role for the decarbonisation of industrial processes. Potentially, when combined with CO_2 storage, and although none of them seem comparable to CCS in terms of potential for CO_2 abatement capacity, these technologies could play a role to incentivise the business cases of CCS, in addition to fostering additional environmental and climate benefits. Should additional regulatory measures and/or incentives be introduced at European level in support of the (most promising) CO_2 reutilisation technologies in combination with CCS? If yes, which potential measures could be introduced? What would be the pros and cons of this approach?

It appears that CDU is outside the scope of the CCS Directive and there were no substantive suggestions to change this. There was some criticism of the attention being paid to CDU given its low mitigation potential in comparison to the power sector. Others say that CDU is important for some regions of the Europe (with concentrations of particular industries) and that it in the right circumstances it can provide a very useful boost to the economics of carbon capture. The heterogeneity of the techniques described as CDU was also highlighted, suggesting that it might be difficult to design incentives to specifically promote it. The clearest message on CDU, which appears valid, was that the ETS regulations should be adjusted to recognise its benefits (where permanent containment can be demonstrated).

10.6.4 Q34 – Need for revision in the environmental risk framework for storage

34. On the basis of the latest scientific knowledge, and taking into account experiences from pilot and demonstration projects in Europe and beyond, are there any potential areas of revisions of the environmental risk management framework for CO_2 storage as set out by the CCS Directive (e.g. with regard to the threshold of 100 kilotons for exclusion of R&D projects from the scope of the CCS Directive)? What would the pros and cons of such revisions be?

The literature review suggests that there has been some good progress made via EU research projects on storage issues. Although some felt there was a lack of experience to consider changing yet there were a number of suggestions on possible changes to the risk framework for storage, as follows:

There was some support for increasing the R+D project threshold (below which the CCS Directive requirements do not apply) from 100kt of CO_2 stored. No specific higher figures were suggested and no clear evidence was presented on why this should be considered (other than the claim that it would help enable CCS projects). Given the lack of evidence the threshold should be left the same until sufficient evidence on the R+D benefits from storing >100kt is provided.

A number of suggestions for more flexibility were made, for example to allow better recognition of the type of injection and storage method and to allow less modelling. These suggestions for more flexibility are in line with other suggestions on other aspects. Given the lack of experience it is not possible to comment on whether such flexibility will, or will not materialise in practice. It appears

premature to suggest additional (or less) flexibility before the current approach has been tested, therefore the Directive should be left as it is until further experience has been gained.

The concerns on the site transfer criteria, specifically the financial security requirements (Guidance Document four) and the 20 year default period were also criticised here. These issues are covered in questions 9, 11 and 20.

10.6.5 Q 35 – Need for an EU storage atlas

35. Capacity estimates for CO_2 storage have been developed across Europe at the European level (e.g. Geocapacity project); this exercise is also ongoing at Member States level, pursuant to Article 4 of the CCS Directive. In light of the latest available knowledge, is there a need to establish an improved EU atlas of storage capacity of CO_2 across Europe? If so, what would be the estimated costs of such an assessment?

It is clear that storage needs to be available for future upscaling of CCS to happen. The CO2Geonet project has estimated that there is sufficient storage in Europe for 60 years of European CO_2 point source emissions. There are some benefits associated with preparing a storage atlas such as that it would help enable better informed policy decisions, help early infrastructure planning and help to maintain EC credibility as a CCS leader. However there are some important provisos to bear in mind. These include the need for a consistent methodology which will not be easy given the wide variation between Member States in data quality and availability. The point was also made that some Member States (e.g. the UK) already have good quality information available and that the information would be better gathered by Member States rather than in a top down way. The value of an atlas based on static modelling (as opposed to much more expensive injection test (drilling)) was also questioned as any developer would require detailed injection test before practically committing to a storage site.

On balance, although there are some concerns over the detailed practical usefulness of an atlas it would be a useful high level tool and would send a positive signal on the EC's commitment to CCS. Therefore it appears that pursuing an atlas is a good idea.

10.6.6 Q36 – Need for review of article 18?

36. In light of the lack of experience with the procedure regarding the Commission's review on the transfer of responsibility pursuant to Article 18 of the CCS Directive, to which extent is it appropriate to already review the procedures under Article 18?

This question was not directly raised in the survey or interviews. There has been no experience yet of the Commission review of site transfer and it seems unlikely that this will occur for a number of years – given that the Directive suggests a 20 year minimum (although many would like to see this reduced) before this occurs and no site has started storing yet.

It is possible to draw some lessons from the opinions and lessons learnt with regard to the Commission review of the storage permit. This is discussed under questions 7 and 11 but in summary some Commission involvement appears useful (for public credibility purposes) but this should not continue indefinitely and a detailed description of the level of detail and information required by the first projects to pass through the process should be shared in in order to reduce the administrative burden (for site operators, the CA and the Commission).

10.6.7 Q37 – Need for EPS?

37. Is it needed and practicable to establish a mandatory requirement for Emission Performance Standard (EPS) for new electricity-generating large combustion installations pursuant to Article 9a of Directive 2001/80/EC, where permanent containment of CO_2 in such a way to prevent and, where this is not possible, eliminate as far as possible negative effects and any risks to the environment and human health, and the environmental and human safety of CCS has been sufficiently demonstrated, as well as its economic feasibility? In light of the progress of CCS demonstration in Europe, is it needed, practicable and justifiable to establish EPS mandatory requirements for fossil fuel power plants, and if so, at which level ?

There are diverse views on the effectiveness and need for EPS in general and its potential role in promoting CCS. The UK already has an EPS in place that effectively prevents any new unabated coal fired generation and the US is considering a similar approach.

The NGOs who responded feel that an EPS is required in order to prevent new unabated coal generation and to speed the closure of (or retrofitting of CCS to) existing coal fired generation.

A number of respondents feel that an EPS would risk undermining / contradicting the ETS as it would be 'double regulation' of the same issue. They predict that the likely impact would be a switch from coal to gas fired generation, with no meaningful impact on the uptake of CCS. Others argue that a carefully designed EPS (with the level reducing over time) would not undermine the ETS and could help encourage CCS.

It is not possible to reach a conclusion as to which argument is most likely to be correct without some consistent modelling of the various options.

10.6.8 Q38 – Any evidence of need for additional regulation of transport?

38. Is there scientific evidence that environmental risks associated to transport of CO_2 should be further regulated, on top of the existing legislative framework?

It is clear that a transport network for CO_2 will be required in order for CCS to become a large scale reality, and that this system needs to be in place before multiple large scale capture installations can become operational. There were no additional (newly identified) risks that suggest that the transport of CO_2 needs to be further regulated.

10.6.9 Q39 – Ship transport of CO_2

39. What has been the practical experience of CO_2 transport by ship so far? In light of this experience, could the EU regulatory framework on CCS better address the issue of ship transport of CO_2?

Transport of captured CO_2 by ship is more cost effective than pipeline transport for small volumes and / or large distances. Both scenarios are likely for early demonstration / pilot schemes. The fact that CO_2 is already transported by ship suggests that there are no legal hurdles to expanding this practice. There are no hurdles identified to ship transport of CO_2 in the CCS Directive. There are clear problems under the ETS related to the treatment of CO_2 transported by ship, it appears that these could be addressed by changes to the ETS regulations and this should be addressed at the earliest possible opportunity.

10.6.10 Q40 – Need for standards to support CCS development?

40. What are the prospects for standards to be developed and applied in a European context to support the objectives of the CCS Directive? Are there any areas in standardisation, which could potentially achieve an important contribution in this respect (e.g. in the areas of risk assessment, CO_2 stream composition)? What are the pros and cons for developing standards for CCS at European level?

The responses and conclusions regarding this question can be split into two groups - those relating to the Guidance Documents and those relating to the development of operational (ISO type) standards.

With regard to the Guidance Documents, it appears that numbers one to three are generally regarded as helpful. There are clear feelings from developers and potential developers that Guidance Document four is over prescriptive in its suggestions, particularly with regard to the type of financial guarantees that storage site operators need to supply to CAs. Despite the fact that the Guidance Documents have no legislative power (with some under the impression that their main purposes was to help MSs in transposing the CCS Directive) it is clear that MSs are interpreting the Guidance Documents like extensions of the Directive. Other comments on the Guidance Documents include that:

- One and two could be updated as a result of completed research.
- It would be possible to now withdraw the Guidance Documents and allow MSs to develop their own detailed guidance.
- There is no Guidance Document on capture.

