COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 23.1.2008
SEC(2008) 47

COMMISSION STAFF WORKING DOCUMENT

accompanying document to the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels

IMPACT ASSESSMENT

{COM(2008) 13}
{SEC(2008) 48}

TABLE OF CONTENTS

COMMISSION STAFF WORKING DOCUMENT

Commission Communication to the Council and the European Parliament on Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels Impact Assessment

Lead DG: **DG TREN**

Other involved services: **DG COMP, DG ECFIN, DG ENTR, DG ENV, DG REGIO, DG RTD, JRC, SG**

Agenda planning or WP reference: **2007 TREN / 024**

Executive summary

The present Impact Assessment relates to item 2007/TREN//024 of the Commission Work Programme on a Commission Communication on supporting early demonstration of sustainable power generation from fossil fuels.

The present Impact Assessment builds on earlier work, including in particular on:

– the impact assessment prepared for the January 2007 Commission Communication on 'Sustainable Power Generation from Fossil Fuels'[1],

– the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide[2], and

– the Impact Assessment and other preparations for the proposals on ETS post-2012[3] and the SET-Plan[4].

These earlier documents already cleared a series of key issues regarding the role of coal, the usefulness of Carbon dioxide Capture and Storage (CCS) as a CO_2 mitigation technique, the role of ETS as the key market-based mechanism, the recognition of CCS in the current and future ETS, the need for a regulatory framework enabling CCS under safe conditions, the role of CCS as one of the strategic energy technologies requiring further R&D and demo, the need to combine CCS technologies with further conversion efficiency improvements, the need to demonstrate CCS technologies at large scale, etc.

The main **problem** highlighted by the present Impact Assessment is that CCS technologies are not used today in large scale power generation plants.

Consequently, the main **objective** is the coordinated and timely demonstration of CCS technologies in large scale power generation (construction of a series of CCS demonstration projects by 2015 and conclusions on their operation by 2020). Around 10 to 12 of these plants

1 COM(2006) 843.
2 COM(2008) 18.
3 COM(2008) 16.
4 COM(2007) 723.

will be needed in order to cover the various combinations of CO_2 capture technologies, storage sites and geographical locations.

Three policy options are considered in the present Impact Assessment: Policy Option 0 envisaging no policy change and demonstration depending on industry initiative alone; Policy Option 1 establishing a mechanism combining EU coordination and strong MS and other stakeholder commitments; and Policy Option 2 establishing a Joint Undertaking.

A detailed **analysis of the impacts** of each policy option has been performed, checking the effects on: the number of large scale CCS demonstration plants in place by 2015, viability of CCS and technology diversity, energy mix and cost of electricity, global environment and air pollution, economic and social dimension, international cooperation and R&D.

Regarding **the potential for CO_2 capture**, the modelling of the scenario "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS enabled under ETS" undertaken in the preparation of the Directive on geological storage of CO_2 estimated that, with CCS generally commercially viable by 2020, the amount of CO_2 captured in the EU27 can be 7 Mt in 2020 and around 160 Mt in 2030, representing then 13% of emissions from power and steam generation. This modelling also indicated the potential benefits of reduced air pollution.

The conclusions of this Impact Assessment are the following.

Policy Option 0 (no policy change) is not recommended, as without additional coordination and support mechanism, only a limited number of CCS demonstration projects would be put on stream by 2015, leaving outside several CCS technologies and many potentially interested Member States and operators.

In this option, CCS technologies will not be sufficiently demonstrated in Europe by 2020 and the potential for CO_2 capture outlined above would remain largely unrealized. Alternatively, with increasing pressure to fight climate change and continued reliance on coal, the EU could find itself in the position of an importer of CCS technologies developed on other continents (in USA, in Japan or even in China). Another alternative would be a radical shift from coal use to other fuels, but probably to the detriment of the diversity of EU energy mix and resulting implications for security of supply. In less extreme conditions, Option 0 would lead to delays in the introduction of CCS, but any delay would compromise current ambitious goals for fighting climate change.

Policy Option 1 (establishing a mechanism combining EU coordination and strong MS and other stakeholder commitments) appears at present as the most recommendable course of action as it can coordinate effectively the demonstration projects and can create a favourable context for the supply of public financial support (investment aid and/or operating aid) at the level of the Member States. The Commission can quickly establish a coordination structure and announce its favourable view on the provision of state aid. Additional finance can be provided partly by industry operators and partly by the public side, from Member State budget or from electricity consumers or from auctioning allowances under the ETS. If the additional finance needs are shared 50/50 between private and public sources, the financial support from the public side can be estimated to be of the order of 250 millions € for a 400 MW plant or 500 millions € for an 800 MW plant (calculated as one upfront payment) assuming that the allowance price is zero. Obviously, the additional finance needs would be reduced by the actual value of the allowances which correspond to the volume of CO_2 stored.

A stable 20 €/t CO_2 price would mean that the above mentioned additional finance needs would be roughly cut by half.

In this option, both industry operators and Member States will be expected to decide without delay on their plans respectively to engage in and to support CCS demonstration projects. With strong industry and MS commitments, it is considered that around a dozen CCS demonstration projects will be commissioned by 2015. CCS technologies will be sufficiently demonstrated in Europe by 2020 and will be ready for wide deployment in Europe and in third countries, to fight climate change. The benefits associated with deployment of CCS and modelled under the "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS enabled under ETS" scenario (see above) can be realized. Furthermore, Europe will become a provider of such technologies on the world markets, generating commercial opportunities for European businesses.

Policy Option 2 (establishing a Joint Undertaking) is not preferable at present, mainly for the reasons of timing and uncertainty. The JU can fulfil the functions of coordinating the projects and bringing financial support. However, a proposal for a new Joint Undertaking is expected to be highly debated in the Council and in the European Parliament. In addition, the JU would need substantial EU funding that is simply not available under the current EU financial arrangements.

In this option, most decisions to engage in the construction of CCS demonstration plants will be delayed by several years and only a small number of CCS demonstration plants will be constructed by 2015. CCS technologies will not be fully demonstrated in Europe by 2020, with the risk for Europe to become dependent on the imports of such technologies. Sufficient demonstration of CCS technologies will be delayed, at least till the mid 2020ies. The negative effects are similar as for Option 0 for the short- to medium term. In the longer term, if the Joint Undertaking is established, most of the benefits of Option 1 could materialize.

Section 1: Procedural issues and consultation of interested parties

1.1. Background

At the Spring 2007 European Council, the EU made an independent commitment to reduce emissions of greenhouse gases by at least 20% by 2020 (and possibly by 30 % if a wider international agreement could be reached) and to continue the emission reduction path further on after 2020. The EU also stated that the future use of fossil fuels must take into consideration the climate change policy and be compatible with the greenhouse gases emission reduction commitments. This confirmed the positions taken by the Commission in a policy document adopted in January 2007 (Commission Communication on Sustainable Power Generation from Fossil Fuels), which recognized CCS as an important future contributor to limiting CO_2 emissions in the power generation sector and outlined a series of actions and initiatives to be undertaken in Europe in order to facilitate early application of CO_2 capture and storage technologies in power generation.

The present Impact Assessment is related to a new Commission Communication on Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels, implementing one among the conclusions of the January 2007 Communication on Sustainable Power Generation from Fossil Fuels. This new Communication will outline in further details several actions, mainly as regards the stimulation of early construction and operation of large-scale demonstration projects in power generation from fossil fuels, using CO_2 capture and storage technologies for the mitigation of CO_2 emissions from the process.

The present Impact Assessment builds on earlier work, and in particular on:

– the impact assessment prepared for the January 2007 Commission Communication on 'Sustainable Power Generation from Fossil Fuels'[5], the Communication itself and the conclusions of the March 2007 European Summit on the subject, and

– the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide[6], which assessed the impacts of developing an enabling legal framework for carbon capture and storage and incentivising the deployment of CCS at EU level;

– the Impact Assessment and other preparations for the proposals on ETS post-2012[7] and the SET-Plan[8].

First, the impact assessment prepared for the January 2007 Commission Communication on 'Sustainable Power Generation from Fossil Fuels' and the Communication itself already cleared a number of key issues, such as:

(1) the important future role of fossil fuels in the energy supply and in particular of coal in electricity generation, in Europe and in the world;

---

5 COM(2006) 843.
6 COM(2008) 18.
7 COm(2008) 16.
8 COM(2007)723.

(2) however, the continued use of coal is conditional to and should be compatible with the environmental objectives and Climate Change, which foresee significant reductions of CO_2 and other greenhouse gas emissions into the atmosphere;

(3) the expected contribution of Carbon Capture and Storage (CCS) as one among a portfolio for solutions for fighting Climate Change, together with increased use of renewable energies, the promotion of energy efficiency and other low/zero carbon energy solutions;

(4) the need to further develop CCS technologies in combination with increasing conversion efficiency in power plants, in order to reduce the energy penalty of introducing CCS processes;

(5) the creation of a legal and regulatory framework enabling CCS at the EU level and in the International Conventions;

(6) the need to achieve the construction by 2015 of a first series of a dozen large scale CCS demonstration power plants and to have these plants operating for a first period till 2020 for drawing conclusions on the feasibility and the economics;

(7) the perspective of CCS coal-fired generation to become economic around 2020 through the converging effects of lower CCS additional costs (with continued R&D and learning from the demonstration plants) and higher ETS prices;

(8) the crucial international dimension of the problem of the sustainable use of coal, and

(9) the opportunities for improving the EU competitiveness and for exporting sustainable fossil fuels technologies to the main coal using third countries (China, India, other), once these low carbon energy technologies are demonstrated in Europe.

Furthermore, the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide, covers the following issues:

(1) permitting of geological storage sites, including risk management, site selection, operation, monitoring, reporting, verification, closure and post-closure;

(2) liability for leakage from storage sites during operation and post-closure;

(3) clarification of the role of CCS under EU legislation, in particular concerning waste and water, and propose appropriate amendments;

(4) the recognition of CCS projects in the EU Emissions Trading Scheme;

(5) the need and possible options for incentivising CCS for commercial use (thus for the CCS equipped power plants that will come after the first series of CCS demonstration plants).

Finally, the Impact Assessment and other preparations for the proposals on ETS post-2012 and the SET-Plan clarified:

(1) the role of ETS as the key market-based mechanism after 2012 to provide incentives not to emit and the confirmation of CCS in ETS as one of legitimate mitigation options;

(2) the role of CCS as one of strategic energy technologies, requiring further R&D and demo in view of speedy arrival to market and in that view further public funds for R&D and demos; priorities for European R&D in relation to CCS have been clearly identified[9] on the basis of the results of EU-supported R&D and knowledge and experience accumulated in the ETP-ZEP[10].

The present Impact Assessment prepared for the Communication on supporting early demonstration of sustainable power generation from fossil fuels will not repeat the analysis done in the above mentioned impact assessments, but will specifically focus on the need and possible options and their impacts to effectively support the implementation of a first series of 10 to 12 CCS demonstration power plants (construction by 2015 and demo operation for a first period till 2020) and in particular to:

(1) coordinate the demonstration projects to aim at a coherent CCS demonstration program in Europe, testing a variety of combinations of CO_2 capture technologies, storage sites and geographical locations;

(2) improve public awareness of CCS and facilitate Europe's interaction with CCS-related initiatives abroad, both in other developed economies aiming at bringing CCS to market soon and in developing economies making use of fossil fuels in power generation;

(3) bring or facilitate access to public financial support, complementing industry commitments and initiative as the CCS demonstration plants will bear addition investment and operational costs in comparison with non CCS generation, for the period when ETS will not compensate enough such costs. This will include clarifying the status of CCS demonstration projects under rules and guidelines for State Aid.

1.2. Inter-Service Group

An Inter-Service Group has been established in February 2007 to follow up the preparation of the commitments taken by the Commission in the January 2007 Communication on "Sustainable Power Generation from Fossil Fuels"[11]and in particular those related to establishing an enabling regulatory framework for CCS and achieving large-scale

---

9 Focal points are: the improvement of power plant efficiency; the reduction of the efficiency penalty associated with CO_2 capture and the reduction of capital costs (so that the capture cost can be further decreased per tonne of CO_2 avoided); the development of innovative capture processes; the development of new materials, including membranes; the better integration of plant components with a concurrent increase in plant availability; the assessment of European CO_2 storage capacity; the safety of storage and monitoring of storage sites for leakage; and the long term assurance of the permanence of storage.

10 R&D work undertaken in EU-supported projects (through FP5, FP6, Carnot, ECSC Research Fund) and through national and industrial initiatives brought CCS technologies to a point where they are currently applied in a number of industrial processes. They will however need to be adapted for the use in large-scale power generation. The European Technology Platform for Zero Emission Fossil Fuel Power Plant (ETP-ZEP) in its Strategic Research Agenda estimates that this will require €1bn R&D money between now and 2020.

11 COM(2006) 843.

demonstration of sustainable fossil fuel technologies. The Inter-Service Group was co-chaired by DG ENV and DG TREN. The other Commission Services who participated in the Inter-Service Group are DG COMP, DG ECFIN, DG ENTR, DG REGIO, DG RTD, JRC and SG. Representatives from the European Bank for Reconstruction and Development (EBRD) and from the European Investment Bank (EIB) were also invited. The Inter-Service Group had 3 meetings during the first semester of 2007 (on 27 February, 30 April and 18 June). An outline of the problematic and of the options envisaged in the present Impact Assessment and of their key impacts was presented by DG TREN and discussed in the Inter-Service Group. The draft text of the present Impact Assessment had been circulated for comments to the members of the Inter-Service Group.

1.3. Consultation and expertise

1.3.1. Consultation of energy industry

The European Commission has established through the Berlin Fossil Fuel Forum a reliable consultation process with energy industry stakeholders on the issues of the security of supply for oil, natural gas (upstream) and coal. Representatives of the Member States also take part in this Forum. The Fossil Fuel Forum, at its plenary meeting of October 2006 in Berlin, established a "Sustainable Fossil Fuels" Working Group which was activated in 2007 and held 5 meetings till end September 2007 (on 21 March, 28 April, 8 June, 25 July and 19 September). An outline of the problematic and of the options envisaged in the present Impact Assessment and of their key impacts was presented by DG TREN and discussed in this "Sustainable Fossil Fuels" Working Group. Some representatives of the Member States and stakeholders had also the opportunity to present their views on how to support the demonstration of CCS technologies.

