Accsept

Acceptance of CO_2 Capture and Storage, Economics, Policy and Technology

Project sponsor:

The conditions to define an acceptable role for Carbon Dioxide Capture and Storage in Europe:

Conclusions from the ACCSEPT project

December, 2007

ACCSEPT is a project under FP6 of the European Commission

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About ACCSEPT

- ACCSEPT was a two-year research project (2005-2007) funded under the 6th research framework programme of the European Commission.
- The project leader was Det Norske Veritas (DNV), and the partners were Baker and McKenzie, the Energy Research Centre of the Netherlands (ECN), the Institute for European Environmental Policy (IEEP), Tyndall Centre for Climate Change Research, and Judge Business School of the University of Cambridge.
- There were three main focuses of the project: a Europe-wide survey of stakeholders and their opinions on CCS; stakeholder consultation through two workshops; and research into the economics, regulation, legal and social aspects of CCS.
- The project website is www.accsept.org, where all the outputs and related material can be found.

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Executive summary of the final report

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Context: the role of CCS in mitigation

- CO_2 reductions of between 60 to 80% are required by 2050, compared to 1990, for industrialised countries such as those of the EU.
- Non-CCS mitigation technology like renewable energy is absolutely necessary and could in theory take on the job alone – but there is little evidence of this happening.
- Current trends and projections show an increased use of coal in the EU over the coming decades. Globally, fossil emissions continue to rise even above IEA baseline projections.
- CCS can help bridge the gap between increasing fossil fuel use and decreasing CO_2 emissions.
- A logical conclusion: the options are using CCS or eliminating fossil fuels - failure to do either one means climate disaster. Given the latter seems unlikely, we need to pursue CCS as quickly as possible.

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Geological storage capacity in the EU

- There are numerous potential geological storage sites in Europe.
- However, as yet there is no robust methodology for calculating CO_2 storage volumes.
- Estimates of storage volumes can differ by a factor of 30.
- Conservatively, millions to billions of tonnes of CO_2 can be stored: sufficient volume for CCS to be regarded as a major option even if the larger estimates of storage volumes prove to be over-optimistic.
- Some of the reservoirs are within reasonable transport distance of major sources of CO_2, but other sources of CO_2 are not in close proximity of suitable storage formations.
- Until more reliable methodologies are available, it is prudent for the geological community to err on the side of caution when presenting estimated storage volumes.

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Risk assessment and management

- Risk is inevitably in any industrial undertaking: that it is present CO_2 storage should be taken in context and not impede development *a priori*.
- Existing knowledge on risks should guide initial decisions about site location and exploitation, while ongoing monitoring and evaluation should be robust enough to draw further conclusions.
- Management decisions about storage are as important as, if not more important than, physical risks.
- Because geological sites *can* be found and managed safely in such a way as to all but rule out leakage, does not mean they *will* be found and managed in that way.
- There is a need for proper guidelines, incentives and oversight to ensure desired site selection and management.

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Legal Issues

- There are no insurmountable legal barriers to CCS deployment in the EU.
- However, a number of issues or 'gaps' in the present international and European framework need to be addressed.
- The long-term storage of CO_2 and the need to implement a robust liability regime presents the most significant challenge.
- Appropriate risk allocation and the need to incentivise CCS projects means that a bespoke legal instrument is likely to be required.
- It is vital to strike the right balance between encouraging investment and maintaining the high procedural standards necessary to ensure the environmental integrity of CCS.

Poor data on costs

- Existing information on the costs of implementing CCS is poor and potentially misleading.
- Much of the detailed information is held by the private sector and is confidential.
- Analyses in the academic literature tend to be based on just a few sources, and have not been updated to take account of rising fuel and material costs.

Economic incentives

- There is a risk that CCS will not be deployed at a sufficient scale sufficiently rapidly to meet climate change objectives without the implementation of economic incentives and/or regulation
- The EU Emissions Trading Scheme is unlikely to be sufficient in itself as an incentive.
- Potential EU-level policies to complement the ETS include:
  - A portfolio standard
  - An emission standard for power production
  - An obligation to capture and store CO2 from all fossil-fuel-fired power production and other large point sources.
- Member State policies could include:
  - Investment support for demonstration projects
  - Guaranteed CO_2 prices to enable domestic implementation
  - Feed-in subsidies for CCS-based electricity supply.