- The tone of the Guidance Documents was also felt to lack recognition of the experience gained in CO_2 injection for EHR.

Having reviewed the opinions on this issue the conclusion of this report is that the Guidance Documents should be retained, as they are useful for MSs as they receive their first CCS applications. Guidance Document four should be updated – based on detailed / specific comments from stakeholders, and consideration should be given to creating an additional Guidance Document related to capture – particularly on Carbon capture readiness. Although MSs should know, it would be a good idea to clearly state in the Guidance Documents that they do not have legislative force.

With regard to the development of detailed operational (ISO type) standard for CCS, the consensus view, which appears valid, is that EU standards of this nature will be useful but that they should only be contemplated when additional experience has been gained. Attempting to define such standards now appears premature and would present a risk of limiting flexibility and stifling innovation. There is also a risk of duplicating ISO efforts, therefore a watching brief should be followed with regard to ISO efforts on CCS, but no independent action should be taken yet.

Section 11 Recommendations

This evaluation has collected stakeholder opinions and views from the literature with regard to the CCS Directive and the EU's CCS enabling policies. This has been done this through a combination of literature review, an on-line survey, interviews, written stakeholder submissions and a well-attended stakeholder meeting in Brussels.

This information has been processed and translated into a set of initial recommendations for the review process and the enabling policy. The European Commission has requested recommendations that are acceptable to the broadest possible group of stakeholders.

The initial ideas for recommendations were discussed and fine-tuned in four focus groups, with 8-10 people in each with representatives from a variety of stakeholder groups. The general line of the recommendations received broad support. The rich contributions during the sessions are included, as far as possible, in this version. These recommendations were presented to all stakeholders on November 7th. The comments received at that meeting and from the Commission are also integrated into this version.

It is virtually impossible to accommodate all possible opinions from stakeholders. The level of agreement of stakeholders is likely to vary according to the level of 'strictness' of Europe's CCS policy. The more binding the CCS policy proposed, the more the opinions are likely to differ. Note that in each section, context is offered in the form of stakeholder opinions ahead of the recommendations highlighted in green textboxes based on the review exercise described above.

The main recommendation of this work is that the Directive is relevant and remarkably fit for purpose and therefore the full review process of the Directive should NOT be opened at this stage. This is mainly because the evidence and weight of opinion suggests that a full review could create uncertainty and could potentially slow or discourage projects, which are currently moving forward towards implementation. In addition, there has not yet been enough practical experience or learning on the EU's-CCS-Directive to justify a full review as the progress of demonstration projects has not been as rapid as anticipated when the CCS Directive was ratified. Through discussion during the stakeholder consultation process it can be concluded that the CCS Directive is very relevant and largely fit for purpose in terms of providing a uniform framework for Member States to transpose into national regulations and in terms of sending a clear message that CCS is seen as a viable long term GHG mitigation technology.

Even though a full review process is not recommended that there are two aspects, which do need attention: Guidance Document 4[97] needs to be altered and there is a need for improved clarity on Article 33 (Readiness to retrofit for CO_2 capture).

The EC is interested to know the issues that are relevant for discussion (after evaluating stakeholder's inputs) and that could/should be altered or deserve attention if the EC were to open a formal review process. These issues are split into two main groups. The first group concerns specific aspects of the Directive that could be improved. The second group concerns the wider governance of CCS and the policies and measures designed to (inter alia) help enable it.

The issues related to the Directive are discussed in section 2. The issues regarding the 'enabling policy' for CCS are dealt with in section 3 of this paper.

[97] Guidance Document 4: Article 19 Financial Security and Article 20 Financial Mechanism http://ec.europa.eu/clima/policies/lowcarbon/ccs/implementation/docs/gd4_en.pdf

11.1 The Directive

11.2 Summary of Issues:

The aspects of the Directive discussed in these recommendations can be categorised as follows:

General	Capture	Storage
Article 38 on review of the Directive	Article 33 on readiness to retrofit for CO_2 capture	Article 10 on storage permits
Carbon Dioxide Utilisation (CDU)	Article 38 on Emission performance standard	Articles 17, 18, 19 and 20 on closure & post closure provisions, transfer of responsibility, financial security and mechanisms
	Bio-CCS	Guidance Document 4
	Industrial CCS	Storage Atlas
		Permanence
		Enhanced hydrocarbon recovery
		Trans-boundary issues

11.3 General CCS Directive Issues

11.3.1 Article 38 on the Review of the Directive

Article 38 (Review) describes, inter-alia, the timing and the need for a review. The Commission should, every three years, transmit to the European Parliament and to the Council a report on the implementation of the Directive. In the report due to be transmitted by 31 March 2015, the Commission is required to review the CCS Directive in light of the experience with CCS and taking into account technical progress and the most recent scientific knowledge. The areas which require consideration in the review under Article 38 are:

- Permanent containment of CO_2 to prevent / reduce negative environmental impacts
- Commission's reviews of the draft storage permits and of the draft decisions on transfer of responsibility
- Provisions on CO_2 stream acceptance criteria
- Provisions on third-party access and trans-boundary cooperation
- Provisions applicable to large combustion plants with rated capacity > 300 MW (Article 33 readiness to retrofit for CO_2 capture)
- CO_2 storage in third countries
- Criteria referred to in Annex I and Annex II
- Incentives for applying CCS on biomass installation
- Further regulation on CO_2 transport environmental risks
- Need and practicability to establish a mandatory requirement for emission performance standards

Based on the stakeholder consultation undertaken for this project, the vast majority of the stakeholders think that it is currently too early for a full review of the Directive. However, there is a consensus amongst stakeholders on the need for a review at some point in the future.

Recommendation	A full review / evaluation of the Directive is conducted in 2020 after a few CCS demonstration plants have been constructed in Europe and after storage of CO_2 has been demonstrated. A fixed date rather than a certain volume or number of installations is suggested as a way or ensuring that a review takes place within a fixed time. A review of the CCS Directive is undertaken periodically afterwards (i.e. during the 2020s). Future review should still consider each of the areas listed under Article 38 (as shown in the text above).

	An announcement regarding this future review is made for example in the report of the Commission due in March 2015.
Justification	There is a need for a more robust and effective review at a time when CCS has been commercially demonstrated in Europe. This should be done by 2020 regardless of the volume of CO_2 stored by then.
Pros	Currently there is not enough experience with CCS in Europe to prompt a full and comprehensive review as required by Article 38. A review in 2020 would mean that enough experience would have been gained by then to allow meaningful and full evaluation.
Cons	There are some issues that demand a more prompt reaction, especially the article on Capture Readiness and Guidance Document 4

Although it is not proposed to open the Directive for full review now, the EC should make a list of issues (in addition to the ones already listed under Article 38) that should be addressed in 2020 when the Directive is fully reviewed. Such a list would be a 'living document' and many of the issues discussed here can be part of such a document.[98]

An important issue to consider with regard to preparation for retrofit for CO_2 capture, relates to the transport and storage infrastructure. An important way of giving a strong signal that the capture installation plant will actually be constructed in the future is to invest in storage characterisation and plan or (in some cases) construct the pipeline infrastructure.

11.3.2 Carbon Dioxide Utilisation

Carbon Dioxide Utilisation is a new development, which offers the potential of using CO_2 as e.g. a feedstock in the chemical industry, for fuel production or for mineralisation. Most stakeholders feel that CDU is a development with a much smaller scale of impact on climate mitigation than CCS has. The majority think it should be addressed outside the Directive. The CCS Directive does not explicitly make reference to CDU and this should remain the case.

CDU and CCS are important and relevant in their own right. CDU is aimed more at finding new (green / alternative) feed stocks for the chemical industry and has a different logic and dynamic than CCS, with CCS being solely intended to address climate changes. Enhanced oil recovery as a carbon dioxide utilisation technology is discussed later in this report being considered worth separate consideration due to the large scale of its implementation.

Recommendation	That CDU policy and regulatory discussions should not be mixed with CCS policy and regulatory discussions. Mineralisation of CO_2 is an area, which can be highlighted as a common area between CDU and CO_2 storage.
Justification	The CCS Directive is focussed on storage. CDU and CO_2 storage are different areas and the fact that they both use CO_2 is not sufficient to combine these developments. CDU is well regulated in the appropriate chemical safety directives. Combining the two discussions at policy level does not help either. CDU is a good alternative to help to green the chemical industry but it is not an alternative to the climate mitigation potential of CCS.
Pros	CDU and CCS are two separate areas which both benefit from being legislated separately.
Cons	Some of the areas related to CDU can also benefit from being associated with CCS. Mineralisation of CO_2 is an important area which should be considered as part of the CCS research and development activities.