1.3.2. Consultation of power companies and Member States

In spring 2007, the Energy Commissioner sent letters to a full range of energy and power companies operating in Europe and to the Energy Ministers of the Member States and Norway, asking them to inform him about their plans with regard to CCS projects and the mechanisms that are envisaged for supporting the implementation of such plans. Many replies have been received and their input integrated in this Impact Assessment.

1.3.3. Wider consultation of stakeholders

The Zero Emission Power European Technology Platform (ETP ZEP), whose Secretariat is currently co-funded by the Commission, established itself in 2006 as a wider group of stakeholders sharing a high interest in the development and use of CCS technologies. There are five groups of stakeholders represented in the ETP ZEP: energy companies, power plant operators, power plant equipments suppliers, research institutes and non-governmental environmental organisations.

During 2007, the activities of the ETP ZEP focussed, inter alia, on the preparation of their views on how to organise a Flagship CCS Demonstration Program. The outcome of this work will be submitted for approved to the General Assembly of the ETP ZEP in October 2007.

The Commission Services and in particular DG ENV, DG RTD and DG TREN had regular contacts in 2007 with the ETP ZEP and attended several specialised working groups. Representatives of the ETP ZEP were invited to attend the meeting of the Inter-Service Task

Force held on 8 June 2007. An outline of the problematic and of the options envisaged in the present Impact Assessment and of their key impacts was presented by DG TREN in the coordination group of the ETP ZEP (on 11 July 2007).

1.3.4. Internet consultation

There was no specific consultation of the general public on the subject of "Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels", as this is a very technical subject.

However, DG ENV launched in February 2007 an internet public consultation on ”Capturing and storing CO_2 underground – should we be concerned?”, covering broader issues related to CCS, such as the level of information, public perception, acceptability as a CO_2 mitigating solution, acceptable increase in the cost of electricity generation and in the price of electricity, etc.

1.3.5. Feedback on consultations

The internet consultation conducted by DG ENV received 787 responses and showed broad support for the four main objectives set out in the January 2007 Communication on Sustainable Power Generation from Fossil Fuels, namely that:

– the EC should support the development of up to 12 large-scale demonostration projects by 2015;

– from 2020 onwards, all new coal-fired plants should be built with CCS;

– before 2020, all new fossil-fuel power plants should be "capture-ready", and should be retrofitted soon after 2020.

The consultations conducted by DG TREN have confirmed the increasing interest in demonstrating CCS technologies in Europe. Although in 2006 CCS demonstration plants were mainly foreseen in four countries (in Germany, Norway, Netherlands and United Kingdom), more CCS demonstration plants are now planned in other Member States (in Bulgaria, Czech Republic, Denmark, Finland, France, Italy and Spain). The survey based on information collected from European administrations, power companies and energy stakeholders has preliminarily identified 33 large scale demonstration projects (with about 20 planned to be CCS equipped, and the others designed as capture-ready for the moment) which are at various stages of preparation. See the list and broad description of these projects in annex.

There is a wide consensus that the CCS demonstration plants will have higher investment and operational costs that will not be fully compensated by the ETS, at least for several years. These additional costs have further increased in 2007, pushed upward by the price of steel and power plant equipments. It is not possible to know precisely how much these additional costs are, as this will be one of the outcomes from constructing and operating the CCS demonstration plants.

Power companies are expecting a substantial financial support from the public side for improving the economics of the CCS demonstration plants. However, there are many different views on which mechanism would be best suited to bring such public support: direct support from Member State budget, feed-in tariffs, low carbon certificates, allocation of multiple CO_2

allowances (if grandfathering ETS), using the proceeds of auctioning of allowances in order to establish a carbon fund or an energy technology innovation programme.

Most stakeholders insisted on the need for having in place appropriate mechanisms for incentivising CCS in a transitional period and for clarifying the status of CCS projects under rules and guidelines for State Aid.

1.3.6. External expertise

The European Commission (DG TREN) has commissioned an external study on "Ex-ante Evaluation and Impact assessment of possible measures for achieving the demonstration of sustainable fossil fuels and determining the most suitable way to support design, construction and operation by 2015 of up to 12 large-scale demonstrations in commercial power generation". This external study has been commissioned to PricewaterhouseCoopers (PwC). Intermediate results of this external study have been taken into account in the present Impact Assessment.

The main conclusions of the external study are supporting the option of combining EU coordination and stimulation of strong MS and other stakeholder commitments as the preferred option, with the additional strong suggestion to also issue EU Guidelines for harmonising the national funding schemes that would be put in place by the Member States.

1.3.7. Consultation of the Impact Assessment Board

The Impact Assessment Board of the Commission (I.A. Board) was consulted on 10 October 2007 on this impact assessment (on the draft version of 5 October 2007). The Board first responded with preliminary comments in which it recognized the case made in the document for early co-ordination at EU level for the development of CCS technology. The Board also in its preliminary comments recommended further improvements and requested some clarifications. The draft Impact Assessment was amended on the basis of the comments of the Board. The amended Impact Assessment and requested clarifications were provided to the Board on 25 October 2007.

The final opinion of the I.A. Board was issued on 29 October 2007 and confirmed that the "comments of the I. A. Board have been agreed by the lead DG in the written correspondence, and concrete suggestions for improvement have already been formulated."

The current version of the Impact Assessment reflects in its content and presentation the results of the above-described consultation process.

Section 2: Problem definition

2.1. Background

2.1.1. The need for an economic and sustainable electricity supply for Europe

The central problem is to reconcile the need for urgent action to tackle climate change with the need to ensure security of energy supply. This was analysed in detail in the Commission's Energy and Climate package of January 2007, and in particular in the Communication on Limiting climate change to 2 degrees Celsius ('the 2°C Communication'), and in the Communication on Sustainable Power Generation from Fossil Fuels.

The Commission Communication on limiting climate change to 2°C[12] showed that significant further reductions are required in the longer term. In the context of the global reduction of 50% by 2050, a reduction in emissions of 60-80% by 2050 is required of the developed world.

The Communication and impact assessment on sustainable power generation from fossil fuels[13] further highlights that:

– fossil fuels in general will continue to be an important source of energy for electricity generation in the future. Coal plays a role particularly for ensuring a diverse energy mix which can contribute towards supply reliability;

– the construction of new and upgraded coal-fired plant in the EU will only be acceptable if technologies are developed and deployed which are able to significantly reduce emissions of CO_2;

– clean coal technologies (improvements in conversion efficiency) can help to reduce emissions, but are insufficient on their own to meet the CO_2 reduction demands of climate change. Indeed, neither the implementation of Clean Coal technologies alone (further improvement of energy efficiency in coal-fired power plants), neither the adoption of CCS technologies alone can provide an economic and environmentally sound approach. The technological solution must combine the advantages of further increasing the conversion efficiencies in power plant with those of the CCS processes;

– thus CCS will be a critical technology amongst the EU's portfolio of measures in delivering on the competing objectives of secure and economic electricity supplies and facing up to the climate change challenge.

In its Spring 2007 Conclusions[14], the European Council recognised that urgent action is needed to limit climate change to a manageable level.

The Spring Council also underlined the importance of substantial improvements in generation efficiency and clean fossil fuel technologies, and urged Member States and the Commission to work towards strengthening R & D and developing the necessary technical, economic and

---

12 COM(2007) 2.

13 Commission Staff Working Document: Accompanying document to the Communication from the Commission to the Council and the European Parliament. Sustainable power generation from fossil fuels: aiming for near-zero emissions from coal after 2020. Impact Assessment (SEC(2006)1722).

14 7224/1/07 REV.

regulatory framework to bring environmentally safe carbon capture and sequestration (CCS) to deployment with new fossil-fuel power plants, if possible by 2020.

The Spring Council also endorsed the preparation of an EU Strategic Energy Technology Plan (SET-Plan). This plan has been drawn in the course of 2007 and has been adopted by the Commission in November 2007. It identifies several technologies as strategically important for EU's ambitions in fighting climate change and reducing the carbon intensity of energy production. CCS is included amongst them and the large-scale demonstration of CCS in power generation is highlighted as the first milestone for European R&D and innovation efforts with respect to CCS.

In this way the SET-Plan provides a strategic framework for further progress on CCS and for keeping EU's initiatives on CCS in the wider context of efforts aimed at the development of technologies for fighting climate change. The Commission Communication, the document for which this IA is made, will thus represent a first technology-specific document following up on the overall message of the SET-Plan. The document may signal that EU initiatives to promote CCS demonstration can be seen as the first case of EU action undertaken in the spirit of all-European approach advocated in the SET-Plan.

To the extent that SET-Plan will result in concrete policy measures (e.g. in R&D coordination across EU or in raising additional resources for EU-wide actions), these can be incorporated in the execution of the specific strategy of CCS demonstration in Europe that will be outlined in the communication document subjected to this IA.

2.1.2. The need for CCS internationally

In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded that the fastest rate of emissions growth over the next 20 years will be in the rapidly industrialising nations of the world – e.g. China, India, Brazil and Mexico. For those countries, coal is likely to form the cornerstone of the energy system as in most cases it is the most abundant, cheap and secure form of primary energy available.

Widespread deployment of CCS in the developed world will lead to technological development and cost reductions that will allow rapid deployment in developing countries that have ample coal reserves, such as China and countries in South Asia.

The competitiveness dimension of CCS

The recent endorsement by the Heads of State of an independent GHG reduction target of 20%, a 20% target for renewable energies and the development of the Strategic Energy Technology Plan indicate a strategic preference that the EU should lead or be among the leaders of the development and deployment of new energy technologies. The competitive advantage on CCS resulting from large-scale deployment in Europe is a collateral benefit of the enabling policy framework.

It would allow European industry to remain among the leading players in a potentially burgeoning global market for CCS technology. Other developed nations, especially the USA and Australia, are putting in place schemes at federal level that will support demonstration of clean coal and CCS technologies there, and Europe must remain at the forefront of global efforts in CCS development. Thus the enabling policy framework for CCS demonstration in Europe can contribute to the Lisbon Agenda objective of making Europe the most competitive

and dynamic knowledge-driven economy in the world by 2010, and the further objective of strengthening European enterprise in the field of environmental technologies.

2.1.3. The specific problems affecting CCS deployment in Europe

Based on the analysis conducted for the 2°C communication, the sustainable fossil fuels communication, and in the related impact assessments[15] and in particular following the Spring Council Conclusions, the present Impact Assessment will take the need for widespread CCS deployment in the EU from 2020 as established.

The present Impact Assessment thus focuses on one of the specific problems affecting CCS deployment, which is the lack of large scale demonstration of CCS technologies in Europe (and worldwide).

There are two other specific problems affecting CCS deployment (the environment, health and safety (EHS) risks from CCS deployment and the commercial barriers for wider CCS deployment after the first series of CCS demonstration plants) which are addressed by the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide[16] and are not included in the considerations of this impact assessment study, related exclusively to the issue of CCS demonstration.

2.2. What is the issue or problem that may require action?

CCS technologies are not being applied today in power generation,

and there are no large scale demonstrations of CCS technologies in power generation, neither in Europe, neither in the rest of the world.

CCS technologies are commercially available and are being used in some industries (such as in the drinks and food industries), but the volumes of CO_2 treated in these other industries are much smaller, in comparison with the volumes of CO_2 produced by a commercial size power generation plant.

There are also some applications of CCS technologies currently in operation which involve larger volumes of CO_2. Transport and re-injection of CO_2 into oil fields in order to enhance oil recovery is done on a regular basis in many on-shore locations in the USA, but the CO_2 is mainly originating from natural sources. The separation of the CO_2 associated with natural gas production and its re-injection in deep aquifers has been tested in off-shore Norway (for 10 years in the Sleipner field) and in one field in Algeria, with good results.

Nevertheless, CCS technologies have never been integrated to nor tested in a large scale power generation plant, neither in Europe, neither in the rest of the World. Technological risks remain for the scaling up of the CCS processes in order to fit them to large scale power generation. The absolute amount of the investment needed for a demonstration at commercial scale (in the range of 1 billion € or more per demonstration plant) and the substantial additional costs involved by CCS processes play a role here.

---

15 See COM(2007) 2, COM(2006) 843 and related impact assessments.

16 COM(2008) 18.

2.3. What are the underlying drivers of the problem?

2.3.1. CCS technologies are not economically viable today, in the context of today's CO_2 prices and limited time horizon of the current EU ETS

The additional costs of CCS

CCS power generation has higher investment costs, as a power plant equipped with CCS will be substantially more expensive to build than a plant without CCS installations. This is obvious in post- combustion capture processes, where all the installation for separation and capture of the CO_2 is added at the end of the process. The same applies in more integrated schemes (pre-combustion capture and oxy-combustion), where the installation with CCS will be more complex and more expensive than a similar installation without CCS. The infrastructure needed for the transport and permanent storage of CO_2 will obviously add to the investment costs. It has been estimated by various sources that the first series of CCS demonstration projects will have investment costs 40 to 60 % higher above the investment costs of a comparable non CCS power plant of the same capacity.

Moreover, CCS power generation plants will also have higher operating costs. It is caused by the fact that the net amount of electricity produced by a CCS power plant is reduced, in comparison with the same plant not equipped with CCS (or not running the CCS part). It results from the electricity consumption of the CCS process it self. For the first series of CCS demonstration projects, this increase of operational costs (the so-called "energy penalty" of CCS processes) is estimated to be close to 20 % of the value of electricity produced by a comparable non CCS power plant (loss of 8 to 10 points of efficiency from the 43 to 46% achieved in modern non CCS power plants).

A very comprehensive analysis done by the investment firm Climate Change Capital Ldt (CCC) in the summer of 2007 collected the costs of electricity generation with and without CCS from publicly available sources, such as the DOE /NETL (2007), the IEA GHG R&D Programme (2007) and the IPCC (2005). Ranges are given for the CCS costs, as additional capital and operational costs depend on the type of power plant, on the CCS technologies used and on other assumptions actually chosen by each source.

For capital expenditure, the lowest estimates are for IGCC with pre-combustion capture (1361 – 2001 €/kW), while higher ranges are given for Pulverised Coal with oxy-fuel (up to 2171 €/kW) and Pulverised Coal with post-combustion capture (up to 2330 €/kW).

For operational expenses, the lowest estimate is for IGCC with pre-combustion capture (6.0 – 8.1 €/MWh), while higher figures are given for Pulverised Coal with post-combustion capture (up to10.2 €/MWh) and for Pulverised Coal with oxy-fuel (11.2 €/MWh).

CCC analysis concludes that to cover the CCS-related costs increases, demonstration projects need to receive €1076-1705/kW in upfront capital grants or continued operating support of €25-67/t CO_2 stored. It is to be noted that the cheapest technologies are very close to being economic viable already at CO_2-prices of around 20€ per ton.