Stakeholder Opinion Survey Results

- 512 respondents, including representatives of academia/research, energy industry, government, NGOs, and parliaments.
- The majority of the sample was at least moderately supportive of CCS and believed that it had a role to play in their own country's plans to mitigate carbon emissions.
- Respondents tended to regard the risks of CCS as being moderate or non-existent.
- 51% thought there would be no negative impacts arising from investment in CCS upon efforts at improving energy efficiency and reducing energy demand; 44% thought there would be *some* effect; very few thought such effects would be large.
- Environmental NGO respondents were much more concerned about the risks associated with CCS and the implications for renewable energy than energy industry and governmental stakeholders.

Public Perception

- Comparative information on public perceptions of CCS in the EU27 countries is not available, though national studies exist (i.e. NL, UK).
- Where storage is offshore, it is likely that CO_2 pipelines may elicit the greatest concern.
- For onshore storage, it may be the storage site itself that emerges as the focal point for opposition.
- CCS will be perceived more negatively if held responsible for rises in consumer electricity bills.
- Existing efforts at communicating CCS to the public have in general not been well coordinated or effective.
- A more proactive and interactive approach to public communication and engagement would be desirable and will require additional resources to be devoted to developing more accessible materials.

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Effect on Coal Supplies

- It is commonly stated that coal supplies are sufficient to last for ‘hundreds of years’, but recent re-evaluations shows there is more uncertainty
- Given a likely increase in the demand for coal, supplies might diminish even more rapidly.
- The uncertainty surrounding coal supplies does not imply that CCS should not be implemented, however, because:
  - many hundreds of coal-fired power plants will likely be constructed worldwide over the next several decades; and
  - CCS can be deployed progressively and more efficiently with the build-up of know-how.

Negative externalities of CCS

- CCS has potential negative externalities, e.g.:
  - greater utilisation of coal with associated impacts,
  - greater demand for water for cooling and running the capture process;
  - an extensive CO2 pipeline infrastructure with space claims and risks;
  - potential conflicts with other users of geological storage reservoirs, etc.
- The nature and cost of these externalities are not currently well understood and more research is therefore needed.

CCS in the Clean Development Mechanism

- The debate around CCS in the CDM has so far mainly focussed on technical and procedural issues, which can be resolved relatively easily.
- The resistance to inclusion of CCS in the CDM is related to more fundamental issues, however, which have their origin in different beliefs and convictions, including:
  - new and risky technology should be tested first in industrialised countries before being implemented in developing countries;
  - CCS might displace adoption of more sustainable project types within the CDM, such as renewable energy;
  - A sense of scientific, technological and economic uncertainty.

CCS and Renewables

- There is no necessary conflict between CCS and other low- and zero-carbon energy technologies (LZCTs).
- CCS could, however detract from LZCTs by:
  - diversion of funding for Research, Development and Demonstration (RD&D) from other LZCTs to CCS;
  - diversion of government incentives;
  - diversion of private sector investment; and
  - diversion of attention by government and policy makers.
- As yet, however, there is little actual evidence that funding or policy attention has been diverted to the detriment of other options, though it is really too early for such an effect to have been detected.

Answering the key questions:

ACCSEPT's main conclusions

1. Is CCS geologically feasible within the EU?

- The major, suitable off-shore sedimentary basins in the EU are located in:
  - North Sea, Hebrides, Norwegian Sea Baltic Sea, Adriatic Sea, Mediterranean (4 basins) and Iberian Peninsula.
- The major on-shore sedimentary basins are located in:
  - Denmark, North German Plain, Hungary, Carpathians, Molasse, Paris, SE England, Belgium, Appenines (Italy), Sicily, SW France, and Spain (3 basins).
- Different estimates on the Utsira formation in the North Sea:
  - 2 billion tonnes of CO2 each year for at least the next 20-30 years (ZEP, 2006).
  - 600 billion tonnes in the Norweigian sector alone: allowing storage of all of the EU's CO2 emissions (at current levels) for over 300 years (European Commission, 2007).

- Questions have been raised regarding the accuracy of storage estimates
- There is no agreed methodology for calculating the storage capacity of saline aquifers for CO2 storage; two approaches are:
  - assume that storage occurs only in the structural traps for buoyant fluids and that a proportion of this volume would be available for CO2 storage.
  - assume that a fraction of the total pore volume of all potential reservoir formations would be available for CO2 storage.
- The aquifer storage capacity of the UK sector of the North Sea according to the first method is nearly 9 billion tonnes CO2, whilst it is up to 240 billion tonnes according to the second method
- The latter approach is probably inaccurate and more detailed work is required to derive a more realistic value.