[98] These issues are compiled in an annex to the final report.

11.4 Capture-related issues in the Directive

11.4.1 Article 33 on readiness for CO_2 retrofit criteria

MSs have interpreted this article in a variety of ways and a minority of stakeholders think it is not having sufficient (or its intended) impact. Serious investigations into the possibilities for CCS are not automatically enforced due to the open formulation. The majority of stakeholders think that a clearer (and somewhat stronger) text is required.

The issue with the current Article 33 is that if the applicant believes that the requirements of economic feasibility are not met then there is no need to take any action. This means that the Article is not strict enough to ensure operators seriously prepare for CO_2 capture. Another issue is that the article does not give binding restrictions when carbon storage is not possible or highly unlikely and thus is allowing power plants that are unlikely to be able to apply CCS in the future.

Two options for addressing the issues with Article 33 are available. The Industrial Emissions Directive (IED; including the LCPD)[99] could be revised and/or a new Guidance Document 5 could be added.

A new guidance document on readiness for CO_2 capture should be developed. This will help interpret Article 33 but, being a guidance document, will be non-binding. This guidance document can learn from the IEAGHG definition and description of readiness for CO_2 capture retrofit and the way this has been implemented by some MS.

Recommendation	Do not open a full review process of the Directive just for Article 33. However, if there was to be a review the following changes in Article 33 are suggested: a. Better clarity on what readiness for CO_2 retrofit should represent, as at present it is interpreted differently across Europe. As a result, we recommend that a definition is developed. IEAGHG has produced guidance on the definition and description of CCS-readiness[100]. b. The conditions should more clearly include the availability of storage; feasibility of CO_2 transport and the requirements for capture readiness. c. We recommend that the CA is encouraged to decline applications if the plant is proven not to be 'ready for CO_2 retrofit'. d. We recommend that provisions need to be added to apply 'CCS-readiness' to large carbon-intensive industrial installations as well as fossil fuel power plants. e. We recommend including that if a MS has the intention to allow a new installation that is not ready for CO_2 capture retrofit it should share the reasoning for doing so with the EC and the EC can comment on this before the permit is issued.
Justification	It is necessary to remove the ambiguity that this article is now generating. The strictness of the level of – readiness for CO_2 retrofit' is directly related to the policy goals of the EC. If the policy goals are to be more inclined to 'enforce CCS in the near future' a very strict article is needed. If the policy goals on CCS are formulated more openly the clause on readiness for CO_2 retrofit can be formulated more openly as well. Although it is important, changing this article is not enough to justify opening the review process for the whole Directive. The review of the IED

[99] NB: Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion will be repealed by the Industrial Emissions Directive with effect from 1 January 2016

[100] IEA GHG CO_2 CAPTURE READY PLANTS Technical Study Report Number: 2007/4 Date: May 2007

	Directive of LCPD could be an option but this has not been investigated in depth. Strengthening the text on capture readiness could be supported by stronger efforts by the EC to evaluate potential storage capacity and site characterisation in EU countries (see enabling policy)
Pros	This would send a very clear signal that readiness for CO_2 retrofit is a high priority.
Cons	This would require reopening the Directive which would impact on investor confidence and reignite fundamental debates on CCS.

However….

Recommendation	If the Directive is NOT opened for a full review, a step-wise approach should be adopted – as follows. • A new guidance document (Guidance Document 5) on 'readiness to retrofit for CO_2 capture' should be developed. This document should address the following: a. Better clarity on what readiness for CO_2 capture retrofit should represent, as at present it is interpreted differently across Europe. As a result, we recommend that a definition is developed. IEAGHG has produced guidance on the definition and description of CCS-readiness. b. The conditions should include availability of storage, feasibility of CO_2 transport and the requirements for capture readiness. c. The CA is encouraged to decline applications if the plant is proven not to be 'ready for CO_2 retrofit'. d. MSs are encouraged to see if they want to apply the same interpretation on readiness for CO_2 capture retrofit to large carbon-intensive industrial installations as well as fossil fuel power plants. e. Include a point in the guidance that if a MS has the intention to allow a new installation that is not CCS-ready it should share the reasoning for doing so with the EC and the EC can comment on this before the permit is issued. • At the next review, the experience of applying Guidance Document (GD 5) is assessed and if evidence shows that a non-binding document is not sufficient, appropriate amendments to Article 33 are then adopted. • In the review of the IED, CCS readiness in general for both power production and large industrial installations is taken into consideration.[101]
Justification	It is necessary to remove the ambiguity that this article is now generating. Even when the article cannot be changed (no review now) this should be addressed through a guidance document and in the IED review. The strictness of the level of CCS readiness is directly related to the policy goals of the EC. If the policy goals are to be more inclined to 'enforce CCS in the near future' a very strict article is needed. If the policy goals on CCS are formulated more openly the CCS-readiness clause can be formulated more openly as well. A non-binding GD 5, with a feed-back loop via the EC is a fast and effective

[101] The list of issues to be addressed by other legislation than the CCS Directive is presented in an annex to the final report.

	alternative. The text suggested above leaves sufficient room for exceptions (e.g. building a plant which is not capture ready when special conditions justify this).
Pros	A new Guidance Document (GD) is relatively easy to develop and will provide more clarity on readiness for CO_2 retrofit without having to open the Directive. This GD will strengthen the Competent Authority position to decline applications if required.
Cons	Guidance Document are not legally binding and are not compulsory. Some industrial organisations fear this could lead to delays in project execution.

11.4.2 Art. 38.3 on the need for EPS

This article describes that, under certain conditions, a review should investigate when and how a mandatory emission performance standard (EPS) should/could be implemented. This raised strong discussions among stakeholders with strong opinions in favour and against. This section sticks to the letter of the Directive and the broader discussion on an EPS is covered under the 'enabling policy' part of this paper.

Not all the preconditions mentioned in the Directive are met. The number of demonstration projects in Europe is below early expectations and the outlook for economic feasibility is unclear. However, evidence indicates that enough technical experience on CCS is available around the globe (including within European industry) to consider this topic.

Recommendation	Discussion on EPS should be part of the future EU CCS policy rather than in the review of the Directive.
Justification	The current Directive states that a mandatory EPS has to be examined as part of the review process only after CCS has been sufficiently proven and is economically feasible. The second criterion, is not yet true so the upcoming review process has no obligation to include any position on mandatory EPS. This does not mean that the upcoming review process does not have the room to include this discussion if the EC deems this is relevant. The fact that some restrictive conditions are not met only means that such discussion should not be 'automatically' included.
Pros	According to Article 38, the conditions for examining a mandatory EPS have not been met yet and so the current discussions on EPS should be in the future CCS policy rather than in the Directive itself.
Cons	EPS is an important issue in general and needs to be considered sooner than later.

11.4.3 Bio-CCS

Bio-CCS is a new development with the potential to enable negative carbon emissions.

The CCS Directive does not explicitly make reference to Bio-CCS (also known as biomass CCS, BECCS or renewable CCS) except in Article 38 where the Commission is mandated to assess progress on experience with incentives for applying CCS to installations combusting biomass. Some respondents stated that the Directive does not incentivise CCS with biomass and that there is a need to somehow address this. The majority thinks that this should be addressed outside the Directive (for example via EU-ETS).

Recommendation	The CCS Directive should not be amended regarding Bio-CCS.

	Emphasis should be placed on studying the potential of Biomass CCS in future EU CCS-policy. The ETS Directive should be revised to allow the rewarding of net negative emissions.
Justification	While the CCS Directive does not address biomass specifically it does not prevent CCS from being applied to biomass. The EU ETS Directive does not incentivise CCS with biomass specifically, and should therefore be amended. Currently there is no reward mechanism in the EU for rewarding negative net emissions.
Pros	Opening the CCS Directive could lead to a lengthy several-year process and will eventually lead to delays in the deployment of CCS in Europe. Issues on Bio-CCS should thus be addressed without opening or altering the Directive.
Cons	Review and update of other Directives could still be a lengthy process and may lead to delays in Bio-CCS deployment.

11.4.4 Industrial CCS

Over the past few years there has been increasing interest in CCS for industrial plants where the flue gas often has a high CO_2 concentration. It is very likely that many of the first few CCS plants will occur on industrial facilities (e.g. chemical plants). While the regulatory framework for storage in geological formations should be the same for CCS in industry, additional incentives are also required here to promote CCS from industrial applications. Stakeholders generally agree that more needs to be done on industrial CCS and that the EU regulatory framework does not adequately take this into account. Suggestions are more focussed on enabling policy rather than changes to the Directive itself.