For an 800 MW demonstration plant storing an average of 5m CO_2 t pa, the amount of additional finance required for investment in CCS is in the range of € 125m – 335m pa (or an amount in the range of € 860m – 1364m as upfront payment).

If the figures mentioned in the CCC analysis are averaged and rounded, each large scale CCS demonstration plant might need additional finance of the order of 500 millions € (for a 400 MW plant) or of the order of 1 billion € (for a 800 MW plant) to cope with the additional investment and operational costs, in comparison with a similar non CCS power plant financed on commercial grounds.

CCC calculations of the additional finance needs assumed that the allowance price is zero. Obviously, the additional finance needs would be reduced by the actual value of the allowances which correspond to the volume of CO_2 stored. A stable 20 €/t CO_2 price would mean that the above mentioned additional finance needs would be roughly cut by half.

The compensation of CCS costs through the EU ETS

CCS power generation and the CCS demonstration plants themselves will start to benefit from the market incentives provided through the EU Emission Trading System (ETS), when the ETS is properly amended.

Several calculations done by different authors, including the MIT report and the Stern report, point to an equilibrium price of 25 to 30 € per tonne of CO_2 for the ETS, expected to provide full compensation of the additional investment and operating costs of CCS power generation from 2020 onwards. It has to be stressed however that these estimates take into consideration the fact that costs for CCS are expected to drastically decrease, due to innovative developments in CCS R&D, experience gained in the demonstration plants and production in series. However, recent information from stakeholders points to an important increase in the prices of steel and of power plant equipment, which could bring the equilibrium price to higher level and it must be stressed that for the first generation of early CCS demonstration plants (first of a kind plants), the equilibrium price will be close or even above the 40 € per tonne of CO_2.

The EU ETS started in 2005 with its first allocation period 2005-2007 as a learning period. Due to a generous allocation as well as other factors, the CO_2 price in ETS strongly fluctuated in 2005 and 2006 (between 10 and 30 €), to finally collapse in 2007 (below 1 €). After the Commission published a first batch of decisions on National Allocation Plans for the second trading period, the forward prices for this second period built up to reach ca. 20 € in September 2007. In the context of today's CO_2 prices, the reward through ETS is insufficient to cover the additional investment and operating costs of CCS power generation estimated above.

This means that the first implementation of CCS technologies in the demonstration projects is in most cases too expensive at this stage to be undertaken on purely commercial grounds. However, the existence of the market and the expectation of ever tighter emissions ceilings will give an incentive to invest in new technologies, provided that industry finds the CO_2 policy credible.

The limited time horizon of the current EU ETS is also a problem. Political commitments in terms of the general direction of the climate policy have been made by the Commission and at the highest EU level, to ensure that the EU ETS will continue after 2012. However, there is inevitably no legal certainty at present on the future of the ETS after the second trading period.

The uncertainties as far as the carbon price is concerned are probably the most important obstacle in the decisions to go ahead with the CCS demonstration projects. Bearing the above in mind, one can not forget that construction of a power plant is a long-term investment and needs a long-term planning and adequate justifiable revenues.

How to cover the additional finance needs of the large scale CCS demonstration projects?

It is thus expected that the CCS demonstration projects would have an additional cost equivalent to 40 €/t CO_2 price or more.

The additional finance needed is the additional investment and operational cost for CCS, but after deducting the value of the reward to be obtained from the EU ETS. However, industry operators do not predict high CO_2 prices for the next coming years. If a stable 20 €/t CO_2 price could be predicted for the 15 coming years, the additional finance needs would be roughly cut by half.

One part of the additional finance needs will be financed by the industry operators themselves, as they will be investing in their ability to remain in the coal-fired generation business in the future. But these operators also expect a significant financial contribution from public sources, in order to improve the insufficient viability of the CCS demonstration projects, which is expected to last some years.

It must be understood that any subsidies provided should take into account the expected return from CO_2 price, in order to avoid overcompensation.

2.3.2. The multiplicity of the CCS technologies to be demonstrated

So far, a series of companies announced their intension to engage in CCS demonstration projects in power generation. These plans already include a variety of CO_2 capture technologies (such as pre- combustion separation in IGCC plants, post-combustion separation in pulverised coal plants and natural gas plants, oxy-combustion in pulverised coal plants).

Most of these projects are in their very initial phase and for several of these projects the CO_2 storage sites are not yet identified. However, there will be here the need to test CO_2 storage sites in various situations (such as in depleted oil and gas fields, in deep saline aquifers, or for enhanced hydrocarbons recovery) for drawing conclusions on their suitability for long term CO_2 storage.

In absence of a coordinated demonstration effort, there is a risk that commercial players will test only some of the CCS technologies (the easiest to put in place or the cheapest in today's terms) neglecting on not putting enough resources on CCS technologies which may offer higher potential and prove better and cheaper in the longer run.

Aware of this risk, the ZEP European Technology Platform has been developing a technology matrix indicating which CCS technologies need to be demonstrated in order to cover the various combinations of CO_2 capture technologies, storage sites and geographical locations that need to be demonstrated.

In addition to this technology matrix for demonstration, the priorities for European R&D in relation to CCS have been clearly identified on the basis of the results of EU-supported R&D and knowledge and experience accumulated in the Zero Emission Power European Technology Platform (ZEP). In particular, the Strategic Research Agenda for CCS adopted by

the ZEP in 2006 has been the subject of further discussions between Commission services and the ZEP in the context of the preparation of the current work program for FP7 in this area.

An efficient interaction between demonstration and R&D activities will further confirm the priorities for European R&D and at the same time facilitate the rapid adoption of R&D innovations in CCS demonstration projects and in the first CCS commercial plants to come on stream around 2020.

2.3.3. The lack of cooperation between CCS demonstration projects in Europe, and with potential projects in cooperating third countries

As mentioned above, a number of companies announced their intention to engage in CCS demonstration projects in power generation in Europe. So far, these projects are prepared by projects teams which, as a rule, work separately from each other. There is no forum and no channel through which CCS demonstration projects could exchange information and communicate and benefit from each other. And the situation is the same as far as exchange of information with potential CCS demonstration projects in cooperating third countries is concerned.

The ZEP European Technology Platform is a place where important issues and problems related to the development and promotion of CCS are debated but the discussion never focuses on individual CCS demonstration projects. Some industrial and regional associations may become involved in CCS issues but they lack coverage and resources to reach all desired interlocutors.

At the same time, there is a good scope for establishing cooperation between CCS demonstration projects, for discussing problems, solutions and results, and for organising links with projects in cooperating third countries (such as in China, in India, etc.), with the aim to improving the definition of the demonstration projects and accelerating their implementation. Disseminating knowledge on CCS demonstration activities among projects promoters and designers will avoid that the same efforts are repeated a number of times in different places across the EU.

An appropriate channel (or network) for systematic exchange of information on the implementation and on the results of CCS demonstration projects and for linking with similar projects in third countries is missing.

2.3.4. The insufficient awareness of the public

The insufficient awareness of the public is also creating uncertainty to projects developers. This may eventually result in delaying the authorisation procedures and consequently the start of the projects. At this stage, CCS technologies are not known in the wider public and this may cause a simple reaction known as NIMBY – not in my backyard. Therefore, providing information to the public on this very novel technology as soon as possible in order to prepare the public for later wide deployment of CCS will be essential. In short term it will help to have the CCS demonstration plants authorised in time.

2.4. Who is affected by the problem, in what ways, and to what extent?

In the short term, the consequences of implementing or not implementing a CCS demonstration program are very limited. In the long term however, implications of the

availability or not of demonstrated CCS technologies could be very serious for the energy supply, the European economy and the public.

2.5. How the problem would evolve, all things being equal?

The problem (the lack of large sale demonstration of CCS technologies in power generation) will remain unsolved to a large extent. A very limited number of CCS demonstration projects will most likely be constructed, involving a few very big operators, but the critical number of projects for firmly engaging in a "CCS technology route" in Europe would probably not be reached. Several CCS technologies and many potentially interested Member States and operators will be left outside of the demonstration activity till 2020.

2.5.1. The energy supply, the European economy and the public

It is expected that, around 2020, CO_2 prices could become firmer and stabilise at higher levels. With continuing restrictions on CO_2 emissions, fossil fuel power plants not equipped with CCS will progressively loose on their competitiveness. There would be a risk that power plant operators are obliged to reduce the quantity of electricity generated from fossil fuels, in order to cope with shortage of CO_2 emission allowances. In theory, this would make the use of CCS technologies more viable. But there is a risk, due to the long investment cycles in the power generation sector and with insufficient demonstration experience, that CCS plants will have difficulties in coming onto the market even if at that time the CO_2 price is sufficiently high. Even if developed CCS technologies might be imported from third countries, the investment cycle would still be imposing its inertia. In the absence of well developed and sufficiently cost-efficient CCS technologies, the use of coal might be increasingly restricted in the production of electricity.

If coal use in power generation starts to be restricted for such reasons, there will be a risk for the security of electricity supply, as there are no easy alternatives to coal for the production of base-load electricity. And this will affect industries, services and private energy consumers.

A spill over effect onto the coal industry across Europe is to be expected. Once coal fired plants become not economically viable, the European coal industry will be faced with sudden drop in demand on their products. It has to be stressed that the spill over effect will not only affect the production of hard coal (which is already balancing on the edge on competitiveness) but also the well functioning lignite production. Social consequences of a collapse of fossil fuel based power generation across Europe would be felt in the regions where coal industry is the main employer. Hence, it should be in the interest of the coal industry to undertake these demonstrations on their own in time.

It is likely electricity prices will go up due to both investment needs and the climate policy, but it goes too far to attribute it to the delayed CCS technology. The global effects would also depend on the assumptions about the global climate policy.

If Europe is not engaging in a substantial CCS demonstration programme, other countries (such as USA, Japan and even China) who have announced or are expected to engage in such activities could become more competitive in the field. These third countries will develop marketable CCS technologies and create jobs in this new environmentally sustainable activity. If industry operators in Europe wait that the ETS sends sufficient price signal, it might be too late to start developing a industry branch supplying CCS technologies. Europe will have missed a chance to develop a new industry branch.

2.5.2. The global climate

The global climate is affected by increasing GHG emissions. And emerging economies and other countries are expected to further increase their use of fossil fuels and their CO_2 emissions. Engaging now in the demonstration of CCS technologies will support EU efforts to convince other countries to accept a reduction path for their GHG emissions. Implementing a CCS demonstration program is a vital step for CCS technologies to become commercial and to enter the portfolio of solutions that could bridge the global climate and energy supply concerns.

2.5.3. The EU GHG emissions reduction targets

The EU has agreed to unilaterally reduce its GHG emissions by 20% by 2020. The EU also announced that it will commit to reduce GHG emissions by 30% by 2020, if a broader international agreement can be reached. And further reductions by 50% or 60% are envisaged for 2050. It will not be possible to achieve such reduction path, in particular for the steps beyond 20%, if we rely only on the increased contribution of renewable energy sources and energy efficiency measures.

It was indeed mentioned during the Spring Summit in 2007 that without application of CCS in fossil fuel power generation, the desired reduction of GHG will not happen.

2.6. Does the EU have the right to act?

2.6.1. Treaty base

There are several grounds on which the EU can base its actions in the area of the demonstration of CCS technologies in power generation:

– environment: CCS Demonstration will make available a new solution for avoiding CO_2 emissions in the atmosphere from fossil fuels power generation;

– research & Development: CCS Demonstration is the last step, before commercial application, of a technology which is among the priorities of the R&D programs of the EU;

– trans-European Networks: cross-boarder CCS infrastructure (for transport and storage) would be needed for CCS demonstration and later for CCS deployment (in power generation and in other sectors), in particular for those power and industrial plants not having CO_2 storage sites in their proximity;

– security of energy supply: CCS demonstration will allow continued use of coal, of which there are large reserves, and of other fossil fuels, in power generation, in an environmentally acceptable way.

2.6.2. Subsidiarity

The justification of subsidiarity (role for the EU) referred to for R&D can also be used here. Demonstration is the last step of R&D. As in earlier stages of R&D, there is a need to focus MS efforts on the most promising solutions on the basis of a coherent matrix; a need to avoid duplication and to get the best innovation return for the money spend; a need to involve partners in less involved MS and support efforts of medium size players. Such stimulation and coordination across the MS can only be done at EU level.

This justification of subsidiarity (role for the EU) can be used both for the EU involvement in effective coordination of CCS demonstration projects and for the provision of EU finance to cope with additional costs and lack of viability of CCS demonstration projects. The practical problem we meet here regarding EU finance is that the EU budget earmarked for Clean Coal and CCS in FP7 is by far not sufficient to cover the needs of the CCS demonstration projects, while, at the same time, the EU considers of high importance to have a dozen of these projects build by 2015. Such dilemma can only be solved by increasing the EU budget (this will require reallocation within or revision of the Financial Perspectives) or having MS support schemes.

Section 3: Objectives

3.1. What are the general policy objectives?

3.1.1. Balanced relation between environmental sustainability goals, energy security and competitiveness

The general objectives of this action are to enable and prove CCS to become the technology of choice in power generation from fossil fuels at around 2020. This will allow for retaining fossil fuels in the European and global energy mix in the coming decades as needed for the purposes of competitive and secure energy supplies, without undermining the key sustainability goal formulated for energy by the European Council of March 2007 - the 3 x 20 objective for the European Union in 2020 (reduction of GHG emissions, share of renewable energy sources in the overall energy, improvements in energy efficiency).

As explained in the Impact Assessment (SEC(2006)1722) of the January 2007 Communication on Sustainable Power Generation from fossil fuels: aiming for Near-Zero Emissions from Coal after 2020 (COM(2006)843 final), the substitution of coal by natural gas in power generation could meet the environmental objective but a massive increase of the consumption of natural gas in Europe, and in other parts of the world, would bear substantial risks in terms of security of supply, prices and in the end availability of natural gas. In the longer term, coal-based power generation with CCS is expected to become a competitive way of producing electricity, cheaper than natural gas-fired electricity and at a cost comparable with wind energy in medium velocity locations.

3.2. What are the specific objectives?

3.2.1. To launch a large-scale CCS demonstration exercise concerted across the EU

The aim is to have a number of large scale CCS demonstration projects (around 10 to 12 plants) testing different configurations of capture technologies, geological storage sites and locations, constructed by 2015 and operated in a first period till 2020 for drawing reliable conclusions (referred to here after as "The Demonstration program").