- Other EU 6th FP funded projects are examining the geological storage capacities of reservoirs within the European Union
- Several projects in particular are worth mentioning: GeoCapacity, CO2GEONET, CCS-SCEN and CO2ReMoVe.
- These projects will likely provide a more reliable basis for estimating CO2 storage capacity within the EU and more widely.

2. **Can the risks of CCS be appropriately assessed and managed?**

- It is difficult to define and identify risks, not just technically, but in terms of the way different people and organisations understand and interpret risks.
- In looking at the risks of CCS, one has to consider the risks both of implementing it and of *not* implementing it: the precautionary principle applies as much to employing CCS to avoid global warming as it does to avoiding leakage from CCS.
- The basic conclusion: because the risk from climate change due to fossil fuel emissions is larger and far more difficult to manage than the risk from CCS, the risk of leakage from storage should not impede CCS development overall.
- It is important to move quickly and to learn by doing.

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- Moving ahead doesn't mean ignoring risks: the already identified major risks should be guide our initial decisions about site location and exploitation, and ongoing monitoring and evaluation should be robust enough to draw further conclusions.
- It may well be that management decisions about storage are as important as, if not more important than, physical risks.
- Because geological sites *can* be found and managed in such a way as to all but rule out leakage, does not mean they *will* be found and managed in that way if the proper guidelines, incentives and oversight are not in place. Many of these elements are already in place, but need reinforcement.

- Governments and institutions can have an important role in harmonizing approaches
- Such harmonization has to take place at an appropriate level to guarantee enough detail is captured to make it useful.
- The higher the level of discussion, the more general is the regulation, which is appropriate for establishing some basic principles.
- Much of the difficulty in regulating CCS, however, lies in the site-specific nature of CO2 storage and associated risks. Hence diverse levels of analysis and action are needed, which will require further capacity building and coordination.

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- Finally, whatever the physical reality of risk, if stakeholders are not convinced, storage will face acceptance problems.
- It may be hard to settle differences of interpretation of risks by appeal to the ‘facts’ because of different interpretations of the salience of those facts, and what ‘the’ facts actually are, or whether particular risks exist in the first place.
- Defining risk in either qualitative or quantitative terms is difficult for new and relatively untested technologies such as CCS. Going beyond defining risk to communicating conclusions about risk is an added layer of complication.
- It is imperative to find a common language for the characterisation and communication of risk both among professionals and between professionals and the public, which is not a challenge confined to CCS, but where CCS proponents will need to succeed.

3. Can CCS be undertaken under existing international and European law?

- Regulating the risks associated with CO2 capture could fall within the scope of the IPPC Directive (96/61/EC, as amended), even though that Directive was adopted without specific reference to CCS activities.
- The regulation of transporting captured CO2 similarly falls in theory within the scope of existing dangerous goods laws and regulations. However, this may be inadequate:
  - First, the scale of future CCS projects may place an unmanageable administrative burden on authorities charged with reviewing EIAs.
  - The infrastructure required to transport large quantities of gas is significant, requires large economies of scale and involves long lead-times. This complicates desire to allow third party access, which has to be guaranteed by law. However, existing law does not lend itself naturally to CCS activities.
- Similar gaps can be found in relation to:
  - property rights (including intellectual property rights over capture technology and the ownership of the CO2 after capture);
  - the role of international incentives to develop CCS projects (such as the inclusion of such projects within the EU ETS and the CDM); and
  - environmental liability for the release of captured CO2 (including the role of insurance).

- The legal framework governing the long-term storage and monitoring of captured CO2 presents the most challenging area for legislators. There are two facets to this:
  - (1) the definition of captured CO2 when it is put into long-term geological storage; and
  - (2) liability for any escape of CO2 from geological storage formations.
- Under current European law, it is uncertain whether CO2 that is captured and then stored would be classified as 'waste'.
  - CO2 in EOR could be argued to be an industrial product.
  - If captured CO2 is deemed to be waste, then its storage would be subject to the permitting regime under European waste law.
  - The Landfill Directive (1999/31/EC, as amended), prohibits land-filling of 'liquid waste'.
- The London Protocol has been amended so as to allow the sub-seabed disposal of "CO_2 streams from CO_2 capture processes" in certain circumstances; The OSPAR Convention has also been amended to allow the storage of CO2 in geological formations under the seabed.