Recommendation	• The CCS Directive should not be amended in this regard. • In a new GD 5, MSs are encouraged to see if they want to apply the same interpretation requiring readiness to retrofit for CO_2, to large industrial installations. • In the review of the IED CCS readiness in general for both power production and large industrial installations is taken into consideration. • More be done on the policy side to encourage industrial CCS.
Justification	The CCS Directive does not rule out industrial CCS but it does not encourage it.
Pros	Opening the Directive could lead to a lengthy several-year process and will eventually lead to delays in the deployment of CCS in Europe. Issues on industrial CCS should thus be addressed without opening or altering the Directive.
Cons	Review and update of other Directives could still be a lengthy process and may lead to delays in CCS deployment.

11.5 Storage-related issues in the Directive

11.5.1 Article 10 on the Commission review of storage permits

Under the current Directive the MS needs to present their permit to the EC for a non-binding opinion. Some stakeholders think this is not necessary as national authorities are sufficiently competent and this can cause costly and unnecessary delay. They are also not convinced that the involvement of the

EC helps boost public confidence in the process. Others are afraid that not all MSs have sufficient know how and therefore the EC could help boost public confidence in the initial period of demonstration and first commercialisation of the technology.

The idea of including this requirement under Article 10 was to emphasise the Commission's role in getting the right balance and to ensure a uniform implementation. However, each project will have its own individual and specific requirements as determined by its geological characteristics and thus each site will require some flexibility. It is also likely that this procedure will slow down the process and will somewhat delay project implementation.

Attention could be given to strengthen the CA in some MSs when CCS processes are likely to take off and the Member State's CA does not yet have enough CCS know how or experience.

Recommendation	This article should remain unchanged.
Justification	Not all MSs have the same capacities and this is, especially in the first 10-15 years of the CCS learning process a valuable 'safeguard' that can help address public concerns.
Pros	Changes to the Directive could lead to a lengthy several-year process and will eventually lead to delays in the deployment of CCS in Europe. Keeping this article unchanged in the Directive will lead to certainty and will enhance public confidence.
Cons	Keeping this article the same will lengthen the process of issuing storage permits by a few months and make it more complicated.

11.5.2 Articles 17, 18, 19 and 20 on closure and post closure obligations, transfer of responsibility, financial security and financial mechanisms

The Directive states that in the period after closure and before transfer of responsibility the operator remains responsible for monitoring, reporting and corrective measures and for all obligations relating to the surrender of allowances in case of leakages pursuant to Directive 2003/87/EC. According to the Directive, proof that adequate funds are available should be presented as part of the storage permit application.

In addition, the Directive, defines a minimum period of 20 years for transferring responsibility from the operator to the competent authority (CA) unless the CA is convinced that all available evidence indicated that the stored CO_2 will be permanently and completely contained.

A financial contribution should also be available to the CA prior to transfer of responsibility. This should cover at least the cost of monitoring for a period of 30 years.

A minority of stakeholders (but all those who work most closely on CO_2 storage) consider the obligations and timing as described in these articles to be 'too heavy a burden' on the CCS industry or 'not flexible enough given the often very different conditions' and as such they are considered to be hampering CCS deployment.

At the same time the wording is such that solutions between future operators and MSs can be found. Many stakeholders highlighted the 20-year minimum period for the transfer of responsibility as being arbitrary and lacking in the ability to reflect the specifics of each situation. This is not a binding requirement however as the Directive states that this minimum period should apply unless the competent authority is convinced that all the available evidence indicates that the stored CO_2 will be completely and permanently stored.

It has also been suggested that the wording on 'closing' could be improved, with better distinction made between 'end of injection', 'post-injection period' and 'permit termination'.

Recommendation	These articles can remain unchanged.
Justification	The wording in these articles is deliberately 'open' and leaves sufficient room for the MSs to make their own interpretation.

Pros	Keeping these articles the same and not opening the Directive for changes is beneficial to the deployment of CCS as it provides stability and certainty. These articles are deliberately open and provide flexibility for MSs to come up with their own interpretation and guidance.
Cons	There are issues which need some consideration. This includes for example the 30-year post transfer period which is thought to be too long and should be considered on a project-by-project basis. It also leaves the door open for a very strict interpretation by MSs and thus making CCS more costly or even impossible.

11.5.3 Guidance Document 4

Most stakeholders think that Guidance Document 4 (GD4) is more restrictive than the above mentioned articles and as such is not 'fit-for-purpose' due to 'open ended risks' for industry. They refer to GD4 as the 'biggest hurdle' for storage and describe the text as 'unnecessarily alarming'. The GDs are not binding but are taken very seriously by MS. The issue of EUA price risk and long term liabilities was highlighted as one area which requires consideration and revision.

While stakeholders agreed that there is a need to revise GD4, it was highlighted that the absolute priority for the industry at the moment is the successful delivery of early projects and so it was thought essential that any process to amend GD4 does not place risks on the most advanced projects currently under development. The appropriate timing and process for amending GD4 should be discussed with industry in order not to jeopardise early projects.

While the Directive is open in the sense that it leaves it to the MS and operator to agree on details, GD 4 gives the suggestion of more binding and restrictive interpretation according to most stakeholders.

Guidance Document 4 highlights the financial risks and stakeholders say that its tone gives the impression that CO_2 is a dangerous substance. This view of CO_2 is detrimental to CCS and prevents investment.

The logic, that if CO_2 leaks then there should be a form of financial security and financial contribution, is acceptable for most parties. However, the link to the price of CO_2 (per volume of CO_2 leaking) creates high uncertainty and risks which makes the business case for a CCS project much more difficult.

Stakeholders stated that the Competent Authority (CA) and operator should be given the freedom to agree on the financial security and financial contribution system and route to follow. It was emphasised that GD4 should be written so that it informs the CAs and operators on potential issues arising from the financial obligations in the Directive to aid them in agreeing solutions. As a result, GD4 should not influence the solution, but should allow CAs to exercise judgement based on their experience and local knowledge of circumstances.

Guidance Document 4 recommends using a 20-year post-closure monitoring period as a default because the actual length of the post-closure period cannot be predicted in advance. The suitability of 20 years is questionable and seems to be arbitrary. The period should be based on specific technology, risks and the performance criteria of each individual project. Some propose that MSs should be able to define the duration of the post-closure period and one believes that: 'This is a main obstacle to CCS in Europe; must be amended to become workable'. In the comments received, on only a couple of occasions do parties question the practicality of having a time-limit at all.

Recommendation	• Revise GD4 to ensure that it is not more restrictive then the Directive. • Liabilities related to leakage (linked to ETS) are restricted or otherwise shared between the operator and the MS. • The handling of this issue should be left to the storage operator and the competent authority.

	• Ensure that the revised GD 4 avoids unnecessarily alarming wording.
Justification	These liabilities present a major barrier for CCS as they are unquantifiable and can be, depending on the price of carbon at the time of leakage, very large relative to the value of storage. Even though leakage is a very unlikely event it can still be an 'insurmountable' financial risk for the industry. The state of knowledge and experience with underground CO_2 handling has advanced significantly, meaning that the wording used cannot be justified. Although not binding, the GD is considered the biggest obstacle by future operators as MS take the GDs very seriously.
Pros	Guidance documents are easier to alter and change than the Directive. Removing alarming wording will provide more certainty to industry. Changes to GD 4 will provide certainty to industry. Guidance documents are easy to change and update.
Cons	Guidance Documents are legally non-binding.

N.B. Other minor comments have been received on the other GDs. It seems that they would benefit from an update as knowledge on many of the topics has advanced. These GDs however do not form a direct obstacle for practicable, safe application of CCS.

11.5.4 Enhanced Hydrocarbon Recovery (EHR)

The Directive does mention EHR; where EHR is combined with geological storage of CO_2, the provisions of this Directive for the environmentally safe storage of CO_2 should apply.

In many projects, especially outside Europe, EHR is a very relevant success factor for CCS development. Most stakeholders see EHR as a positive first step to make CCS more affordable, to build up further experience and to develop infrastructure. However there were no suggestions to change the Directive to include anything more specific on EHR as this is already sufficiently regulated through other legislation.

Recommendation	Do not include further references to EHR in the Directive.
Justification	The specific issues related to EHR without CO_2 storage are already sufficiently regulated in other places. The aim of EHR is also different to CCS.
Pros	The Directive does not discourage EHR and so there is no need to open the Directive as this could, unnecessarily, lead to uncertainty delays in the deployment of CCS.
Cons	The issues related to EHR are already sufficiently regulated and this provides the CCS industry with the required signals and certainty.