The first outcome of the Demonstration program will be to provide evidence of the technical feasibility, under safe conditions, of large scale capture, transport and permanent storage of CO_2.

The second outcome of the Demonstration program will be to confirm the economics of CCS fossil fuel generation, in particular the total additional costs for producing electricity with CCS, and to provide indication of the level of CO_2 price that would make CCS commercial. This will be the level of CO_2 price that will provide a sufficient market incentive, without any additional aid, for CCS generation from fossil fuels to become commercial and to penetrate the power generation business.

In addition, the Demonstration program will further trigger R&D activities in this field, improving the perspectives of reaching higher energy efficiencies, of reducing the energy penalty and of achieving even more innovating solutions. All these new developments are expected to be used in the first generation of commercial plants that will come on stream after 2020.

3.3. What are the operational objectives?

3.3.1. Coordination and networking of the CCS demonstration projects to be constructed by 2015 (in the EU and in collaborating third countries)

It will be in the interest of the EU, and of the individual project operators, not to leave each CCS demonstration project developed and constructed as a stand alone one but to link these projects through an effective communication channel (a "network" or "umbrella structure") through which all projects accepting to share information would cooperate.

There is indeed a good scope for establishing cooperation between CCS demonstration projects, with the aim of:

– improving the definition of the projects, with a view to demonstrating various configurations of capture and storage technologies and geographical locations;

– accelerating their implementation, through exchange of results and experiences between projects. Periodic information on the progress and results of the individual projects is expected to avoid duplications and to speed up the projects, each one benefiting from the feedback from other projects. Feedback to and from ongoing R&D activities in the area will also be valuable, as there will be a constant race to improve the CCS processes;

– organising the contacts and links of projects implemented in Europe with projects in cooperating third countries (in China, in India). A coordinated approach for networking projects in the EU with similar projects undertaken in third countries will also be of the interest of the EU and of the individual project operators, as it is not easy for each of them separately to be informed and to follow CCS developments in each third country;

– preparing for the establishment of CO_2 infrastructure that would serve the needs of the demonstration projects but put in the wider perspective of the deployment of CCS technologies.

3.3.2. Bringing additional support for improving the financial viability of the CCS demonstration projects

By its nature, power generation with CCS will have higher investment costs and higher operating costs than comparable power generation without CCS. As each CCS demonstration plants will deliver electricity on the market, the basic part of the investment (corresponding to a similar non CCS plant) and one part of the additional finance related to the implementation of CCS will be supplied by industry operators. But these operators also expect a financial contribution from public sources, in order to cope with the additional costs and improve the insufficient viability of the CCS demonstration projects.

The market incentives to CCS generation will be provided through ETS. But, the compensation from ETS might prove insufficient for the projects to take off in the present levels of CO_2 prices. It is envisaged to make possible the provision of public support specially dedicated to the CCS demonstration projects, in order for these projects to reach financial viability. The aim would be to achieve a fair compensation. The additional support schemes should cover the gap between the revenue provided by the ETS and the real cost of implementing and operating CCS in each demonstration plant.

This additional support could be provided at the level of the EU and/or at the level of the Member States. In the absence of an EU budget line with sufficient appropriations, the support would be provided at the level of the Member State, mainly through state aid tools. In order to trigger sufficient level of aid, the Commission could announce that it views favourably state aid to CCS demonstration projects, without prejudice to the state aid procedures.

Creating a common logo for CCS demonstration projects could give them additional commercial value. Giving the demonstration plants identity could be later used in the market in order to increase electricity prices for environmentally orientated consumers. Obviously, this would have no effect without launching an information campaign.

3.3.3. Informing the public

Providing information to the public and to the local and regional authorities on CCS technologies will be very important part of this exercise. So far, the use of CCS in fossil fuel power generation is a very novel technological solution which is only understood by a limited number of specialists. Both the CCS technologies themselves and their contribution to the fight against Climate Change must be explained to the wider public.

Some information starts to be circulated by the media already but much more will need to be done. It would make sense to coordinate public awareness activities on CCS technologies and their sustainability, rather than leaving such efforts only to the companies proposing the CCS demonstration projects. An information campaign on CCS processes undertaken by the 'network", a more neutral body in comparison with the companies directly involved in CCS demonstration projects, would certainly be better received by the public.

The construction and operation of CCS demonstration projects in several part of the EU would contribute to such information campaign, as it will be possible for journalists and other opinion leaders to visit the sites and get direct experience.

3.3.4. Further stimulating R&D in CCS technologies

The research community and the operators must be motivated to continue and further develop their R&D activities in the CCS field. Innovating solutions are in sight that would improve the energy efficiency of the plants and reduce the costs and the energy penalty of CCS. These innovations will strongly facilitate the wider penetration of CCS technologies around 2020 and in the post 2020 period. The construction of a number of demonstration projects in 2015 will be a tangible sign that the CCS technology route is firmly established and that further R&D development can be justified and could bring profits.

3.3.5. Providing input for the development of EU Emission Trading System (EU ETS)

ETS will be needed post-2012 to provide an economic tool stimulating low- CO_2 practices and putting effectively CO_2 emitters at an economic disadvantage. Integration of CCS in ETS will be an important element in developing the future ETS into a robust scheme providing clear economic incentives not to emit commensurate with climate policy goals.

However, the demonstration projects will be decided and their construction will start under the present EU ETS but they will be commissioned under the future EU ETS (post 2012) and will operate well beyond. There will be scope for fine tuning the future EU ETS (post 2012)

on the basis of the feed-back from the first years of operation. Developments such as progress of CCS demonstration projects will provide useful source of information on the real impact of ETS in creating a system achieving the expected reduction of GHG emission from the power generation sector.

3.4. Consistency with other EU policies and horizontal objectives

3.4.1. Supporting the Lisbon and EU sustainable development strategies

The implementation of a CCS Demonstration program is fully in line with the strategy for the promotion of a competitive and knowledge-based European economy.

The CCS Demonstration program will test, in real plants, technologies developed earlier under successive R&D programs financed by the EU and by some Member States. It will bridge the last gap between R&D and commercial CCS applications in power generation.

The CCS Demonstration program will generate additional revenues and create new jobs in the power plant suppliers industry and in the construction industry. It will give European companies the possibility to master innovative CCS technologies and to compete on the export markets. Indeed, in the longer term, the main markets for CCS technologies will be outside Europe, in countries which massively use coal in their energy supply, such as China and India. In the longer term, the CCS Demonstration program will contribute to a competitive electricity production in Europe and this will allow maintaining the level of activities and jobs in several industrial sectors highly dependent on electricity.

3.4.2. Supporting the Kyoto agreements and process

The contribution of the Demonstration program, with approx 10 to 12 demonstration plants running, in achieving the 2020 GHG emission reduction target will be modest but real (minus 20 M tonnes per year of CO_2 emissions, in comparison with 2007). In the longer term, the wide penetration of CCS technologies will bring a huge contribution to the reduction of GHG emissions.

The full potential for CO_2 capture in coal-fired generation in 2050, in a scenario where coal-fired capacity in the EU is increased in line with electricity demand and where all coal plants are CCS equipped, was estimated in the range of 800 – 850 Mt in the impact assessment prepared for the Communication on Sustainable Power generation from Fossil Fuels (in annex III – § 4).

Section 4: Policy options

4.1. Overall presentation of the policy options

Three policy options are considered in this Impact Assessment.

Option 0 assumes that no additional or new mechanisms are put in place for supporting the early demonstration of sustainable power generation from fossil fuels. Demonstration depends on industry initiative alone.

Option 1 assumes that a mechanism combining EU coordination and strong Member State and industry commitments is put in place for supporting the early demonstration of sustainable power generation from fossil fuels. The main characteristics of Option 1 are the effective coordination by the Commission of the demonstration projects, the favourable view of the Commission to state aid envisaged for CCS demonstration projects, the decisive involvement of industry operators and the firm commitment of interested MS to establish support schemes for such projects. Option 1 can be implemented using existing legal instruments and agreed EU financial arrangements.

Option 2 assumes that a Joint Undertaking, implementing a Joint Technology Initiative, is proposed by the Commission for supporting the early demonstration of sustainable power generation from fossil fuels. The main characteristics of Option 2 are the more complex mechanism (a JU) for the coordination of the demonstration projects and the possibility for the JU to transfer EU funding to the projects as well as funding from the Member States who will decide to join the JU. The JU would be established through a new EU legislative procedure and would require additional EU financial arrangements.

Without prejudging the results of this assessment, it can be expected that a mechanism foreseen to be put in place on the basis of existing EU legal instruments and agreed EU financial arrangements could be implemented much quicker than a mechanism based on new legislative proposals passing through Council and European Parliament and having financial implications not currently foreseen in the financial perspectives.

It should be noted that the solutions sought in this exercise specifically target the demonstration period and are thus meant to be of temporary nature. In the longer term, post-2020, CCS technologies will be expected to stand on their own feet in technical and economic terms. The technical feasibility in this time horizon is to be achieved partly through the early demonstration but also by continued R&D. The economic feasibility is expected to come in the same time horizon through a combined effect of decreased CCS costs (through R&D, learning curve effects started by demonstration as well as effects of economies of scale stemming from wider-scale spread of the technology after its demonstration) and a suitable general economic environment creating clear incentives for the use of non-emitting energy production methods (largely resting on a robust ETS scheme).

Here follows a more detailed description of the three policy options considered.

4.2. Policy Option 0: No policy change

Option 0 would leave things as they are. This is the business-as-usual scenario.

R&D actions will continue predominantly on improving the individual components of each CCS technology (through FP7 and research financed by Member States). No immediate use of results achieved in R&D in demonstration will be possible. Not much feedback from demonstration will be received for better defining the research priorities.

Demonstration of the integration of CCS technologies in large scale fossil fuel power plants will depend on industry initiative alone, with some Member State involvement. Not much ground will exist for increased involvement of the Commission. No specific mechanism to coordinate and support demonstration projects is established. Little cross fertilisation and exchange of information and results between demonstration projects can be expected to happen.

At EU level, some very limited financial support to demonstration of CCS technologies could come from FP7 (for design and engineering studies related to the CCS demonstration plants). At Member State level, some additional support might be made available for CCS demonstration through national support schemes providing some compensation for the additional investment and/or operating costs of CCS demonstration projects. However, it is expected that only a few Member States (possibly United Kingdom and the Netherlands) and Norway would be ready to give substantial financial support to such projects. No convincing incentives will exist for other concerned Member States and industry operators to engage firmly in CCS demonstration activities.

All decisions on launching or not launching a CCS demonstration project would be made in the context of the current climate policy. CCS can already be recognised under the current ETS and is expected to be fully included in the ETS as of 2013. CCS will thereby receive support through the CO_2 market. However, CO_2 prices are expected to remain below the current additional costs related to CCS projects for several years from now.

The dilemma for Europe is either to take part in the development of CCS technologies (with the associated cost for having an early CCS demonstration programme, but with the resulting benefits of having the know-how and being able to export these technologies to the world markets) or to abandon the role of a pioneer in this technology field and to rely on importing CCS technologies developed by others (probably at higher costs and with uncertain availability around 2020, when CCS technologies will be greatly needed to curb CO_2 emissions).

4.3. Policy Option 1: Combining EU coordination with strong MS and other stakeholder commitments

Option 1 envisages the establishment of a mechanism combining effective EU coordination with strong MS and other stakeholder commitments. This mechanism will perform the functions of coordinating the preparation of the large scale CCS demonstration projects expected to come on stream by 2015 and facilitating access to public financial support for these projects.

The Commission will establish its part of the mechanism through a more focussed use of existing EU legal instruments and in the context of the current EU financial arrangements. For the large scale CCS demonstration projects, the Commission will take responsibility for coordinating the projects and will be assisted for this by an "umbrella" structure to be established under FP7. For triggering financial support from Member States, the Commission

will create a favourable context for state aids to those demonstration projects. However, this will not affect notification obligation by Member States and later case by case scrutiny.

The industry operators will be expected to come forward with firm decisions regarding their large scale demonstration projects.

The Member States concerned by the large scale demonstration projects will be expected to announce support schemes for covering some part of the remaining additional costs of such projects, without delay. These extra public funds should take into account the relative effect of the CO_2 price has on alternative applications, and limit the funding to the difference.

Option 1 can be implemented by the Commission through a more focussed use of EU existing legal instruments and in the context of the current EU financial arrangements, as explained here below.

Firstly, the Commission would take the initiative for the coordination and networking of the CCS demonstration projects. In particular, the Commission will be responsible for:

– selecting around a dozen demonstration projects which cover different project configurations (with respect to technologies used, size, geographical spread as well as criteria related to the maturity of the projects, the commissioning by 2015, the readiness to exchange information, etc);

– organising the exchange of information on implementation and results of the demonstration projects;

– linking projects in Europe with similar projects in cooperating third countries, and

– increasing public awareness.

Indeed, clear benefits can be obtained for the individual projects as well as the Community if the synergies between the projects are maximized. To this end the Commission can take the initiative in order to establish a "network of projects" implemented, at least at first, as a support action under FP7. This would serve as a common European base for the demonstration projects both in the period of their design and construction (ca 2009-2015) and their first five or more years of operation (ca 2012-2020 or even longer).

The "added value" of such a support action both to the projects and to the Community can come from:

– combined knowledge and experience from the individual demonstration projects;

– simplified interaction on behalf of the EU with initiatives in third countries in view of sharing experience with other similar initiatives and/or promoting CCS (and possibly technology transfer) towards countries heavily relying on coal use;

– a marketable identity for the participating projects as part of a crucial EU initiative (an EU logo) and a higher visibility of individual efforts;

– clarification of eligibility for available financing options (state aids, loans from European financial institutions) and other suitable support sources (FP7 co-financing, etc.) as further outlined in sections 4.2 and 4.3.

Selection of projects for participation in the Network should be done by the Commission, assisted by an informal advisory group consisting of independent experts and representatives of Members States. The selection procedure will have to ensure that the projects in the Network collectively fully cover all relevant fuel combustion and capture technologies, geological storage options and key geographical locations.

In this context, the Commission can take into account the knowledge and experience accumulated in the Zero Emission Power European Technology Platform and, in particular, its recommendations on the need for a CCS Flagship Program[17]. The Commission would at the same time continue the close cooperation with the ZEP TP and in particular could focus the discussion on clarifying the possible terms of a "Flagship Programme", its potential for the advancement of CCS and its possible interaction with the Network. The Network could represent a broader base for linking all relevant CCS demonstration projects while the Commission and the industry could aim to develop the Flagship Programme on the top of the Network as a selective European programme for the most innovative, pioneering, promising and complex CCS projects with the highest potential of cross-benefits for all the EU, and possibly also with higher than usual needs for the involvement of the public sector.