- Much of the potential damage attributable to the escape of CO2 post-injection would in theory fall under the scope of the Environmental Liability Directive (Directive 2004/35/EC). It suffers three shortcomings:
  - it does not address damage to the climate system caused by leakage
  - it does not extend to potential sub-seabed geological formations; and
  - it does not impose liability if more than 30 years have passed since the emission
- It is vital to strike the right balance in the liability regime between government and private entities.
- If, for example, a company can be held liable for leakage for too long a period, then it is unlikely to invest in CCS activities.
- Weighed against this consideration are the high procedural standards that are required to ensure the integrity of storage sites.
- Without clarity on this issue, potential project participants will remain concerned about exposing themselves to an unquantified risk in the future.

4: Is the information on the costs of CCS good enough to make robust decisions?

- There are numerous studies on the costs of CCS exist in the peer-reviewed literature, including economic modelling using various models, but many gaps and uncertainties still exist, as follows:
- Many studies use data from just a few base studies, creating the false impression that many studies converge on similar cost estimates.
- Most studies assume pre-2005 oil and gas prices and do not take account of the rising costs of materials, particularly steel prices; this affects IGCC in particular.
- Due to corporate confidentiality concerns, detailed information on CCS technologies and their costs are not fully available in the public domain and it is difficult for independent researchers to assess the validity of assumptions in their cost models.

- Those closely involved in developing a particular technological option frequently need to attract policy attention and resources, and this may lead them to underestimate the costs, leading to information bias.
- Whilst confidence in CCS has been growing rapidly, the risks of seepage are still uncertain, as are the scale-up costs for CO2 capture from a fully-fledged power plant.
- The uncertainty surrounding the course of future policy development generates large uncertainties regarding the costs of CCS development.
- Unless these different sources of uncertainty are taken into account by all decision-makers, modellers, policymakers and the private sector alike, poor decisions on CCS may be taken, resulting in disappointment and harming the reputation of CCS.

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5: What policies can help to make CCS more economically feasible?

- Except for some EOR, the only reason why CCS is implemented is to reduce CO2 emissions: economic feasibility of CCS depends on how it is incorporated into a policy response to climate change.
- The primary option is inclusion in the EU Emissions Trading Scheme (ETS): but even if the ETS could be guaranteed over a long period and the prices were high enough for CCS, it may not fully address the barriers (economic and otherwise) that exist for new technologies such as CCS.
- Consequently it may be justified to consider additional policies to complement the ETS, Member State options include:
  - Investment support for demonstration projects
  - guaranteed CO2 prices to enable domestic implementation
  - feed-in subsidies for CCS-based electricity supply.
- EU-level policies under consideration to complement the ETS include:
  - a portfolio standard
  - an emission standard for power production
  - an obligation to capture and store CO2 from the power sector and other large point sources.

- A coordinated CO2 infrastructure across several projects and countries may be more efficient than leaving it to individual projects and countries.
- The institutional design of such a network should be considered, especially if analysis indicates that CCS could be deployed at a large number of facilities.
- Since the eventual deployment of CCS may be contingent upon the success of such a pan-European network, the role of the EU in coordinating such a CO2 pipeline network may be important.
- The actual arrangement and ownership could be organised amongst the Member States.
- Natural gas could serve as a useful precedent, although the problems and lessons learned, will need to be taken into account.

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- Firms are quite optimistic about the future economic feasibility of CCS, and the climate policy environment is seen as conducive to CCS development.
- However, there have been no positive investment decisions regarding potential large-scale demonstration projects; in fact, two proposals have already been cancelled because of increasing costs and disappointing projected revenues.
- The companies are not worried that CO2 capture and storage will fail for technical reasons.
- One of the concerns is potential public resistance to CCS
- Most companies express a high degree of confidence regarding the permanence of CO2 storage in geological reservoirs. On the other hand, they are unwilling to remain liable for those reservoirs long after site abandonment.
- Due to long time spans involved, the State is the more appropriate organisation for assuming long-term liability; firms may be liable for a number of years after site closure, and/or required to pay into a fund that could be used in situations where unexpected risks became evident only after the liability period of the private sector.