11.5.5 Permanence (reference to 'permanently' contained in several places in the Directive, e.g. Article 1, Article 13(g))

Stakeholders were split on this. Some stakeholders were of the opinion that the wording is sufficient and there was no need for change. Others were of the opinion that there is lack of consensus on the definition of permanent containment and that the statement 'complete and permanent containment' would benefit from revision. Most of the people that called for revision did not think that the term permanent should be replaced with a specific number of years.

Recommendation	No changes should be made to the terminology regarding 'permanent' in the Directive. A specific number of years should not be defined.
Justification	The current situation leaves it open to the CA in each MS to see if they consider the proposed storage to be 'permanent'. This enables the local and site specific situation to be properly reflected. It is very hard to define, in an evidence based way, an alternative definition such as a number of years, to replace 'permanent' (10 thousand..? 10 million..? up to 10 thousand ?). Therefore the current text should be retained. Retaining the text will help maintain credibility and public confidence.
Pros	Avoiding changes in the Directive provides certainty to the CCS industry and could, in the short-term, lead to increased deployment of CCS in Europe. There is no consensus on the specific number of years that could replace the terminology of 'permanent'.
Cons	While avoiding changes to the Directive provides certainty and stability, many stakeholders still believe the terminology used (e.g. 'complete and permanent containment' is vague.

11.5.6 Trans-boundary transport of CO_2

The London Protocol has been interpreted by contracting parties as prohibiting the export of CO_2 from a contracting party to other countries for injection into offshore, sub-seabed geological formations. It states that a country can store within its own jurisdiction. The London Protocol was amended in 2009 but this amendment has not yet been ratified to allow trans-boundary transport of CO_2.

The latest ratified version of the London Protocol allows for offshore EHR but CO_2 export is still not allowed. This is a legal barrier, which needs to be overcome. In order for trans-boundary transport to be allowed under the London Protocol, two thirds of the members need to ratify.

11.6 Draft recommendations for actions related to CCS enabling policy

The next part of the recommendations concern 'enabling policies' and what changes are deemed appropriate to Europe's CCS policy, attempting to incorporate the multitude of views and responses received.

The consensus amongst stakeholders is that Europe is well behind some other countries and is no longer leading in terms of progress on the uptake of large scale CCS technology. The lack of demonstration projects due to insufficient funding per individual project in NER300 and EEPR was highlighted, as well as the low EUA price making a business case for these demonstration projects difficult. The call for stronger support, both at MS and EU level, and the call for a fair playing field with other mitigation technologies was widely heard.

The recommendations for actions are related to the following three policy-related themes:

Theme 1. General governance and CCS roadmap

Theme 2. Financial support of CCS

Theme 3. Regulatory measures on CCS

The three overall guiding principles for the policy-related issues, which emerged from this review of the interventions, are:

- Technology neutrality creating a fairer playing field for CCS compared to other low carbon technologies.
- EC and MS complementarity action (better coordination) in governance and supporting measures.
- Coherence of short and long term roadmaps, plans, governance and measures.

11.7 Theme 1: General governance and CCS Roadmap

11.7.1 Rationale

Following the European Council of June 2008, European heads of government aspired to realise 12 CCS projects by 2015. To date (2014) no positive final investment decision (FID) for a commercial scale demonstration project has been taken. One CCS project in the Netherlands, the ROAD Project in Rotterdam, has continually delayed a FID due to financing problems, despite having all permitting procedures and operational plans in place. In the UK, the Peterhead CCS Project and the White Rose project have been selected for national funding and are currently in FEED stage, with operation expected to commence in 2019; the Don Valley project is progressing as far as the work on CO_2 transport and storage is concerned (these installations would be used jointly with the White Rose project), but for the construction of the capture plant it requires a Contract for Difference (CfD) for projects not covered by the UK CCS Competition and such a CfD scheme is still in the preparatory phase. Due to various global economic and political constraints, for example the global economic crisis in 2011, and the absence of a successor to the Kyoto global climate agreement, the enabling framework established by the EU CCS Directive in combination with the inclusion of CCS in the European Union Emission Trading Scheme has not enabled development of CCS in-line with initial aspirations.

A recurrent theme was the request by stakeholders for the development of specific long-term goals and targets for the deployment of CCS. Remarks included the inclusion of CCS targets akin to those already included for renewable energy and energy efficiency in the EU's 2030 Framework for Climate and Energy, and the development of MS and EU CCS roadmaps. Without these clear signals that CCS is indeed going to play a serious role in carbon mitigation within the EU it is not likely that industry will invest in CCS. Many respondents expressed the opinion that an EU wide roadmap should include targets for CCS deployment for both the power and industrial sectors for 2030 and 2050. This roadmap would form a basis upon which to design incentives, regulation and policy to achieve a clear goal (financial and regulatory support of CCS are covered in Themes 2 and 3, respectively).

Some respondents argued that Roadmaps are not binding enough and called for CCS deployment plans. Others argued that, if instructions are clear enough, Roadmaps can also be concrete and deployment oriented and they make the political acceptance process easier (and thus faster).

During the discussions the debate on energy security in Europe was also mentioned several times. Stakeholders were united on the political relevance and opportunity of that subject. However, when it comes to the use of 'indigenous fossil fuels' there was discussion over the consequences of this for the development of CCS. Some see CCS as a threat to the use of domestic coal reserves, while others see CCS as an enabling technology to increase the use of coal (under the condition that it will be abated). As such a strong CCS industry could be a contribution to a clean and competitive Europe, creating jobs, reducing imports and still achieving alignment with Europe's climate goals.

In general it was felt that the 2030 discussions favoured renewable energy much more then CCS and that this was not based on sound analyses. There was a call for a more pro-active role for the EC and many asked for a CCS vision and CCS strategy document.

11.7.2 Recommended actions

The recommendations have been grouped under three interlinked, approaches:

a. MS 2050 low carbon roadmaps
b. EU wide CCS Roadmap
c. CCS incorporated in 2030 climate and energy package process, including in national plans and an EU CCS strategy document

A. EC to propose to MSs that they develop national 2050 low carbon roadmaps

In order to develop a good understanding of the most effective approaches to the challenges of climate change we believe long term planning is crucial. A consolidated governance process between MSs and the Commission to coordinate an effective approach is necessary.

In order to achieve the EU goal of minus 80% CO_2 by 2050, each MS should make a roadmap researching the most likely approaches towards 2050 (including intermediate goals for 2020 and 2030).

Recommendation	All MSs develop national 2050 low carbon roadmaps. The Commission should give guidance on this process and should propose that each Member State explicitly looks at a possible role of CCS in power and industrial sectors from 2020 onwards. The roadmaps should be completed before mid-2016 in order to be able to feed in the two following steps.
Justification	The long-term 2050 climate goals need to be accompanied by long-term strategic thinking. Each MS should carefully consider how they see the carbon emissions of power and heavy industry around 2050 and judge per country if a need for CCS will arise. The inclusion or exclusion of CCS by MSs based on their energy and industrial mix or preferences will highlight potential mismatches between MS interest and the energy and climate goals of the EU Community. The need for trans-boundary CCS operations will also become clearer.
Pros	The roadmap meets the requirement to produce a coherent plan of short and long-term measures for enabling CCS. In this way MS need to clarify their position with respect to CCS, although some MSs may struggle to go into much detail.
Cons	Roadmaps in itself are not sufficiently binding and call for CCS deployment plans. The development of MS roadmaps may lead to a period of inactivity, in particular on behalf of the EC. This could be compensated by the EC by developing a strategy paper.

B. Development of an EU CCS Roadmap

Many stakeholders suggested a need for more long-term planning on CCS in Europe. As such an EU Roadmap for CCS was often mentioned. The completion of national plans mentioned above can form the basis for a dialogue between MSs and the Commission regarding the role of CCS in Europe. Leading from the national strategies, a dedicated EU CCS Roadmap could be developed (in close cooperation between DG CLIMA, DG Energy and DG Enterprise) with quantified emission reduction targets for the EU as a whole towards 2030 and 2050, which fit the overall objective of emission reduction to 80% by 2050, compared to 1990 GHG emission levels. Comments were made that this European target needs to be clearly linked to the required reductions (ceiling) from the ETS and the targets for renewable energy and energy efficiency to make sure that they mutually support each other. The roadmap should be broken down into practicable transparent measures, and EU and MS roles and responsibilities for successive milestones (2020, 2030 and 2050) should be described. The existing EC energy scenarios can be used as input for this exercise.