To prepare the launch of the "network of projects", the Commission can run a tender under FP7 to select an external entity to establish and administer the "network of projects" with terms of reference corresponding to the following main aims:

– facilitating the selection of projects for inclusion in the Network with the indicative goal of around a dozen of projects by 2015;

– providing coordination and organizing the exchange of information and experience sharing among the participating projects;

– gathering experience from the projects to provide input in the process of establishing a long-term ETS-based value chain for CO_2;

– ensuring coherent and effective interaction with Community research actions and policies (namely FP7 and SET Plan), particularly in view of quick practical implementation of R&D results;

– promoting common practices in monitoring and verification of storage sites;

– increasing public awareness of CCS and building for it a recognition as a safe and effective technique for mitigation of CO_2 emissions as long as fossil fuels are needed in energy mix;

– underpinning Commission activities with third countries on the issue of climate change control in general and CCS in particular.

Secondly, for triggering financial support from Member States, the Commission would announce that it views favourably state aid to CCS demonstration projects, subject to later notification and case by case scrutiny. Such a favourable view on state aid would be justified, as this first series of CCS demonstration projects will have higher investment and operation costs which are not fully compensated by the market, and in view of the long term environmental benefits of such a demonstration program.

---

[17] An explanation of the concept of the Flagship Programme as circulated by ZEP.

Thirdly, the Commission will try to convince Member States to adopt measures at national level for supporting the CCS demonstration projects in view of alleviating their additional costs. The concrete form of such assistance will be specific to each Member State. It can be expected that Member States will draw on existing experience in supporting other forms of clean energy. The mechanisms implemented so far for other forms of clean energy include capital grants (from budget resources) or feed-in tariffs or special certificates (reflected in the electricity price paid by the consumers). Member states could also envisage the use of revenues from auctioning allowances under the ETS.

4.4. Policy Option 2: Establishing a Joint Undertaking

Option 2 envisages the establishment of a Joint Undertaking (JU), implementing a new Joint Technology Initiative (JTI). The JU will perform the functions of coordinating the projects and bringing in public financial support.

Option 2 will be implemented through the following steps.

The Commission will make a legislative proposal for the JU, earmarking also the EU funding that will be transferred to the JU. This legal proposal will be submitted for approval to the Council and the European Parliament.

The Commission will need to indicate where the EU funding will come from. To this end, the Commission could propose to increase very substantially the EU budget available for Clean Coal and CCS under FP7 in order to co-finance large-scale CCS demonstration projects, or to establish a specific budget line. The order of magnitude of such budget increase should be around one billion of € or more, to offer a credible perspective of bringing EU support to a CCS demonstration programme of the order of 5 billions € or more. Such budget increase will need the approval of the Council and the European Parliament, as it will represent a major reallocation of resources within - or a revision of - the current Financial Perspectives of the EU.

When established, the JU will be able to start the coordination of the demonstration projects and to channel the EU funds to these projects (the funds that it would have received in the decision establishing it).

The Member States that will join in the JU will commit them selves to add to the budget made available to the JU, or to transfer money to the projects in some proportion with regard to the EU funding. In such cases, no state aid clearance will be needed for JU spending, as long as no particular Member State will have a control over the money transferred to a given demonstration project.

The support through the JU (including Member States contributions) and the funding committed by industry to individual projects will constitute a Public Private Partnership for financing the demonstration of CCS technologies.

Section 5: Analysis of impacts

This analysis focuses on the impact of individual policy options on the process of CCS demonstration on industrial scale in Europe. Demonstration itself is not likely to lead to a major immediate improvement in climate or to immediate economic benefits. Also, the direct social and employment impacts are likely to be very limited due to the scale of the CCS demonstration projects.

However, the individual policy options differ in their impact on the extent and timing of demonstration efforts and their likely results. This in turn can be decisive in bringing CCS to timely commercialization and then have much more substantial implications for climate, economy and social/employment situation in Europe. The evaluation of individual options therefore focuses on the likely results and characteristics of CCS demonstration in Europe under each policy option.

5.1. Analysis of the impacts of Policy Option 0: No policy change

In the consultation of energy companies done in spring 2007, no company declared itself ready to invest in a large scale CCS demonstration plant, unless it receives some compensation for the additional costs of CCS.

Thus in Option 0, most of the CCS demonstration projects announced so far will not materialize and most power companies will simply shelve their projects.

Most power plant companies will indeed have problems to justify the use of own funds (before the companies boards) or to have access to loans (as they will not reach the status of bankable projects). In the present context, bankers consider CCS demonstration projects as non bankable (because of the lack of positive cash flow from operating CCS equipped power plants).

This will lead to an uneven development of technologies and among Member States in Europe. This will postpone/delay investment in demonstrating CCS technologies in Europe.

Only a few very big operators have the financial resources and might be willing to take some early risks, anticipating an upwards trend of the CO_2 price while national funding will only be made available in a few Member States. Consequently, most planned CCS demonstration projects will be postponed or cancelled because of their lack of financial viability under current conditions. However, long term economic viability of CCS can only be achieved if a variety of CCS technologies and concepts are tested on a large scale. So far, there is no clear view on a winning CCS technology. Each CCS route could bring a solution to a different problem: post-combustion for retrofitting existing plants; IGCC for base load power production and for hydrogen; Pulverised Coal with oxy fuel for a modulating power output.

It can be assumed that, with no additional actions, only a small number of large scale CCS demonstration projects will be constructed out of the over 20 full chain CCS projects currently planned by industry (see list in annex): in total two to three coal-fired projects (in the Netherlands and the UK) and one to two natural gas–fired projects (in Norway), bringing the total of full-size CCS demonstration projects in Europe to five at maximum. The construction of only a limited number of demonstration projects in the EU will have several negative impacts as the critical mass of demonstration efforts would probably not be reached.

This can have the following particularly repercussions on the progress of a comprehensive development of CCS in Europe:

– some interesting CO_2 technologies and combinations of them will not be tested;

– smaller cost reduction of future CCS installations will be induced as the learning curve can only be exploited for very few technologies in individual operations;

– only a very limited number of transport and storage options will be tested, which will considerably delay the implementation of a European CO_2 transport and storage infrastructure and thereby also put additional obstacles to new investments in CCS equipped power plants;

– CCS can have no impact on reaching the CO_2 reduction aims of 20% by 2020 and also reaching the reduction aims for 2050 will be difficult as the commercial deployment of CCS will start considerably later than 2020;

– research efforts will not be triggered by real life experiences and thus might not be as focussed and as efficient as if a large number of demonstration projects were in place;

– several potentially interested Member States and power plant operators will be excluded from taking part in this technological development;

– in all major economies relevant investments in CCS are currently being taken. The EU risks loosing its technological leadership in power plant equipments integrating CCS technologies and will thus risk its role in the future world market for CCS technologies.

5.1.1. Impact on the economic viability of CCS and technology diversity

As result, CCS development in Europe would probably slow down, loosing the current momentum and limiting itself to a few advantageously disposed locations (most likely the North Sea shores of the UK, Norway, Netherlands, plus a few industrial areas in Germany). Most of the Member States that foresee to continue to rely on coal fired generation in the future, but are not among the few European front-runners of CCS today, would not see much incentives to get involved in CCS technologies. The same would apply to most power generation companies, except for a few largest European operators already involved in CCS.

There is also a risk that the best CCS solutions are not tested in Europe. It could be anticipated that the few CCS demonstration projects that will be implemented in a business-as-usual scenario would try less innovative, most "obvious" CCS technology routes. This could lead to the development of solutions that could address some most immediate emission challenges through retrofits, but would have a relatively high energy penalty (like post- combustion capture for retrofitting existing coal-fired plants) and would provide solutions only for specific cases and on temporary basis. More promising CCS technology routes with more development requirements at the present stage but promising lower energy penalties (like pre-combustion capture in IGCC plants or oxy-fuel in Pulverised Coal plants), would risk not to be tried at all or given only cursory attention.

The ultimate consequence for Europe could be to become an importer of CCS technologies in the medium and possibly even longer run. If the EU does not take early action that would lead to a similar progress in similar timeframe (large scale demos on stream by 2015), it may indeed start lagging behind. In view of the general length of the investment, innovation and

policy cycles in the energy sector, this could by 2020 or soon afterwards result in the risk of EU inability of indigenous production of CCS technologies. An opportunity to develop a new industry, with exporting potential, would thereby risk to have been missed.

Furthermore and as outlined earlier, CCS requires additional investment and its deployment increases operation costs which are not yet paid for by the market. In the long term, this compensation mechanism can be provided by the ETS. However, in the initial phase grants or loans are needed to finance the risky and costly initial investments and operations for which currently neither the energy market nor ETS fully compensate. In a business as usual scenario, such incentives mechanisms are not provided in a coordinated manner. Any support might only be available on Member State level which is currently only expected to be available in a very few Member States and Norway and thus limiting the number of demonstration projects, the technologies used for fossil fuel combustion/gasification and carbon capture, the transport and storage concepts and the geographical spread.

Relevant cost reductions for CCS can only be achieved in a relatively short timeframe if the technologies are tested on a large scale and if there is sufficient exchange between different CCS projects. Such an exchange is not expected to take place in efficient manners if only a limited number of demonstration projects exist which do not have institutionalised information exchange mechanism. Thus the learning curves in CCS technologies and the related cost reductions will be delayed as well as the commercialisation of CCS.

In addition, in Option 0 these learning curves can only be exploited for very few technologies. Different technology routes for coal combustion/gasification (post combustion, pre combustion and Oxy-combustion) as well as for capture technologies exist, resulting in around a dozen main technology solutions for the whole CCS process. Unless demonstrated on industrial scale, no definite statement can be made on which of the various solutions proofs to be the most viable one. In Option 0 only a few of these technology solutions can be tested, possibly leaving out viable technology routes and thus delaying economic profitability. As result, the break-even CO_2 price for individual CCS technology options is likely to remain for most solutions at relatively high levels for quite some time. The break-even CO_2 price is for individual technologies currently in the range of €25-67 above long-term ETS average.

In Option 0 only a very limited number of transport and storage solutions would be tested, which will considerably delay the implementation of a European CO_2 transport and storage infrastructures. This will also put additional obstacles to new investments in CCS equipped power plants as access to transport and storage capacities might be difficult.

5.1.2. Impacts on the environment (on global environment and on air pollution)

Regarding the potential for CO_2 capture, the modelling undertaken in the preparation of the Directive on geological storage of CO_2 estimated that with CCS generally commercially viable by 2020, the amount of CO_2 captured in the EU27 can be:

– around 7 Mt in 2020 and 161 Mt in 2030 (representing in 2030 13.2% of emissions from power and steam generation) in the scenario "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS enabled under ETS" and

– around 75 Mt in 2020 and 517 Mt in 2030 in the scenario "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS made mandatory on all new coal- and

gas-fired power plants from 2020 onwards, together with retrofit of existing power plants from 2020".

This modelling also indicated the potential benefits of reduced air pollution.

If a critical number of CCS demonstration projects are not implemented in the coming years, CCS technologies will not be fully demonstrated and will not be ready for commercial deployment after 2020. It could then take an additional decade or longer until CCS in power generation will be used on a commercial basis. Thus CCS would have no impact on the CO_2 reduction aim of 20% by 2020 and the potential for CO_2 capture by 2030 would remain largely unrealized. The modelling mentioned above estimates that the total costs of meeting an EU reduction target of 30% for GHG by 2030 would increase by some 60bn € (or 40%) if CCS were not enabled. Also the economically attractive CO_2 reduction potentials of CCS in power generation would not be fully exploited by 2050.

In less extreme conditions, Option 0 would lead to delays in the introduction of CCS, but any delay would compromise current ambitious goals for fighting climate change. Indeed , studies (e.g. Shell 2007 Scenarios) show that every year of delay in the introduction of CCS can have serious global consequences. The consequences of a global shift of CCS planned activities by 7 years will lead to 90 Gt CO_2 (90 Giga (Billion) tonnes) of avoidable CO_2 emissions being released world wide over the scenario period to 2050. This is equivalent to 3 years current global emissions (of about 30 Gt CO_2 per annum). This translates in a 10 ppm difference in the atmospheric CO_2 concentration, which is significant relative to the 120 ppm bandwith between 380 and 500 ppm that policy makers world wide are targeting.

Furthermore, the construction of only a limited number of demonstration projects in Europe will not support EU efforts to engage more third countries on a GHG reduction path. With not sufficient demonstration effort at home, the EU will not be able to set an example and convince third countries to join the GHG reduction strategy.

Regarding air pollution, as only a very small number of CCS demonstration projects are expected to be constructed under this Option 0, the impacts on emissions of SOx, NOx and particulates can be neglected till 2020 and probably later.

5.1.3. Impacts on diversification of the energy mix and on the cost of electricity

There is a possibility of a radical shift from coal use to other fuels in Option 0 when CO_2 emissions are strictly constrained, but such development will be to the detriment of the diversity of EU energy mix and resulting implications for security of supply.

In the short term, electricity (production) cost will not increase due to the use of CCS, as it will not be deployed widely.

However, delaying the demonstration and wide deployment of CCS can have a strong negative impact on energy costs and also on the role of fossil fuels in the energy mix in the long term, when the availability of CO_2 allowances will have been reduced. The scarcity of CO_2 allowances might then raise costs for energy produced by fossil fuels without CCS and might thereby also decrease the share of coal in the energy mix which in turn will lead to a higher energy dependency on third countries.

5.1.4. Impacts on the economic and social dimension, international cooperation and R&D

Currently the EU is among the technology leaders in clean coal technologies and in emerging CCS technologies. However, in other major economies, significant investments are being made into CCS technologies and large scale demonstration projects. Today, Australia and the USA are not ahead of Europe in the sector of power plant equipment and CCS technologies. However, they have taken initiatives in the field of CCS demonstration which could bring them ahead in 10 years time, if Europe is not progressing in parallel.

In Option 0, the EU risks loosing its technological leadership and consequently shares on the upcoming market for CCS technologies if large scale investments in CCS are not being made in Europe now. With increasing pressure to fight climate change and continued reliance on coal, the EU could find itself in the position of an importer of CCS technologies developed on other continents (in USA, in Japan or even in China.