6: Is CCS acceptable to European stakeholders?

- 512 stakeholders from across Europe participated during 2006 in the ACCSEPT survey of opinion regarding the role of CCS in Europe's possible energy futures.
- The majority of the sample was at least moderately supportive of CCS and believed that it had a role to play in their own country's plans to mitigate carbon emissions.
- Respondents tended to regard the risks of CCS as being moderate or non-existent, and did not perceive there to be highly negative impacts arising from investment in CCS upon efforts at improving energy efficiency and reducing energy demand.
- However, 44% of the sample did think that there might be *some* negative impacts arising from CCS for investment in other low- or zero-carbon energy technologies (LZCT), compared to 51% who did not think that there would be *any* negative impacts or thought that impacts might even be positive.
- A similar response was observed with respect to the possible impacts of CCS upon moves to a decentralised power generation system

- NGO respondents tended to be the most sceptical concerning the role of CCS and to have a more negative perception of the potential risks than did other stakeholders.
- NGOs also typically regarded CCS as having a strongly, or at least moderately, negative impact upon investment in energy efficiency, energy demand reduction and moves towards a decentralised power generation system.
- Energy sector stakeholders were the most optimistic regarding the role of CCS, including a low perception of the risks and generally not sharing the NGO respondents' concerns
- Government and research / academic stakeholders tended to have a similar response to that of the energy stakeholders
- Parliamentarians were typically somewhere in between the opinions of the energy and NGO respondents.

- Respondents from Norway, the UK and Netherlands were the most enthusiastic about CCS and least concerned about the potential risks, of which Norway stands out as exceptionally optimistic.
- Several explanations are posited:
  - All three countries are actively engaged in CCS projects, either existing (Norway) or planned.
  - There are distinctive ‘CCS communities’ in these countries which have emerged over the past 5 years
  - CCS has been reasonably high on the agenda of the national energy and climate change policy debate and each country
- Less enthusiastic countries include the other Scandinavian nations and many of the Central and Eastern European countries. Most other counties adopt a position which is some what in between these two groups
- Countries with fossil fuel supplies tend to regard availability of coal, and of opportunities for enhanced hydrocarbon recovery through use of CO2, as more important.
- Those countries with a lower GDP per capita are some what more sceptical concerning the role of CCS, possibly in part because of impacts on electricity costs.

7: Is CCS acceptable to the European public?

- There has been no EU-wide survey of public perceptions of CCS.
- Work has been undertaken to investigate public opinion in the UK and the Netherlands and, to a lesser extent, in France, Germany, Sweden and Spain.
- There has been no assessment of public acceptance in a number of European countries which have been identified in the ACCSEPT study as being of critical importance (e.g., Norway, Italy, and Poland).
- Those studies which *have* been conducted tend to indicate a lukewarm acceptance of CCS
- CCS is considered more acceptable when it is combined with other elements of a low-carbon strategy. The concept of CCS as a 'magic bullet' is unlikely to be acceptable to many stakeholders and large sections of the public.
- Studies also tend to show that acceptance of CCS as a mitigation option increases when more information is made available on CCS (relative to a baseline of no information).

- Where storage is offshore, it is likely that CO2 pipelines may elicit the greatest concern, whereas for onshore storage, it may be the storage site itself that emerges as the focal point for opposition.
- Apart from siting issues, the broadest implications of CCS might be the impact that CCS will have on electricity prices. If CCS is perceived as being responsible for rises in consumer electricity bills, then one might expect that CCS will be perceived more negatively.
- Efforts at communicating CCS to the public are not yet convincing. There are very few - if any - examples of high quality communication activities in the area of CCS.
- Those communications efforts which are underway have been undertaken in isolation with next to no attempt at coordination.

- The identity of the messenger is as important as the message itself: less trust for those with a vested commercial interest.
- The benefits of CCS are more evident if potential projects can demonstrate 'real-world' salience and have clearly demonstrated socio-economic and environmental benefits.
- Benefits to local communities beyond CO2 reduction is likely to be an important element in determining their wider acceptability, alongside the more formal processes of risk assessment and management.
- Amongst the other issues which influence perception are:
  - energy supply security;
  - risk aversion in the face of global and regional climate change;
  - what society is prepared to pay for carbon reduction;
  - the reversibility or otherwise of technological choices;
  - Europe's wider role in the world in promoting low-carbon technologies; and
  - the potential local, national, regional and international impacts of promoting different zero- and low-carbon technologies and options.