Recommendation	Develop a European roadmap for CCS with quantified EU targets for both 2030 and 2050. Regional cooperation following from the MS's capture needs and storage options should be actively supported by the EC. The CCS roadmap for Europe should be ready by the end of 2017.
Justification	Clear targets, including intermediate milestones, will give a strong signal to all stakeholders and increase the incentive for carbon intensive sectors to invest in CCS.
Pros	Creating a coherent plan of actions by MSs and the EC; see also previous recommendation A
Cons	See also previous recommendation A

The 2030 and 2050 roadmaps should include consideration of transport and storage infrastructure and the need for pre-investment in storage and transport. Large-scale deployment of CCS requires assurance of available storage capacity (bankable capacity). Development of geographical databases with storage capacity potential including dynamic testing of selected storage is important, with a leading role for MSs and a complementary role for the EU.

Furthermore, the Roadmap should also propose policies to overcome the inability of certain MSs to implement CO_2 storage, due to limitations in geology. This could include for example, a similar flexibility mechanism to that seen within the Renewable Energy Directive.

The EU CCS roadmap should form the basis for actively pre-investing in transport and storage infrastructure. This can be a joint effort between MSs and the EC that will not only speed up CCS deployment but will also be (a long awaited) strong signal to industry that CCS is part and parcel of the EU's mitigation policy and should therefore help trigger further industry involvement and investments.

C. CCS better incorporated in the EU 2030 Framework for Climate and Energy

Stakeholders referred to the 2030 framework as a major opportunity to give more clarity on the position of CCS in Europe. Under the EU 2030 framework national plans for competitive, secure and sustainable energy up to 2030 are foreseen with specific targets for greenhouse gas emissions, renewables and energy efficiency.

Many commented on the on-going 2030 climate and energy package and judged that the attention and mandate for CCS was felt to be weaker than for renewable energy. This could be altered if the EC were to publish an EU CCS strategy paper, which helps strengthen the mandate for CCS and improves the clarity of its inclusion in the 2030 framework

Recommendation	The EC propose to the MSs that they include the results of the 2050 roadmaps, including industrial abatements and including the possible role of CCS and associated targets in their 2030 plans.

	In the iterative process proposed within the 2030 Framework[102], the 'end goal' for MSs during the development of the plan should be to reach an 80% reduction in GHG emissions by 2050. The EC should come with a CCS strategy paper to clarify the role of CCS in Europe and to give guidance to the above mentioned processes.
Justification	There is recognised pressure and preference to focus more on energy efficiency and renewable energy. Yet all projections for Europe from virtually every institution suggest that CCS is required in Europe to make the deep reductions required by 2050. Progress on CCS by 2030 is therefore essential to be able to reach these deep cuts by 2050.
Pros	See previous recommendation A
Cons	See previous recommendation A

D. Develop a 'storage atlas'

Note: The term 'atlas' is to be avoided in any follow-up action as it is not really covering the type of actions, which are needed. A better title could be 'Appraisal of CO_2 injectivity and storage capacity'.

Stakeholders were not convinced that the development of a general Europe wide storage atlas would accelerate CCS developments. However they were much more convinced that more detailed work on field characterisation for the most promising regions and locations could speed up future developments. It should incorporate a sound appraisal of CO_2 injectivity and storage capacity.

A project to establish an EU-wide atlas of CO_2 storage capacity focussing on promising sites and focussing on field characterisation and including injection tests was suggested. This will help in driving data collection and could help create a large-scale CCS industry. MSs should contribute to this exercise with data that is already available (mainly from oil and gas exploration) if this is possible given the confidentiality requirements of these data. MSs can also stimulate oil and gas operators to actively engage in characterising the surrounding areas of their production fields. Member States should be able to oblige license holders for CO_2 storage to share data (within the boundaries of commercial acceptability). CO_2 storage sites are well known and well explored in some MSs but this is not the case in the majority of MSs. The EC can substantially speed up the future use of storage sites by initiating this research now, focussing on the most relevant and promising locations first.

An EU Plan for CCS transport and storage infrastructure matching sources and storage sites will ideally be done as a part of an EU CCS Roadmap, but this could be developed separately to enable inter alia, the use of Connecting Europe Facility funding.

Recommendation	Develop a project to establish an EU-wide 'CO_2 storage: appraisal of CO_2 injectivity and storage capacity' focussing on promising sites and focussing on field characterisation and including injection tests. Priority should be given to promising areas which are the closest to CO_2 point sources. This appraisal should ideally consider the whole CCS value chain with special reference to the transport and storage infrastructure. The EC should encourage MSs to make data available for detailed site characterisation where practicable within commercial confidentiality requirements.
Justification	Early knowledge of realistic sustainable injection rates and the genuinely available storage capacity could be a major driver for successful project development and increase the accuracy of CCS projections and planning.

[102] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0015&from=en

Pros	This will lower the risk in the development of the CCS business case. This will increase the possibilities for planning CCS developments. This will increase the speed for CCS developments.
Cons	MSs have variable regulation for access to geological data from the oil and gas industry which may hamper a uniform approach for the whole EU. The EC could consider starting a process for more easy access to this data. The work should not reproduce what has already been initiated by the Commission but fill in the gaps of detailed regional and local characterisation. Project developers may doubt the added value of this work and still need to do their own more detailed site-specific characterisation work.

E. CCS as leverage for a global climate agreement

The EU does not function in isolation. Asymmetric climate policies have the potential to reduce short term competitiveness for industrial production and place financial burdens on energy consumers. Strong concrete support for CCS, which allows the achievement of ambitious greenhouse gas reductions, can be used to lever stronger commitment from other developed and developing nations. An EU roadmap for CCS with binding targets for 2030 sends a clear signal of intent to members of the UNFCCC process that the EU's CO_2 ambitions will be realised and thus maintaining a leading position for the EU in the climate debate. It could also articulate a role for Europe to help other countries with the implementation of CCS policies, as this is required in many countries outside Europe.

F. Stimulate better knowledge and understanding on CCS

Public support for CCS varies, it is not high in most MSs and very low in some MSs. Most stakeholders thought it wise to start with offshore storage in order to build trust with the public, in spite of the higher cost of off shore storage.

A strong effort needs to be made to explain the need for CCS to the public (and many politicians), a realistic perspective of its potential, its costs and its risks, and to better show the long-standing experience with CO_2 underground operations.

11.8 Theme 2: Financial Support for CCS (The 'carrots')

11.8.1 Rationale

From the survey and stakeholder engagement carried out in this evaluation, a broad consensus has emerged that the current European policy framework is not sufficient to enable a transition to CCS deployment. Almost 70% of the respondents state that additional policy measures are required and the interviews on this point repeated that virtually every report on mitigation options describes CCS as an important and efficient means of achieving deep emission cuts. Many reports and advisory bodies (e.g. the IEA and others) state that without CCS it is not possible to make the required deep emissions cuts. Therefore a more pro-active CCS policy framework is called for according to almost all stakeholders. Although this assignment is not focused on assessing the suite of policy options to enable CCS in EU, emission performance standards (EPS) are mentioned in Article 38 of the Directive, as a mechanism that will be examined for consideration during the review to be completed by 31 March 2015. Strong opinions in favour and against EPS were presented.

Some stakeholders said there is no evidence that current emission performance levels implemented in various countries, such as the UK (450gCO_2/kWh), the US (440gCO_2/kWh) and Canada (420gCO_2/kWh) incentivise CCS, though it could be seen that such EPS would encourage a shift from

coal to gas. As CCS technology is not sufficiently demonstrated in European projects and/or is not economically feasible, many (industry) stakeholders feel it is too early to consider EPS. For an EPS to effectively encourage CCS, an EPS of 300gCO_2/kWh or lower would be needed. This would mean that gas fired power plants would also need to apply CCS. Other stakeholders noted that of the CCS projects proposed in the first NER 300, the majority came from the UK and involved coal-fired plants. It is also relevant to note that many expect that no fossil generation will be built, with or without CCS under these conditions.

Approximately 60% of survey respondents support a higher CO_2 price in the EU ETS as an effective way to boost CCS. A general consensus could be distilled that the EU ETS is envisioned as the best long-term policy support mechanism for low carbon technologies in the EU. Feed-in tariffs for CO_2 storage, contracts for difference (CfD) and emissions performance standards (the latter as a medium term measure) also attracted support as short to medium term options. The survey for this evaluation also indicated strong support for public grants to subsidise the capital and operational costs of CCS plants. CCS certificates were mentioned as a possible instrument by a small number. Most of the stakeholders feel that support for CCS should be at similar level as that for RES, to provide a 'technology neutral' field for the diverse mitigation technologies. Much stronger support from MSs, well-coordinated with the EC should provide this 'technology neutral' support until the time that full commercial implementation is achieved.