The loss of EU's technology leadership can also have consequences for the global development of CCS technologies as EU represents one of just a few economies (besides US, Australia, Japan) with the capacity to bring CCS to market.

In this context, the cost of inaction is the effect to be really considered. The Stern report makes clear that addressing climate change will be costly but avoiding action will be even costlier. The report estimates the cost of inaction at 25% of future GDP by 2050. Inaction related to CCS can be expected to contribute an important part of such GDP decline, adequately to the fact that CCS is estimated to have the potential of reducing global CO_2 emissions by 37%.

Also the European leadership in CCS-related research might be lost. It is expected that the large scale demonstration of new technologies will give clear indications for research needs to make CCS technically and commercially more viable. In turn research result can easily feed back to large scale demonstration to test their applicability. In the absence of a coordination mechanism which stimulates and channels the cooperation between industry and research, this much needed exchange and feed-back might not take place with the needed intensity. The construction of only a limited number of demonstration projects in the EU will not trigger additional R&D needed for further improving the CCS technologies. As a consequence, only a slow progress towards reducing the cost burden of CCS technologies could be expected.

Public acceptance especially of CO_2 storage is very important to apply this technology on a wide basis. Convincing the public through dedicated campaigns initiated by the coordination program and through early demonstration of the safety of storage will be crucial for a fast roll out of this technology after 2020. This public acceptance will not be reached if no coordinated actions on a European level are taken.

There will be very few opportunities for cooperating with third countries on CCS technologies if Europe is not taking the lead in CCS R&D and large scale demonstration.

5.2. Analysis of the impacts of Policy Option 1: Combining EU coordination and strong MS and other stakeholder commitments

Under option 1 an effective coordination of the demonstration projects can be carried out and a favourable context can be created for the supply of additional public support (through investment grants and compensation schemes) at Member State level. This option can be

quickly implemented by the European Commission using existing instruments and agreed financial envelopes. The structure for the coordination and networking of the demonstration projects can be in place in the course of 2008.

Policy initiatives at EU level as outlined in Option 1, including but not limited to the speedy creation of a coordination network for CCS projects, can be expected to mobilize several interested Member States to seriously consider CCS demonstration activities on their territory and to devise appropriate support schemes at their level. It can also incentivise industry operators to go forward and convert their declared intentions into firmer commitments, starting with a preliminary earmarking of available own resources and a detailed design and evaluation of the announced projects. All this is expected to open the way to increased investment in CCS demonstration, including the involvement of public funds, albeit mainly on Member State level.

It is expected that such an approach (an EU-wide coordination structure, supported by policy measures on EU level and by strong financial commitments at Member State level) would facilitate the decision making of project promoters and operators and will lead to accelerated preparation and construction of the individual CCS demonstrations projects.

Besides the mobilizing effects, the initiatives under Option 1 will enable more efficient spending of financial resources made available at Member State level to support CCS demonstration. An EU-wide coordination and information exchange will lead to welcome synergies between projects, avoiding duplications and focusing projects collectively on the problems remaining to be solved, etc.

On the basis of consultations undertaken to date, the preliminary following criteria could be considered for use in the selection of projects for participation in the "network of projects":

– capacity of at least 300 MWe, with significant use of fossil fuels (but allowing e.g. also biomass co-firing); in case of multiple-purpose installations the power generation element should represent a fraction of the total capacity corresponding to at least 250 MW;

– inclusion in the project concept of technical solutions for all parts of the concept of sustainable fossil fuels in power generation, ie. efficient power generation (at BAT level), capture of CO_2, its transportation and injection underground for a safe long-term storage;

– provisions for the capture and storage rate of at least 85% of the carbon content of the fossil fuels used;

– commissioning before end of 2015;

– demonstration of a clear commitment for the project to be undertaken (e.g. presentation of a FEED study for the project[18]);

[18] FEED = "Front-end engineering and design" study, specifying in concrete terms the details of the project and including binding indications on location, equipment parameters, contractors, operating plans. The preparation of a few of such studies could be co-funded from FP7 under cross-over activity Energy 5&6 ("Cross-cutting activities between Clean Coal and CCS"). Specific EU financing should only be provided to a few most deserving projects, e.g. by rewarding the most innovative and/or cost-efficient ones.

– readiness to share information on the project, subject to protection of intellectual Property rights (IPR).

The network of CCS projects will maximize its utility if it is open to all projects that qualify. The list in Annex 1 has more than 30 projects with around 20 projects proposing the full chain (capture, transport and storage of CO_2). The number of projects which could participate in the "network of projects" in Option 1 is between 5 (minimum, as per Option 0) and 20. In reality, it can be expected that a number somewhere in the middle (10-15) would be most likely. This would represent a significant improvement (and added value of the Option) over Option 0 and would be compatible with the indicative target of ca 12 projects.

With such result, it can be expected that by 2020, CCS technologies would be sufficiently demonstrated and ready for quick penetration in the energy sector and possibly beyond it. Their commercial deployment and wide use would be dependent on the market incentives provided through the ETS at that time.

For Option 1 to be really effective, there are two indispensable conditions to fulfil:

– industry operators having announced CCS demonstration plants will be urged to indicate how much of the additional cost of their plant they will be ready to finance from own resources;

– for their part, the Member States which will continue to rely on coal and other solid fuels for their electricity mix will be urged to announce without delay their plans for financial support to CCS demonstration projects to be built on their territory. The Commission would expect that such commitment is endorsed by the European Council.

5.2.1. Impact on the economic viability of CCS and technology diversity

It is expected that with the coordinated operation of around a dozen co-operating demonstration plants economic viability of CCS can be reached considerably faster than without a coordinated approach. This is due to a number a factors:

– the coordinating organisation will guarantee that all technology routes for coal combustion/gasification as well as for capture technologies are well represented in the demonstration program. Thus it is likely that the most viable solutions will be included in the program which can be competitive in a short timeframe;

– the exchange of information of the demonstration projects will help to identify best solutions for the individual demonstration projects and thereby the learning curves in CCS technologies will be achieved considerably faster;

– also the constant exchange with European and national research programs will help to achieve commercial viability faster than in an uncoordinated approach.

Moreover, the presence of a coordinating mechanism (even in the absence of a centralized programme) will allow the EU to leverage initiatives taken at the level of individual Member States and industrial players. This should help the EU efforts on CCS to cover the widest range of technological options for capture, transportation and storage with a number of geographical and organizational choices. This will in practice mean that by 2020 European public authorities and the energy sector could have at their disposal technological solutions based on CCS for both existing fossil fuels power plants (post-combustion applications

enabling retrofits) and for new installations (presumably based on pre-combustion technologies as the ones likely to be by then developed and confirmed as most efficient).

Finally, also different transport and storage concepts in different geographical locations will be tested. This will give clear and early signals to the Member States and the European Commission on best options for transport and storage and thus help them in defining and establishing a European CO_2 transport and storage network.

All this is expected to lead to a substantial reduction CCS costs, contributing to the economical viability of CCS applications.

The modelling of the scenario "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS enabled under ETS" undertaken in the preparation of the Directive on geological storage of CO_2 estimated that the EU ETS could deliver a price of around 45 €/t CO_2 in 2020 and around 50 €/t CO_2 in 2030. If CO_2 prices stabilises at such levels, it can be expected that CCS will be generally commercially viable and could rapidly penetrate the electricity generation market, without the need of subsidies.

5.2.2. Impacts on the environment (on global environment and on air pollution)

It is estimated that plants equipped with CCS would be able to capture at least 85 % of the volume of CO_2 generated in their combustion/conversion process. Assuming that 12 CCS demonstration power plants will be constructed with an average capacity of 330 MW each, the corresponding CO_2 emissions could be reduced from 24 Mt per year to 4 Mt per year. The demonstration program represents only a very small part (2%) of the coal-based generation capacity in the EU-27.

The impact assessment prepared for the January 2007 Communication showed that systematic use of CCS technologies from 2020 onwards, through construction of new CCS equipped power plants and through retrofit, could greatly contribute to reaching the ambitious CO_2 emissions reduction targets in the EU as there is a potential for CO_2 reductions of 135-170 Mt/year in 2030 and an ultimate potential of 800-850 Mt/year in 2050, if all coal based power plants in the EU are equipped with CCS and have access to sufficient CO_2 storage capacity.

Regarding air pollution, depending on the CCS technologies that will be used and on the level of de-polluting installations that will be integrated in the power plants, there may be some negative effects on SOX, NOx and Particulates emissions, at the initial stage as the CCS demonstration plants will use more primary fuel to produce the same amount of electricity (because of the energy intensity of carbon capture). These negative effects would mainly occur in post-combustion CCS plants (separation of the CO_2 after combustion with air). On the opposite side, pre-combustion IGCC and oxy-combustion CCS plants will radically reduce some of these emissions because they will be fully captured in the process or because they will not produced at all. In the longer term (after 2020), with continuous R&D improving the energy efficiency of the plant and reducing the energy penalty of the CCS process, any additional volume of pollutant emissions resulting from operation with CCS will be proportionally reduced.

The net impact of the Demonstration program on air pollution could be quantified only on the basis of precise information on the share of each CCS technology in the demonstration program and the level of de-polluting facilities that will be installed in each demonstration plant. However, the long term net impact on air pollution (after 2020) is expected to be

positive, as the new generation of less polluting power plants technologies based on pre-combustion (IGCC) and oxy-combustion CCS plants will progressively replace the existing more polluting power plants.

The environmental results of the analysis done in the present Impact Assessment are supported and are compatible with the detailed quantitative impacts on global environment and on air pollution done in the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide[19], which for the scenario "20% GHG reduction target, 20% renewable energies, full auctioning, and CCS enabled under the EU ETS" estimated that:

– with CCS generally commercially viable by 2020, 21 GW of coal-fired installed capacity will be equipped with CCS in 2030. The amount of CO_2 captured in the EU27 in this scenario will be 7 Mt in 2020 and 161 Mt in 2030. Higher volumes between 267 and 517 Mt of CO_2 could be captured already in 2030 in other scenarios, if CCS is made mandatory in 2020 for coal only, or for both coal and gas, and with rapid retrofit;

– there will be additional benefits on air pollution in this scenario due to CCS.

5.2.3. Impacts on diversification of the energy mix and on the cost of electricity

As highlighted earlier, the demonstration program would facilitate and accelerate the equipment of large parts of the fossil fuel power plants fleets with CCS after 2020. This will allow using fossil fuels in a sustainable way. Thereby the demonstration program will contribute to the diversification of the energy and electricity mix and to the security of energy supply in the long term.

On the other hand, CCS electricity is more expensive than electricity produced in a comparable plant without CCS.

The immediate impact on the cost of electricity from the implementation of the CCS demonstration programme itself will be negligible. Indeed, even with an assumption of a 40% increase of the cost of electricity generated from the CCS demonstration plants, the average production cost of electricity would increase by less than 1%. This price effect will probably be hidden by larger electricity price fluctuations caused by other factors.

Without pricing the CO_2, Climate Change Capital analysis indicates that the electricity production costs would increase:

– from the current range of 37 - 51 €/MWh for a Pulverised Coal plant without capture;

– to the range of 48 – 70 €/MWh for an IGCC plant with pre-combustion capture;

– to the range of 55 – 77 €/MWh for a Pulverised Coal plant with pos-combustion capture; and

– to the range of 55 – 85 €/MWh for a pulverised Coal Plant with oxy-fuel.

[19] COM(2008) 18.

In the longer term, and with continued R&D efforts, it is envisaged that the additional cost of producing electricity with CCS could be progressively reduced. Taking this into account and assuming a fully functioning ETS, electricity production costs in CCS plants will be fully competitive with traditional electricity production.

With a wider penetration of CCS in the generation sector, the impact on the average cost of producing electricity will start to increase, but such increase could be balanced by firmer CO_2 prices. These results of the analysis done in the present Impact Assessment are compatible with the detailed quantitative impacts on global environment and on air pollution done in the impact assessment prepared for the Commission Proposal for a Directive of the European Parliament and of the Council on the geological storage of carbon dioxide[20], which for the scenario "20% GHG reduction target, 20% renewable energies, full auctioning and CCS enabled under ETS" estimated that:

– the CO_2 price required in this scenario to achieve the 20% GHG reduction target is 44.5 €/t CO_2 in 2020, increasing to 50.5 €/t CO_2 in 2030;

– the additional cost to supply energy in this scenario would be in total in the order of 70 € billion /year (but only one part of this additional coast is due to CCS). And 15 € billion /year would be added if CCS is made mandatory on both coal and gas, with retrofit required;

– the commercialisation of CCS would increase the average cost of electricity generation by up to 9% in 2030, if CCS is made mandatory on both coal and gas, with retrofit required.

5.2.4. Impacts on the economic and social dimension, international cooperation and R&D

In Option 1, the additional finance needed for coping with the higher investment and operating costs of CCS demonstration projects could come from four sources: (i) the industry operators proposing the CCS demonstration plants, as they will be investing in their future capability to remain in the power generation business; (ii) the Member States, if budgetary resources are allocated; (iii) the electricity consumers if feed-in tariffs or low carbon certificates are implemented; and (iv) funds from the auctioning of ETS allowances.

If this additional finance is shared 50/50 between private and public, the financial support that will be expected from the public side (from MS budgets and/or electricity consumers and/or companies under ETS) can be estimated to be of the order of 250 millions € for a 400 MW plant or 500 millions € for a 800 MW plant (calculated as one upfront payment) assuming that the allowance price is zero. Obviously, the additional finance needs would be reduced by the actual value of the allowances which correspond to the volume of CO_2 stored. A stable 20 €/t CO_2 price would mean that the above mentioned additional finance needs would be roughly cut by half. In total, for the dozen of CCS demonstration plants, the commitment for the public side could be of the order of 4 billions € (in all MS together) assuming that the allowance price is zero or in the order of 2 billions € assuming a price of 20 €/t CO_2. This is obviously a substantial amount of money, but it should be compared to the expected advantages of demonstrating the CCS technologies (the huge potential for reducing CO_2 emissions in Europe and in the world). (see the impact assessment prepared for the revision of ETS).

[20] COM(2008) 18.

The suggested CCS demonstration program will help to maintain the EU's technological leadership in clean coal and CCS technologies and thereby contributes to the Lisbon strategy. In a growing world wide market for these technologies this leadership opens opportunities for job creation and for export to third countries.