8: Is there sufficient fossil fuel to make investment in CCS worthwhile in the long term?

- It has been widely assumed that coal will be abundant for at least another century: 164 years (USDOE, 2007), 255 years of hard coal and 130 years of lignite (BP, 2006).
- There are reasons for concern regarding the reliability of such estimates, however. For example:
  - German estimates were reduced by 92% in 2004 because of the use of more restrictive mining criteria.
  - In the USA, the National Research Council has admitted that the often quoted estimates of resource lifetime of coal have a very shaky foundation
  - The USDOE considers that coal consumption might increase by 77% between 2005 and 2030, which would reduce the resource life globally to about 70 years.
- It would appear that the historical abundance of coal has prevented serious efforts in reliable accounting of its long-term availability.

- A new coal-fired power plant has a design life of approximately 40-50 years. If CCS were not to be implemented in any serious way until 2020, it may be that only one generation of CCS power plants is constructed.
- Nevertheless, CCS could find application in hundreds of power plants built in succession between 2020 and 2050 and learning can take place with experience as it evolves from the earliest plants.
- Much learning can be incorporated into design changes which take place through upgrading and retrofitting of plants once they have been in operation for a number of years.
- CCS could be applied to biomass, so that the technology, and associated regulatory and legislative frameworks could have greater longevity than that implied by the estimated coal resource life.

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9: How large are the externalities arising from CCS and how important are they?

- CCS has potential pollution impacts arising from:
  - increased coal extraction and associated sludge production;
  - increased sludge production from the capture process itself;
  - increased water usage;
  - completely new emissions from chemical scrubbers that are not well understood.
- Because of the energy penalty, overall energy generation capacity must be increased, implying more coal use, which means:
  - more intensive use of existing mining and transport infrastructure and/or development of new infrastructure;
  - attendant impacts on landscapes, local environmental impacts, human health and safety, etc.
- CCS will mean greater use of water for cooling and capture: already some thermal power plants in the EU face the problem of insufficient water for cooling purposes at times of water stress.
- Therefore, there is a high probability that capture plants will have lower capture efficiency in hotter, drier regions where general scarcity of water and periodic water stress are common.

- Some of the potential CO2 storage sites might also find an application as a storage site for other substances, such as compressed air in association with renewable energy systems, or of natural gas.
- Competition for pore space could complicate the economic assessment of CCS if regard has not been taken of these possible further applications.
- Overall, the range of potentially negative externalities associated with CCS have not yet been thoroughly investigated but require detailed scrutiny to ensure that negative impacts can be averted or ameliorated.

10: Can CCS be incorporated into the Clean Development Mechanism (CDM)?

- The inclusion of CCS in the CDM would be the only structural incentive for reducing greenhouse gas emissions in the developing world.
- Without the potential incentives given by the CDM, or an alternative means of technology transfer, CCS in developing countries will only take place sporadically in niche sectors.
- The debate, however, has developed into a highly polarised discussion, with a deep divide between proponents and opponents and no view at present on reconciliation between the various perspectives.
- The strong views of proponents and opponents are preventing resolution of technical and procedural issues that could be addressed.

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- The convictions (of both proponents and opponents of CCS) that have been identified include the following:
  - CCS is not ready for market-based deployment, therefore it is unsuitable for a market-based mechanism like the CDM.
  - Technology should be developed and tested in industrialised countries first, and only after that be implemented in developing countries.
  - CCS will overwhelm the CDM market and crowd-out other, more desirable, projects.
  - CCS does not contribute to sustainable development so should be excluded from the CDM period.
  - Enhanced hydrocarbon recovery will lead to a net increase in greenhouse gas emissions and should therefore not be eligible under the CDM.
  - Renewable energy is to be preferred over CCS, but the CDM market will prefer CCS.

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- Research is needed to address the following concerns:
  - the impact of CCS on the CDM market,
  - the issue of enhanced oil emission accounting,
  - sustainable development aspects,
  - whether developing countries could actually benefit from technological leadership in the field of CCS, or whether they will be worse off.
- If CCS projects are to become eligible under the CDM, accounting issues will require clarification and a system would need to be established for measuring, monitoring and verifying stored CO2.
- Long-term liability for future releases must be ensured, but current accounting and verification systems have been designed to operate over periods of only a few years.
- A primary concern for the architects of a legal framework incorporating CCS in the CDM will be whether liability should be dealt with through crediting or be left to national legal regimes.