Several industrial stakeholders commented on the issue of 'state aid'. Although there has been positive supportive policies at EC level to avoid state aid complications industries lawyers still feel that the present policy is running the risk of state aid complications.

However, almost all stakeholders stressed the high importance of giving a clear long-term perspective in the support mechanisms in order to send the right signals to the industry so that they will be willing to co-invest. At present industry is very uncertain and unclear about the direction Europe wants to take in the field of CCS.

11.8.2 Recommended actions

A combination of funding and regulatory measures is needed which connects short term and long-term support of CCS deployment in a coherent way (regulatory measures are dealt with in Section 3.3). In the short term, the funding of large-scale CCS demonstrations (soon) is vital. This can primarily be achieved through targeted support measures, which reduce the burden of capital and operational costs associated with 'first mover projects'. Improved governance on CCS between the Commission and MS should help facilitate coherence between MS and EU support for demonstration projects. However, a clear vision on the role of CCS within Europe is also required. Without that even the best support schemes will fail to attract co-investment from industry.

Three levels of interdependent financial support that would also illustrate a rising level of 'eagerness' in the EU to realise CCS are recommended:

A. Continue research and expand EU funding for CCS demonstration projects

Horizon 2020 offers good support for CCS research. However, stakeholders were afraid this could be reduced (as seems currently under discussion at the preparation of the next work programmes under H2020). CCS research projects which link to actual demonstration of capture and storage in demonstration projects should be most encouraged.

In order to move from research to demonstration plants there is a need for on-going and stronger support. Stakeholders were interested in a NER300+ type scheme with a larger amount of funding per project, and with clear support for both Capex and Opex. It was also mentioned that smaller projects (like in Canada 125 MW instead of 250 MW) could also be considered. The uncertainty of the actual financial contribution (as in the current NER 300, based on auction results) should be avoided. Such a scheme should be 'fuel' neutral and not favour e.g. coal over gas. It was suggested that future payment schemes should be on the basis of clean output - kWh clean power or tonnes of clean steel (or other industrial output).

Sufficient MS support per project especially for large scale demonstration and first-of-its-kind plants is key. Such additional MS support could take the form of preferential access to the grid, feed-in tariffs or a 'contract for difference' approach.

Recommendation	Sustained support from H2020 for CCS projects which need to be linked to actual demonstration of CCS. A NER 300 type of funding for demonstration projects, with a better match between required volume of the project and the available funding per project. Predictability of the actual financial contribution is important. Funding of smaller projects could also be considered. A better combination of funding and regulatory measures which connects short-term and long-term support of CCS deployment in a coherent way. Specific support for developing CCS transport infrastructure, which could include EU level capital grants (such as the EEPR or projects of common interest) and research on viable business models for CO_2 transport infrastructure. A more active, and progressing over time, role for MSs in co-investing with the EC in demonstration projects, which could include feed-in tariffs or contracts for difference. Investigation of a further streamlining of the State Aid regulations for CCS deployment. The major existing support schemes like 'projects of common interest', regional funds and other EC supporting schemes are open to support CCS support. More regional level action, e.g. in the North sea region, similar to renewables and regional clusters.
Justification	The former NER 300 scheme did not bring enough support per project to make CCS projects attractive in the current market conditions. The unpredictable auction revenues were partly to blame. So far MSs have supported other mitigation technologies with much more budget then they do for CCS. As MSs have a leading role in their energy policy they should also take a leading role in CCS development. State aid: Although the current policy is already to facilitate CCS projects in 'State Aid' discussions, the current practice is that several industry parties still think this to be problematic.
Pros	More concerted action between EC and MS will result in more reliable funding of CCS in the demonstration phase.
Cons	Currently too little financial support from MSs; CCS is far behind renewables in getting MS support. A 'fair' support of CCS is needed.

Additional funding should be clearly included in the 2030 climate and energy package. The support that is likely to achieve the most impact would be to invest public money in CCS transport infrastructure (combined with the CCS storage support as mentioned under 'Storage atlas' above), ahead of the capture projects, to facilitate commercial deployment. In supporting CCS deployment, the EC and MS governments have complementary roles and responsibilities. The driving force should arguably move more to the MS governments. The MSs allocate their energy budget and distribute funds among the various issues – renewables, energy efficiency etc. It appears that to date CCS has received comparatively minor financial support from MSs (estimated at less than 1% of their total support to all mitigation options).

B. Strengthen the business-case for commercial deployment of CCS

B-1. The preferred support for CCS deployment by stakeholders is a higher carbon price. **The ETS system can be used to give strong signals to the market that would stimulate CCS deployment.**

An ETS system with long term fixed CO_2 reduction rates (e.g., minus X% in 2030, minus Y% in 2040 and minus Z% by 2050) could create clarity for investors. Also, other policy options exist to make the ETS produce a stronger and more predictable price-signal.

Recommendation	Investigating the possibilities of strengthening the ETS system to the level that carbon prices are such that required new mitigation technology like RES and CCS become economically feasible more rapidly and that ETS gives more long-term price signals / clarity to investors.
Justification	A well-functioning ETS system is the most efficient system to choose between the diverse mitigation options. However, it should not only focus on the short term but also on the long term price signals that are in line with the required and agreed climate mitigation efforts.
Pros	Achieving emission reduction with CCS as one of the cost-effective abatement options.
Cons	Conflicting industrial interests in simultaneously reducing emissions and increasing competitiveness in a global market economy. ETS market distortions by other instruments like 'capacity mechanisms'.

Other support mechanisms using the ETS can also be envisaged – such as increased rewards for first-movers or extra allowances for low-income countries. This needs careful further investigation in order not to disturb the overall ETS functioning of the ETS.

N.B. 1. Industry has widely expressed the view that the ETS is their preferred tool to achieve CCS. But at the same time evidence suggests see that the public credibility and the impact of the ETS has reduced, partly due to industry lobbying activities. The industry is squeezed between their short-term interest in cost saving to remain competitive in a global market and the long-term desire for a market based CO_2 mitigation mechanism. We see this inconsistency in industry efforts as an obstacle for further CCS development.

N.B. 2. The situation in the European electricity production market is problematic. Although a 'free market'-based system is still the official policy, the reality shows more and more government interventions to achieve domestic priorities. The uncertainty between 'market based' and 'public governance' has now led to a call for so called 'capacity mechanisms' in many markets, compensating utilities for keeping some commercially less interesting power production reserve operational. Although the situation of utilities is difficult, in these unclear situations a capacity mechanism that is not linked to CO_2 abatement is a road that is not desirable and would frustrate the further development of CCS.

N.B-3. Many stakeholders questioned why there is not more support from MSs and they compared the good financial support for RES with the significantly lower financial support for CCS (around 1% of RES support). Extended use of operational support, such as Feed-in tariffs, contracts for difference, preferential access, at MS level, could be an important driver for commercial CCS deployment. However this kind of support (as a subsidy scheme and not market based) should, in the opinion of the evaluators, only be used in the early years of commercial deployment. The high financial risks for first movers were highlighted and more suitable compensation was asked for.

Recommendation	MSs should investigate their long term need for CCS (see roadmaps above) and align their national contribution to CCS projects in the early phases, to be able to later meet the long-term mitigation requirements. Extended use of operational support, such as feed in tariffs or contracts for difference could be important drivers for the early deployment phase. Investigate the possibilities for the EIB to participate in CCS projects to (partly) de-risk the commercial investments of industry. CCS should also be included in other future initiatives such as the proposed Jobs, Growth and Investment Package.
Justification	As CCS is deemed a necessity in the longer term (2030-2050) for many countries, the first projects to develop CCS have to start well ahead of commercial viability. There is a strong case for this deserving financial support. A rough indication is demonstration projects until 2020,

	supported early commercial use: 202o-2030 and from then only/mainly market based (based on ETS system).
Pros	Taking away the barriers for early movers and continuing support from demonstration to early deployment
Cons	Distortions in creating a level-playing field for all abatement options and improper alignment with transition to a mature well-functioning ETS system

11.9 Theme 3: Regulatory Support for CCS (Including some 'sticks')

Short term financial support of demonstration and early commercial projects can only be justified if this is followed up by deployment in the medium term (from 2030 onwards). There appears to be general agreement that the ETS with a suitable CO_2 price is the best long-term instrument to support CCS.