Implementing the Demonstration program will reveal and confirm additional needs for further R&D in CCS technologies from real life experience. It will also provide a strong indication to the research community that ongoing and new research activities in CCS will have a good potential to be used in the demonstration projects or in the first generation of commercial plants. The demonstration program is planned act as an intermediary between projects and research institutions and thereby helps to communicate research results and industry needs. Moreover, the demonstration program will maintain close contacts with R&D stakeholders on member state ad EU level and thereby contributing to the efficient use of financial resources.

The envisaged demonstration program will maintain and organise international contacts to take up industrial developments and to identify market needs in third countries. These cooperation activities are expected to be crucial when it comes to technology developments.

Coordinated activities to raise public awareness for CCS technologies will be carried out through the umbrella structure, increasing public information and acceptance and there bye paving the way for fast deployment of this technology.

5.3. Analysis of the impacts of Policy Option 2: Establishing a Joint Undertaking

In principle, option 2 could have – in the long term - similar impacts as the coordination mechanism described in option 1. Moreover, a joint undertaking has own financial resources to be allocated to demonstration projects and thus the program could channel investments more proactively. These financial resources would be made available by Member States, industry and the EU.

However, a proposal for a new Joint Undertaking is expected to be highly debated in the Council and in the European Parliament and the discussion will probably not be concluded in the present term of the European Parliament. In addition, such a proposal would raise financing issues, as EU funding for a joint undertaking is not available under the current financial arrangements. Also the financing by Member States and industry may be critical. It can be expected that reaching an agreement on the financing issues could take a long time leading to a delay of the implementation of the joint undertaking not before 2012. Consequently, a sufficient number of demonstration projects would not be constructed by 2015 and CCS technologies will not be fully demonstrated by 2020.

In this option, most decisions to engage in the construction of CCS demonstration plants will be delayed by several years and only a small number of CCS demonstration plants will be constructed by 2015. CCS technologies will not be fully demonstrated in Europe by 2020, with the risk for Europe to become dependent on the imports of such technologies. Sufficient demonstration of CCS technologies will be delayed, at least till the mid 2020ies. The negative effects are similar as for Option 0 for the short- to medium term. In the longer term, most of the benefits of Option 1 could materialize.

It is possible to consider both Option 1 (the Mechanism) and Option 2 (the Joint Undertaking) as a phased approach instead of alternatives. Indeed, options 1&2 can be seen as not mutually exclusive but rather could be time-complementary. It can be imagined that option 1 can

represent an immediate solution for jump-starting demonstration efforts in Europe, for ensuring that the momentum which CCS has gathered in the EU in the past 1-2 years is maintained, and for leveraging and extending the achievements in CCS R&D in Europe to date. Option 2 can follow in due course as the next step in order to complement or take over from Option 1 once the conditions are ripe for such progress. This can take just 2-3 years in the current EU reality and with regard to global trends but probably not significantly less.

It can be generally stated that the possibility of a phased approach does not imply the need to develop specific mechanisms or criteria for Option 1 differently from a situation where Option 1 would be not only the first but also the only one to be pursued even in the long term. Quite the contrary - defining Option 1 adequately universally and flexibly (in terms of criteria and individual mechanisms involved) seems as the best way to enable it to deliver on its own or to provide a stepping stone for later actions in the sense of Option 2 (if and when future developments require/enable so). In sum, Option 1 could be the starting mechanism, while Option 2 would come at a later stage.

However, there are several conditions for Option 2 (Joint Undertaking) to become feasible, but which do not condition the feasibility of Option 1:

– industry operators should come with clear figures on how much they are ready to spend on each demonstration project;

– a coherent approach should be adopted for all energy technologies in the EU (this is the aim of the SET-Plan);

– it should be clarified where the EC funding for the Joint Undertaking would come from and how much. The SEP-Plan foresees to evaluate this next year. The options are to find a solution in the mid-term review of the current Financial perspectives (and eventually of the mid-term review FP7) or outside of the EC budget.

These conditions may take several (3 to 5) years to materialise. This is why Option 1 (the Mechanism) can be an immediate (and intermediate) step while Option 2 (the Joint Undertaking) could be the further step assuming that the situation does not develop in the meantime in a way to indicate otherwise.

5.3.1. Impact on the economic viability of CCS and technology diversity

This option is relatively similar to the choice made in other advanced economies, especially the US where the FutureGen Alliance was set up as a kind of public-private partnership with the aim of one large-scale demonstration project by 2012. As such, it concentrates the efforts on one selected technology option being tested in one particular facility. This seems quite risky in the area of technology development. On the other hand, it is clear that concentration resulted in beneficial budgeting decision as the FutureGen Alliance currently disposes with a budget of $1.5bn.

Similarly, Option 2 could bring more EU funding to the CCS demonstration projects than Option 1, but only if such additional funding can be made available within the EU financial perspectives, which is for the moment very uncertain. It is likely that only a few member states (those with a considerable fleet of fossil fuel plants and in which concrete plans for CCS power plants exist) will be interested in joining the program in the beginning, dissipating the effect of a centralized scheme.

However, as only a few projects will be funded the net impact for each participating Member State and industry is very difficult to predict and might make it questionable for some players to invest money in this initiative instead of supporting individual projects in their country.

In general it seems doubtful if a joint undertaking which will fund a

– relatively small number of projects

– with a small number of beneficiaries

– from only a few member states

– with very high amounts

can raise the needed political and financial support from all Member States and a critical mass of industry players.

Thus the establishment of a Joint Undertaking can even reduce the available funding or lead to separate member state programs which in turn will reduce the positive impact of a European coordinated program as outlined in option 1. Only if all interested member states and industries join the joint undertaking and contribute financially to it, the positive impacts on financial viability of a coordinated program as outlined in option 1 can be reached. However, due to the legal and organisational complexity of a joint undertaking these positive impacts can only be achieved with a delay of approx. 5 years in comparison to option 1.

5.3.2. Impacts on the environment (on global environment and on air pollution)

The impacts will be similar to those described under Option 1. However, all described CO_2 reduction potentials – for the demonstration program as well as for the wide CCS penetration - will only be effective with a delay of approx. 5 years. Thus, CCS will not help reaching the CO_2 emission reduction targets for 2020 and for several years after.

5.3.3. Impacts on diversification of the energy mix and on the cost of electricity

The impacts will be similar to those described under Option 1 but will only be effective with a delay of approx. 5 years. In a fully functioning ETS this delay in using CCS in commercial operations might lead to a higher, non competitive price for coal generated electricity. This might reduce the share of coal in Europe's energy mix and thereby increase energy dependency.

5.3.4. Impacts on the economic and social dimension, international cooperation and R&D

In Option 2, the total amount of financial support from public sources would be the same as estimated in Option 1, but will be needed later, if the dozen CCS demonstration plants are simply delayed by around 5 years. This total amount will be lower, if a smaller number of CCS demonstration plants are constructed. If one part of the public funding is provided from the EU budget, the amounts that would be needed from the MS side (from budget, electricity consumers and/or companies under ETS) will be proportionally reduced.

The delay in implementing the JU and erecting the demonstration projects bears high risk for European competitiveness. Third economies already started investments in CCS technologies and demonstration plants (USA, Japan, etc.). By delaying its demonstration program, the EU

risks losing its current technological leadership in clean coal and CCS technologies. As a potentially very big market for CCS is developing, European companies will lose export opportunities and this will weaken European competitiveness.

The task of international cooperation will also be taken up by the JU, but with a delay of several years.

The positive impacts on R&D will also be delayed. Improved coordination of research and demonstration on Member State and European level will only come in place once the demonstration plants will be running, thus with at least a delay of approx. 5 years. This might be critical as important research result will only be taken up with delay from the European industry putting an additional risk that third economies take over technological leadership.

The information campaign and public awareness will also be delayed, and this will have a negative impact on the issuing of authorisations to engage in CCS activities in power plants and for the CO_2 infrastructure (in particular for storage).

Section 6: Comparing the options

By comparing the individual impacts per option the following conclusions can be drawn from the impact assessment.

In business as usual (Option 0), only a very limited number of demonstration plants will be constructed in a few European countries where strong support for CCS exists.

When establishing a Joint Undertaking (Option 2), it can be expected that a greater number of projects can be developed. However, the establishment of a Joint Undertaking is a time consuming process involving different actors on European and Member State level. It can therefore not be expected that such an undertaking can take up its work before 2012 and that demonstration plants will only be constructed by 2020 but not sufficiently tested. In addition, there is a great risk that a JU will not get the needed financial and political support from the EU budgetary authorities (the European Parliament and the Council) and that it will not take off at all.

The ETP-ZEP estimates that a "Flagship Programme" of a dozen large scale CCS demonstration projects would require the capitalization of €9-16bn. This would correspond to a contribution from EU public funds in the order of magnitude of €5 billions or more.

But only a limited amount of EU funding could be made readily available for the JU from the FP7 budget currently foreseen for Clean Coal and CCS (in the range of 100-200 millions €) and such amount can not finance a comprehensive demonstration program.

A mechanism for coordinating demonstration projects (Option 1) can be set up by mid 2008 and start immediately its coordination and support tasks. If coupled with strong commitments by industry operators to engage in demonstration and by the concerned Member States to put in place CCS support schemes, it is likely that around a dozen demonstration plants will be running by 2015.

The operation of a large number of CCS demonstration plants will also have an impact on the establishment of European transport and storage infrastructure. It is only if a sufficient number of projects will be in place that a critical mass for infrastructure investments can be reached. This is likely to happen by 2015 only under Option 1, while it will be delayed under Options 2 and might even never happen in Option 0. The timely establishment of a European infrastructure is a pre-requisite for investment decisions in commercial CCS power plants and for capturing and storing CO_2 emissions from power generation and from other industry sectors.

6.1. Conclusions on the economic viability of CCS and technology diversity

In Options 0 and 1, financial incentives for investments in CCS power plants will mostly be available at Member State level. While under Option 0 no coordination is carried out and access to financial support is not facilitated, the mechanism as suggested in Option 1 will coordinate the definition of projects, will urge concerned Member States to provide support schemes and will assist potential investors in accessing available funds and loans.

In Option 2, the Joint Undertaking would have its own financial resources from EC and Member States, to supplement the funds to be committed by industry to the CCS

demonstration projects. However, it is very probable that the available budgets will not be larger than in Option 1, as no additional budgets for CCS actions are foreseen in the EU Financial Perspectives. Member States could be tented to prefer keeping full control of their funds, rather than going through a Joint Undertaking structure. Also industry might be reluctant to have their projects selected through the procedures of the Joint Undertaking and would rather take their investment decision independently. On top, these financial incentives can only be made available after the Joint Undertaking will have been fully established and funded, which is expected to be too late for demonstration plants to be operational by 2015.

In Options 1 and 2 the status of an official project under the CCS demonstration program will be granted by a selection board or experts committee. This body will take care of that all technology routes and different transport and storage concepts are represented in the program and thus a variety of concepts will be tested and brought to the market. Under Option 0 no selection of projects will be done on a European level and only a very small number of technologies will be tested, with the risk of leaving out promising technology routes.

Only the mechanism as presented under Option 1, which supposes that strong MS and stakeholder commitments are announced without delay, will be capable of supporting projects actively and pave the way for funding from 2008 on. While under Option 2 the same could probably be achieved with at least approx a 5 year delay, the business as usual (Option 0) can neither guarantee that all technology options are tested nor can facilitate access to funds and loans.

Option 1 will allow closing the viability gap of the first generation of early CCS demonstration projects. It will initiate a process of testing the real prices of CCS. It will trigger without delay a downward trend of CCS costs through the combined effects of innovative R&D, demonstration, scaling up of capacities and progressing on the learning curve.

6.2. Conclusions on the environment

Under Option 0 almost no favourable impact on CO_2 emissions can be expected by 2020 as just a very small number of demonstration projects will be in place. In the long term, the CO_2 reduction perspectives are not favourable without CCS. CO_2 emissions from fossil fuel power plants will remain high (unless forced to decrease by very high CO_2 prices or a ban of non-CCS electricity), as market uptake of CCS technologies will take considerably longer as in cooperated actions as described in option 1 and 2.

Under Options 1 and 2, emission reductions achieved in the demonstration plants phase can reach at least 20 Mt/year in 2020 in Option 1 (or later in Option 2) with a full potential of CO_2 emissions reduction of up to 850 Mt/after after all coal fired plants will have been equipped with CCS (possibly by 2050). These positive impacts can be realised faster in Option 1 which proposes implementing, without delay, EU coordination and MS financial support, as accompanying measures to strong industry involvement.

6.3. Conclusions on diversification of the energy mix and on the cost of electricity

It is likely that the price for electricity would marginally increase due to the higher production costs of energy with CCS. The earlier demonstration plants will be in place, the sooner this effect will be realised. However, in the long run it is expected that the ETS will fully

compensate for the higher CCS costs and the use of CCS will not lead to higher energy prices, in comparison to the production of electricity without CCS, at that time.

Regarding the impact on the energy mix, it is expected that coal can only keep its share in energy supply if its CO_2 emissions can be drastically reduced. The early adoption of CCS technology is therefore crucial. Under Options 0 and 2 this adoption is delayed. This might put a risk on the share of coal in the energy mix and thereby to the security of supply. In Option 1, the timely availability of demonstrated CCS technologies (in 2020) in Europe will allow continuing the use of fossil fuels and in particular hard coal and lignite, securing in this way a share of base load electricity supply.

6.4. Conclusions on the economic and social dimension, international cooperation and R&D

The implementation of a dozen of large scale CCS demonstration power plants will require additional finance.

The average additional finance needed is of the order of 500 millions € for a 400 MW plant (or 1 billion € for an 800 MW plant). The reward through the EU ETS (for storing the CO_2 underground) of will provide some part of the additional finance needed, but nobody can presently foresee how high this part will be (especially in the early period).

In these circumstances, both private resources (by the operators proposing the plants) and public resources will be needed to mobilise such additional finance, for the projects to happen. In total, for the dozen of CCS demonstration plants, the commitment for the public side could be of the order of 3 to 5 billions €.

There is a high risk that the current European technology leadership in clean coal and CCS technologies will be lost if the implementation of demonstration plants covering all technology routes is delayed in Europe, while third countries are progressing with CCS demonstration projects. In the long term this also puts a threat to European competitiveness on the evolving market for CCS technologies. Only, Option1 will facilitate the timely implementation of a variety of demonstration plants using different technologies and thereby strengthening European competitiveness in this field.