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- The potential for CCS under the CDM is unlikely to be very large in the first Kyoto commitment period, unless gas processing potential combined with CCS can be fully and rapidly exploited.
- Gas processing could in theory have a similar impact on the CER market as the HFC-23-destruction projects have had.
- Coal-to-liquids (CTLs) plants could also provide an early opportunity for CCS deployment and should be evaluated in greater detail, particularly in China, though close proximity of CTL facilities to cost-effective geological storage reservoirs is less likely.
- Once CCS in the power sector has been proven, the potential for its deployment under the CDM could be large if the high growth rates of coal-fired power production are maintained in China and India and if CER prices rise.
- It is unlikely that power-sector CCS will be deployed in the CDM before 2012. For the CDM to make CCS economically feasible, however, CER prices must increase substantially, and storage potential needs to be available and demonstrated.

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- CCS might be economically feasible under the CDM at an earlier stage, if opportunities in the field of Enhanced Oil Recovery (EOR) exist, though data are scarce.
- Meeting the criterion of ‘additionality’ for EOR-CCS will be difficult under the current high oil prices.
- There might also be scope for agreement on CCS in the CDM if they include a component of renewable energy, i.e. significant contributions from biomass.

11: Will CCS detract from other zero- and low-carbon energy sources?

- One of the principal concerns of NGOs and the public is that CCS development might derail the growth of renewable energy sources.
- Under every scenario modelling future stabilisation at 550 ppmv or below, there is a need for drastic increases in renewable energy, with or without CCS.
- Naturally, to reach the same reduction target, addition of CCS to the mix decreases the role of other low carbon energy sources.
- If one assumes we need CCS (economically or politically), then there is no necessary conflict between CCS and renewables.
- Negative outcomes *would* result if attention to CCS derails renewables in such a way that CCS is relied upon more than is likely to be desirable, or, even worse, we are unable to meet mitigation goals.

- There are at least four ways in which CCS might detract from other low- and zero-carbon energy technologies (LZCTs):
  - diversion of funding for Research, Development and Demonstration (RD&D) from other LZCTs to CCS;
  - diversion of government incentives;
  - diversion of private sector investment; and
  - diversion of attention by government and policy makers.
- Based on examination of RD&D budgets there is no indication that, *currently,* CCS is diverting RD&D resources away from renewable energy and other LZCTs.
- However, it is unlikely that we would have detected any such effect as yet since it is only in the last several years that CCS has begun to attract moderate to large funding. CCS does not yet feature as a first order driver of research funding, apart from in Norway.
- Macro-trends include the reduction in expenditure for nuclear RD&D and increased expenditure on renewable energy RD&D.
- One anecdotal case of diversion of funding is in the Netherlands, where the government has extended the remit of the natural gas income fund to include CCS RD&D alongside that on renewables and energy efficiency.

- CCS might also divert resources if generous financial incentives for CCS were to be put into place.
- Much depends upon whether governments would increase overall financial incentives for *all* LZCTs, including CCS, or divert resources to support CCS in particular.
- A further related question is whether the private sector has sufficient finance available to support investments in a range of different LZCTs.

- CCS might also detract from renewables and other LZCTs in terms of the attention given to CCS by government decision-makers, Ministers and other members of the energy policy community.
- This is a highly intangible consideration and it is far from clear what would constitute ‘proof’ of this effect or of its impact or indeed of whether such an impact is desirable or undesirable.
- It is not immediately obvious that CCS would currently have much of an impact upon the ‘balance of power’ between the existing lobby groups for various LZCTs.
- Certainly, CCS provides the coal industry, and the suppliers of coal-fired power stations, with a much stronger stake in the ‘low-carbon’ supply sector.
- What is important is to create and nurture a dynamic and inclusive climate change and energy policy decision-making process in which the different options can compete on a level playing field and their respective merits and disadvantages and wider implications can be thoroughly debated.