Stakeholders were divided over the need for stricter 'enforcing' policies for CCS. Most reports speak of CCS as an inevitable tool in CO_2 mitigation efforts. As such this tool cannot be a 'promise for the future' forever and CCS enforcement, according to some, needs to become part of the policy toolbox for Europe. Others argue that CCS remains too costly and 'enforcing' is only logical when the commercial viability is proven. The recommendations below are designed to give some indications on possible future 'enforcing' options as it is apparent from the consultations carried out in this work that clear signals to industry are paramount at this stage. However, this is partly breaking 'new ground' and more research needs to be done on the best possible options, the impact on different industrial sectors and the international context of such policies.

A. Strengthening Article 33 on retrofit for CO_2 capture

As already indicated in the first section many stakeholders think a more restrictive article 33 on overall CCS-readiness (not only readiness for CO_2 capture retrofit, also realistic transport and storage options should be included). They mentioned this CCS-readiness not only for power production but especially also for heavy industry, because for them alternatives (like RES for power) are more difficult and are likely to be more costly.

But at the same time they see this not as 'important enough' to open a full-scale review of the Directive so options were to address the outside the Directive as proposed in 2.3.1.

Recommendation	Readiness for CO_2 capture refit should be strengthened soon, either in or outside the Directive (see 2.3.1). It should be applied on both industry and power production. It should be formulated in such a way that no new major production facilities are built that do not have a future full abatement option.
Justification	Given the need for deep emission cuts by 2050, it is important to avoid creating locked in emissions and plan abatement options for the near future now. Choosing a strong enabling policy for CCS, in our opinion, automatically results in a more stringent CCS readiness clause.
Pros	See section 2.3.1
Cons	See section 2.3.1.

B. Consider EU ETS compatible emission performance standards for implementation toward 2030

The conditions stated in the EU Directive that would trigger a review of emission performance standards have not been fully met. CCS technology could arguably be considered to be sufficiently demonstrated (although not in Europe) but is still not yet economically feasible. An EPS may be effective if it was brought in on the medium term and if it was set at a level that is low enough to be 'fuel' neutral (150-300g CO_2/kWh). EPS would provide a long term signal to operators. The level needs to be set as part of a broader review of energy policy and impact assessment. Any EPS discussions must be well aligned with the ETS discussions to make sure that the emission ceilings set in the ETS includes the use of EPS (ceiling revised equally downwards).

An EPS can be introduced in a variety of ways, all with different impacts. Further research seems required into the possible EPS scenarios, the relation with ETS and the impact on energy security. Some argue that measures such as EPS, could in the short term extend the life of inefficient plants, rather than replacing them with newer more efficient plants. Such undesirable side effects must be avoided and further investigation is needed to show the best possible use of the instrument. If an EPS is to be developed it seems to us more logical to do so under the IED (including LCPD) rather than under the CCS Directive.

It should be noted that an EPS does not automatically drive CCS investments, depending on the overall energy and CO_2 cost situation. Under the current conditions a strong EPS would merely block further investments in fossil generation without increasing CCS investments. But under other market conditions a strong EPS could lead to power generation including CCS.

Recommendation	Investigate the possible use of EPS under diverse scenarios, the relation with ETS and the impact on energy security. Initial research could widen the scope for a range of incentives, specific support measures for industry to protect their international competitiveness and/or actions for specific CCS components, e.g. transport.
Justification	The US recently introduced an EPS system to regulate carbon emissions. It is an effective tool that brings, if well-implemented, predictable emission cuts.
Pros	If well-implemented this instrument contributes to emission reduction in the short to medium term.
Cons	No consensus on the supporting role of EPS in addition to ETS and other incentives. EPS may have unwanted impacts on the security of supply. Examples on the role of EPS in North American CCS projects, e.g. Boundary Dam and Kempner are disputed. EPS may extend the lifetime of inefficient plants rather than replacing them with more efficient plants. EPS will invoke extra cost. NGOs emphasised that these costs need to be compared with the costs of 'doing nothing'.

C. Making CCS mandatory for power and/or large industries

There was little support from industry for mandatory CCS. However there was support from academics and NGOs. At the current and predicted carbon price, CCS is not viable before 2030. Early deployment will help achieve the EU and global climate objectives and will relieve some of the pressure on the security of supply. A mandatory CCS could stimulate the use of indigenous fossil fuel. Making CCS mandatory for power and large industrial plants will speed development of the technology, especially regarding efficiency and costs through learning-by-doing effects and will open export opportunities. In the current environment, Europe is losing leadership and potential future markets. Making CCS mandatory will leverage private investment. Ensuring financial support for first-movers and low-income countries will be needed.

Recommendation	Develop this policy option now, as a strong possible 'stick' for the future if other policies have not achieved sufficient CCS developments.
Justification	Given that almost all advice speaks of CCS as 'unavoidable' in the fight against climate change we cannot accept that CCS will remain a promise for the future. If other policies do not deliver enough developments and if the mitigation scenarios still require CCS then the EU must be prepared to take appropriate action.
Pros	Assuring that emission reduction will be accomplished in the long term
Cons	May harm competitiveness of EU industry and security of supply. Industry is clearly afraid to lose in the global market place if this were the case.

Section 12 Summary of conclusions and recommendations

12.1 Conclusions

The headline conclusions of the evaluation are:

- The overall need for CCS (addressing climate change by decarbonising power supply) remains high. The Directive has a useful and important part to play in this.
- Progress in the uptake of CCS has been slower than predicted, but this is largely due to the global economic downturn and the Directive has had little influence on this.
- The lack of practical experience of the vast majority of the practical Articles of the Directive make detailed evaluation very difficult.
- There are some concerns with specific aspects of the CCS Directive but there is not yet enough experience with it to justify high level changes.
- Revising the Directive at this stage will create increased regulatory risk and thus cause additional delays – in a technology where investor confidence is still not well-developed.
- A revision of the Directive should only occur after more experience is gained with CCS in Europe.

12.2 Recommendations by recipient:

See annexe F for more detail on each of these recommendations.

Do NOT open the full review process of the Directive at this stage.

Issues for immediate / short term attention by the EC - Directly Related to the CCS Directive

- Update Guidance Document four.
- Develop a new Guidance Document (GD5) on 'readiness to retrofit for CO_2 capture'
- Clarification of the difference between major and minor leakage in GD3.
- Confirm the appropriate amount of information required for plan approval.
- Share the information provided on the completed applications.

Issues for immediate / short term attention by the EC - Related to CCS policy

- Request member states to develop national 2050 roadmaps, based on an 80% emission reduction target and including an assessment of whether or not CCS is required.
- Develop an EU roadmap for CCS with binding targets for 2030 and integrate CCS in the on-going 2030 national roadmaps if needed.
- Finalise the NER 300 successor as soon as possible, learning lessons from NER 300.
- Develop an EU-wide 'CO_2 storage: appraisal of CO_2 injectivity and storage capacity' document.
- Strengthen readiness for CO_2 capture refit.

Issues for immediate / short term attention by the EC - Related to Wider Energy and Climate policy

- Investigate how to substantially strengthen the ETS.

- Investigate the possible use of EPS under diverse scenarios and its relationship to ETS.

Issues to be covered in a future review / reopening of the Directive - above and beyond the Article 38 requirements.

- Review Guidance Documents, including on readiness for capture retrofit.
- Clarify wording in Article 12 (CO_2 stream acceptance criteria).
- Extent of storage monitoring requirement.
- Duration of Article 18 (Commission review).
- Clarify if an Unincorporated Joint Venture can be the 'operator'.
- Review the R+D project threshold.
- Review of the scope of Article 21.

Recommendations for the Member States

- Develop national 2050 low carbon roadmaps – as requested by the EC.
- Consider capture readiness regulation for new industrial installations.
- Consider making data on existing oil and gas fields available to enhance the CCS exploration phase

Recommended changes / issues for other Directives and policies;

- Five issues for the ETS Directive; status of EHR and CO_2 storage, BioCCS, ship transport, future leakage value and CDU :
- Consider CCS readiness in the review of the Industrial Emissions Directive (IED).
- London protocol ratification.

Annexes

See separate document.

Annex A: On line survey results

Annex B: Written submissions

Annex C: Interview summaries

Annex D: Case studies

Annex E: Summaries of the two stakeholder meetings

Annex F: Detail of recommendations by target group

Annex G: Guidance Document Four – suggested changes