Close links in the fields of R&D and Demonstration, both on an international level and between demonstration projects and between national as well as European R&D will be established under Options 1 and 2. These close links guarantee early take up of research results and feed back of research needs from real life experiences. Under Option 1 these links can be established from 2008 on while under a Joint Undertaking such cooperation will only be in place approx 5 years later and this will delay innovations in CCS processes. Under option 0 no institutionalised exchange between research and industry will take place risking that relevant innovations addressing market needs will not be made and/or will not be transferred as fast to industrial scale plants as under the other options.

	CCS Demonstration Plants in place by 2015	Financial viability of CCS (in dependance of functioning ETS)	Emissions	Energy Mix	Economic and Social Dimension, international cooperation, R&D
Option 0: Business as usual (no change)	Financial incentives only available in a few MS. Only a limited number of demonstration plants will be in place. CCS technologies not sufficiently tested by 2020.	Viability tested only for a small number of CCS technologies. No conclusive indications on the viability of CCS. Development of transport and storage infrastructure will be delayed; this will put additional limitations on later exploitation of CCS.	Very little impact by 2020. Small (if any) contribution to CO_2 emissions reduction after 2020.	Little short term impact. But high risk in long term that role of coal will be reduced in energy supply due to its high CO_2 emissions and/or to very high CO_2 prices under ETS. This will have a negative impact on security of supply.	CCS only available in few Member States. Europe risk losing technology leadership due to insufficient demo projects in Europe. CCS acceptance is not improved, without coordinated information. Long delay for R&D results to be used by real projects.
Option 1: EU coordination and strong MS and industry commitments	MS are urged to announce financial incentives without delay. The projects become bankable. The coordination facilitates implementation and access to grants and loans. A dozen demo plants using different CCS technologies are likely to be established across Europe.	Viability tested for a range of technologies. Commercial exploitation of preferred technology options can start. Accelerated establishment of a European CO_2 transport and storage network.	Small but positive impact on CO_2 by 2020 (- 20Mt). In long term, sharp decrease of CO_2 emissions once CCS is widely applied. Little temporary negative impact on other pollutants.	Costs of electricity might rise slightly initially. In long term, when ETS gives strong signals and CCS technologies are further improved, costs will be comparable to non CCS technologies. Coal will contribute to security of energy supply.	Public support of 125 to 250 M€ for each CCS demo plant, assuming a CO_2-price of 20€ per ton. CCS widely spread. European technology leadership maintained. International cooperation and export will be accelerated. Research needs will be identified in real life demos. Research results will be used. Raising public acceptance.

Option 2: Joint Undertaking	Will only have impact if JU is taking off, with sufficient EU and MS funding. Establishing a JU will take time (approx 2012) and delay demonstration.	Viability and commercial exploitation of preferred technologies only possible from mid 2020ies. Same delay in the development of the CO_2 infrastructure.	As in Option 1 – but impact will be delayed by some years	As in option 1 – but impact delayed by some years. Share of coal in energy supply may decrease. EU more dependent on natural gas.	Public support as in Option 1. Risk to lose European technology leadership and export opportunities due to delay in demo projects. Delay in using R&D results.

Table: Impact Assessment: Overview of the impacts

6.5. Final conclusions

On the basis of the overall impacts of individual policy options, the following final conclusions can be drawn from this impact assessment.

Option 0 (no policy change) is considered as not being able to deliver the specific objectives of the action (as stated in §3.2.). Only a limited number of CCS demonstration projects would be constructed which would not be sufficient for drawing conclusions on the wider commercial use of CCS technologies from 2020 onwards. In particular, the longer term benefits of wide use of CCS (a substantial reduction of CO_2 emissions) will be much delayed and could take another decade from 2020 to begin to materialise. In addition, Europe risk to lose its technological leadership in fossil fuel power plant equipment.

Option 1 combining EU coordination and strong MS and stakeholder commitments is considered as being able to deliver the specific objectives of the action (as stated in § 3.2.). It is envisaged that the Demonstration program could be implemented, with the construction of around 12 large scale CCS demonstration projects by 2015 and its commercial use from 2020 onwards. While some limited negative impacts may initially appear (local air pollution and increased electricity production cost), the prospects are for reducing them progressively. The main positive impact will be the substantial reduction of CO_2 emissions: from a reduction of 20 Mt of CO_2 in 2020 (when 12 demonstration projects run at full capacity) to a reduction of 800 - 850 Mt of CO_2 if all coal-fired capacity existing today is equipped with CCS and has access to sufficient CO_2 storage capacity (possibly by 2050). It is anticipated that CO_2 allowances prices will increase under a full functioning ETS by 2020, to a level that would make CCS technologies competitive. Policy Option 1 is the preferred option.

Option 2 establishing a Joint Undertaking is considered as not being able to deliver the specific objectives of the action in the appropriate timing (as stated in §3.2.). It would take several years before a Joint Undertaking is in place. Moreover, it might prove impossible to activate appropriate funding for this Joint Undertaking at the EU level (as 3 to 5 billions € would be needed from public sources).

While Option 2 might still be considered to bring the desired demonstration plants into place in the long term, the time consuming and risky process of its implementation will delay the construction of demonstration plants till after 2015. Consequently, the target to demonstrate technological and economic viability of CCS by 2020 will be missed. And commercial deployment of CCS technologies in Europe will be delayed, at least till the mid 2020ies.

Section 7: Monitoring and evaluation

The present Impact Assessment focuses only on one moment - the demonstration phase - in the whole innovation chain. But it goes without saying that demonstration in only one part of a process leading to deployment of CCS technologies, which is the final objective. Other actions and conditions will be necessary in order for the expected positive outcome of the demonstration phase to lead to wider penetration of CCS technologies.

A wider analysis of the impacts of adopting (or not adopting) CCS in power generation has been prepared for the January 2007 Commission Communication on "Sustainable power generation from fossil fuels"[21].

The focal actions/conditions to follow or complement early demonstration in the interest of timely arrival of CCS as a technically and economically feasible emission mitigation option are:

– the adoption of an enabling legal and regulatory framework at the EU level (see proposal for a directive on geological storage of CO_2 and the impact assessment prepared for this proposal) and at the international level (the London and OSPAR conventions are being amended). This will need to be followed in due course by a decision on the suitability of mandating (or not) the use of CCS[22];

– the acceptance by the public of these new technologies, in particular the acceptance of the geological storage of CO_2 (a lot needs still to be done; the Mechanism proposed under Option 1 will act on this);

– the preparation of the construction of the required CO_2 infrastructure (mainly transport pipelines and storage sites) which would allow implementing CCS in locations which are distant from possible / accepted storage sites. (As a first step, the Commission will undertake a feasibility study for such a system in 2008. With positive outcome from the study, the Commission will propose a revision of the Trans-European Guidelines for the energy sector, integrating the CO_2 infrastructures).

– the continued efforts in R&D in order mainly to develop a second generation of much cheaper CO_2 capture technologies (through FP7 and future FP8). The strategic framework for such research will be created through the SET-Plan. The impact assessment prepared for the SET-Plan proposal includes a consideration of institutional and administrative measures that will be needed in this regard (in the general interest of a better coordinated European R&D in strategic energy technologies of which CCS is recognized as one) as well as the assessment of further requirements for EU financial resources this may entail;

– and, finally, the level of CO_2 prices delivered through the ETS in 2020 and later. The post-2012 ETS is expected to be the market mechanism that would provide full compensation of

---

21 Which confirmed the necessity to have fully demonstrated CCS technologies around 2020, as a CO_2 emissions mitigation solution. It has also shown that CCS will then be needed for keeping coal in the energy and electricity mix (with all the resulting benefits for the security of supply and competitiveness of European energy production in the medium term).

22 The Impact Assessment prepared for the Commission proposal of the Directive on the Geological Storage of CO_2 addressed the issue in a preliminary manner and concluded that for the moment there is not ground for proposing mandatory application of CCS from certain future date onward.

CCS cost in the deployment phase, without subsidies. This would be the case if CO_2 prices reach a level above 40 € / t by 2020, as predicted by the modelling of the 20/20/20 scenario in the impact assessment prepared for the proposal of a Directive for the geological storage of CO_2. A longer time horizon is needed for the post-2012 ETS, as the pay back period of investment in electricity generation can be of 15 to 20 years. (The Commission will propose in the coming months the revision of the ETS for the post-2012 period).

Progress on all these issues would need to be monitored, in parallel with the monitoring of the core indicators relating to the specific objectives of construction by 2015 and operation of a sufficient number of large scale CCS demonstration plants.

7.1. Core indicators of progress towards meeting the objectives?

Several core indicators are proposed for following the implementation of the demonstration projects in Europe and for comparing with similar projects in third countries.

The following data will need to be collected on the CCS demonstration projects, splitter respectively for projects implemented in Europe, for projects implemented outside Europe with the involvement of European companies and for projects implemented outside Europe without the involvement of European companies:

- number of CCS demonstration projects;
- capacity of the CCS demonstration projects;
- net energy efficiency of the CCS demonstration projects;
- volume of CO_2 stored by the CCS demonstration projects;
- investment and operating costs of CCS demonstration projects;
- public financial support to CCS demonstration projects (in addition to reward from EU ETS or similar systems).

7.2. Broad outline of possible monitoring and evaluation arrangements

7.2.1. Monitoring

The European Commission will monitor and report periodically on decisions taken by Member States and operators and on the progress of the early demonstration of sustainable power generation from fossil fuels. The monitoring of the support to and of the results of the CCS demonstration projects will be done through the network that will be established to coordinate the implementation of CCS demonstration projects in Europe and in third countries when European companies are involved. Information on CCS demonstration projects implemented in third countries without the involvement of European companies will be obtained through the existing international forum for CCS, the Carbon Sequestration Leadership Forum (CSLF), of which the European Commission is a member.

7.2.2. Evaluation

There are no specific arrangements for evaluation.

ANNEX

List of large scale CCS electricity generation projects in Europe (250 MW_{el} and above)

Updated: 15th September 2007

Country	**Location and Company**	**Fuel and Capacity**	**Technology**	**Start**
Bulgaria	Maritsa lignite basin	Lignite 650-750 MWe	Pre-combustion IGCC + shift	
Czech Republic	North Bohemia, CEZ	660 MWe	Post-combustion Storage in deep saline aquifers	2012-14
Denmark	Kalund DONG	Hard coal 600 MWe	Post-combustion Retrofitting of a 600 MW CHP plant. Storage in Havnso aquifer.	2013
	Nordjyllandvaerket / Aalborg, Vattenfall	Hard coal with biomass co-firing 700-900 MW	Oxy-combustion in CHP. For storage, five options are under investigation.	
	Amagervaerket / Copenhagen, Vattenfall	Hard coal with biomass co-firing 350-700 MW	Oxy-combustion in CHP. For storage, two options are under investigation.	
Finland	Meri-Pori, FORTUM	Hard coal 560 MW	Oxy-combustion In SC and CFB processes. Transport of CO_2 by ship. Storage in the North Sea.	2013
France	Le Havre, Poweo			
Germany	Spreetal, Siemens	Hard coal 1000MW	Pre-combustion IGCC + shift	2011
	Schwarze Pumpe, Vattenfall	Lignite 300-600MW	Oxy-combustion EGR in Altmark region	2012
	Ludwigshafen BASF	Hard coal, Biomass 1000 - 1500MW_{th}	Capture ready IGCC + shift + poly-generation, (storage?)	2012
	Germany, RWE	Hard coal, Lignite 450MW	Pre-combustion IGCC + shift Storage in depleted gas field in Lower Saxony	2014
	To be defined, E.ON	Hard coal 400MW	Comtes700 upscale project PC Ultra super-critical Capture ready.	2014

	Irsching, E.ON	Natural gas, 530 MWe	Pre-combustion Retrofiting towards CCGT	
Italy	To be defined, Enel	Hard coal 660 MW, of which 1/3 shall be captured	Post-combustion Currently tested at 50 MWe on Brindisi site. Storage in aquifer (near Torrevaldaliga site?)	2012
	Southern Italy, Rezia Energia Italia	Hard coal	Oxy-combustion + CFB Storage options are under investigation	
Netherlands	Eemshaven, Nuon	Hard coal, Biomass, Natural gas 1200MW	Pre-combustion IGCC MAGNUM project (initially, CCS on 400MW)	2011
	Eemshaven or Zuid-Holland, RWE	Hard coal, Biomass 1600-2200 MW	Capture ready PC (super-critical, η=46%)	2011
	Rotterdam area, E.ON	Hard coal	Post-capture Super Critical PC Construction starts in 2008	
	Rotterdam area	Natural gas	Pre-combustion	
Norway	Mongstad, Statoil	Natural Gas 280 MW elec. + 350 MW heat	Post-combustion, CHP plant Storage with EOR option in North Sea.	2014
	Karstø, Naturkraft	Natural Gas 400MW	Post-combustion amine NGCC Storage in oilfield –EOR	2011
	Tjeld-bergodden, Statoil & Shell	Natural gas 860MW	Post-combustion amine NGCC Storage in Draugen oilfield – EOR	2011
Poland	Poland, BOT/RWE/CEŽ /EDFPolska/GE/ Vattenfall	Hard coal 800MW	Pre-combustion IGCC Capture >85% and storage	2013
	Lagisza / Katowice, PKE	Hard coal	Post-combustion Supplement to a SC CFB plant under construction	2012-14
	Siekierki / Warsaw, Vattenfall	Hard coal 800 MWe	Oxy-combustion Retrofitting of a CHP plant.	

Spain	North/Central Spain, Union Fenosa	Hard coal		
United Kingdom	Teeside, Progressive Energy	Hard coal (+ petcoke) 800MW	Pre-combustion IGCC + shift Storage in UK North Sea (EOR).	2009
	Hatfield, Powerfuel	Hard coal 900MWe	Pre-combustion IGCC + shift	2010
	Killingholme, Lincolnshire, E.ON UK	Hard coal (+ petcoke) 450MW	Pre-combustion IGCC + shift	2011
	Ferrybridge, Scottish & Southern Energy	Hard coal 500MWe	Post-combustion PC (super-critical retrofit)	2011
	Immingham, ConocoPhillips	Hard coal (+ petcoke) 1180MWe	Pre-combustion IGCC for CHP plant and H2 production. Storage in UK North Sea (EOR).	2012
	Tilbury, RWE	Hard coal 1600MW	Post-combustion PC super-critical retrofit	2013
	Kingsnorth, E.ON UK	Hard coal Biomass 1600 MWe	Oxy-combustion Super critical steam cycle	2015

NB 1: For some projects, details of planned storage facilities are not yet determined, as legal and commercial considerations are still pending.

NB 2: For comparison, a 400 MW coal-fired power station emits around 2.5 Mt of CO_2 per year.