Recommendations

Legal frameworks

- The most efficient method of expressly including CCS activities in European law would be to adopt a bespoke legal instrument that would disapply inconsistent or unclear provisions in other legal texts..
- Consultation on any legal instrument(s) relating to CCS should be as universal as possible, encouraging the participation and review of as many stakeholders as possible. Above all, the central themes in preparing and drafting the legal framework should be simplicity and clarity.
- Any European instrument should be harmonised, as far as possible, with international agreements. A number of European Member States have ratified international agreements which have a direct bearing on CCS activities, such as the OSPAR Convention and London Protocol.
- Subject to the appropriate economic rationale, the legal framework will need to provide for incentivising the development of CCS. In addition to the EU ETS and possibly CDM, particular measures like capital grants or guaranteed returns on investment may be needed. Such measures would need to comply with existing European law (e.g. on state aid).

Risk Assessment, Risk Management, Best Practices and Regulation

- There is significant scope for information sharing, capacity building and common coordination among Member States and their competent authorities, whether amongst themselves or via an overlying expert body.
- Compromised wellbore integrity is the main source of geological hazards from underground storage sites; regulatory practice must support better performance than found historically in the oil and gas industry.
- The same is true for surface movement and displacement due to underground injection and production, which can potentially cause massive, acute emergencies and damage to surface infrastructure, buildings and people.
- CO_2 geological storage projects must include the whole geosphere in a consistent way in their long-tem flow predictions in order to have a basis for adequate risk assessment.

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Stakeholder Communication and Engagement

- There is sense in attempting to consolidate existing stakeholder engagement activities under EU and national programmes. Engagement should not be confused with a pro-CCS information campaign however.
- There is a need for better information to be made widely available in a range of European languages and a debate stimulated within the context of climate change and energy policy more widely in all 27 Member States.
- There would be value in a focused CCS communication and awareness-raising activity with Central and Eastern European stakeholders, augmenting the efforts of existing projects such as CO2NET-East.
- The ambivalent position of parliamentarians is of interest, and could be followed-up by a dedicated study of the opinions of legislators in Member States.
- Stakeholder Panels might be a useful institutional innovation to assist in the democratic debate surrounding low-carbon energy options and policy.

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Public Communication and Engagement

- Plan an information campaign – now – among national and European parliamentarians, journalists, environmental pressure groups and representatives of civil society are particularly important targets.
- Ensure communication is a dialogue, not one way. The advice of professional agencies is required to help define the message, the messenger, the medium used and the target public.
- Planning for such a campaign needs to begin soon, with a focus on providing clear scientific information as part of a dialogue that encourages all voices to be heard and involved.
- Assign a significant budget: A well-organised outreach campaign is not cheap – around €250k per country – and funds must be set aside.
- Both before and after the launch of any campaign, public opinion needs to be gauged, and listened to, regularly. The Eurobarometer survey instrument could be used, supplemented by focus groups in different countries.
- An information and communication campaign needs to be supplemented with public and stakeholder engagement activity, recognising that the aim of engagement is not to 'win over' or change the opinions of stakeholders or the public, but rather to understand and engage with different perspectives.

Policy for Securing a Role for CCS within a Portfolio of Sustainable Energy 'Solutions'

- A thorough and updated assessment of the costs of CCS should be undertaken before policy decisions are made. Energy modellers should employ realistic cost levels.
- Governments should ensure, and communicate, that deployment of renewables will not be materially impaired by the introduction of incentives for CCS.
- If CCS funding were to substitute for funding of other options, the funding agency or government explain clearly the rationale (e.g. in terms of specific national circumstances, assets, opportunities and technological capabilities).
- Incentive mechanisms for CCS need to be appropriate to the different maturity levels of the relevant technologies – this differs per application.
- CCS in the power sector, for instance, is not yet fully demonstrated on the scale that will probably be required.
- An argument can be made for the use of fixed-price tariffs as incentives in such instances, as opposed to market-based schemes, which are more appropriate for well-proven technologies.

Research, Development and Demonstration Needs

- The negative externalities of CCS differ from those of other low- and zero-carbon energy technologies and should be illuminated through more research.
- Better and more transparent methodologies for calculating CO2 storage capacities are required.
- Better understanding of the engineering costs of CCS, with updated data on fuel and material costs, is required. These updated values should also be used in energy models and in economic studies.
- Better understanding of public perceptions of CCS is desirable, in particular through use of standardised methodologies, and through study of public reaction to real storage sites.
- The effectiveness of different types of educational materials, methods of communication and the impact of different messengers should be investigated.

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