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

Project sponsor:

www.accsept.org

Fact sheet on Carbon Dioxide Capture and Storage (CCS)

Below we present a summary of key issues related to CCS. For more detailed information please see the Special Report on *Carbon Dioxide Capture and Storage* produced by the Intergovernmental Panel on Climate Change (IPCC) in 2005. The Summary (in French, Spanish and Russian in addition to English) and the full report (in English) are available at the following site:

http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/IPCCSpecialReportonCarbondioxideCaptureandStorage.htm
or by following links at: www.ipcc.ch

Policy Context

The European Community and its Member States are signatories to the United Nations Framework Convention on Climate Change (UNFCCC). A key aim of the treaty (Article 2) is: "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The EU Council of Ministers has agreed that a mean 2°C rise in global temperature represents the limit which should not be exceeded. The Council has stated that, in line with that limit, reductions in developed country greenhouse gas emissions of between 15 and 30% below 1990 levels will likely be required by 2020, while the Environment Council noted the probable need for a global reduction of up to 50% in greenhouse gas emissions by 2050.

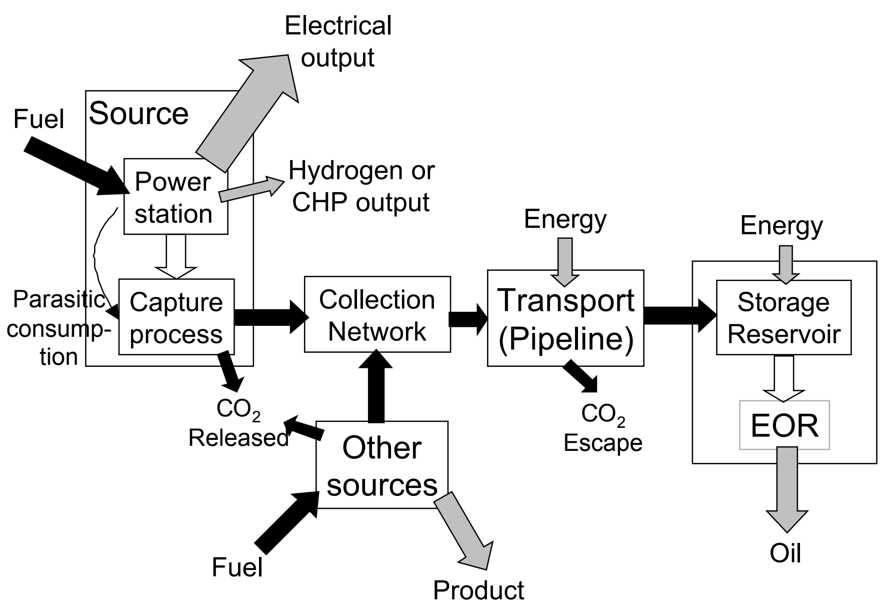
The European Community and its Member States have also ratified the Kyoto Protocol under the UNFCCC, requiring reductions in greenhouse gas emissions in the period 2008-2012. As one mechanism for meeting this target, the EU Emissions Trading Scheme (EU ETS) was established in 2005 for thousands of installations in Europe, for instance steel factories, refineries, and power plants larger than 20 Megawatts in size. The EU ETS covers about 45% of all EU CO_2 emissions (the other 55% of emissions are from other industrial sectors, transport and households). The second phase of the EU ETS will run from 2008-2012, concurrent with the 'first commitment period' of the Kyoto Protocol, and the system is designed to continue beyond 2012.

Overview of Concepts and Technologies behind CCS

CO_2 capture and storage or CCS is the removal of carbon dioxide from the emissions arising from power plants or from other large 'point sources' of CO_2 such as cement works or steel plants. The CO_2 is then compressed and transported as a liquid for storage in a suitable geological structure. Figure 1 shows the CCS process, whilst Figure 2 on the final page is a pictoral representation.

CCS can, in theory, be applied to all processes using fossil fuels (coal, gas and oil) and biomass. It can therefore be said to permit the continued use of fossil fuels whilst still limiting CO_2 emissions into the atmosphere. CCS is most often discussed in combination with coal. The amount of carbon contained in known coal reserves far exceeds the quantity which can be safely released in to the atmosphere if dangerous levels of climate change are to be avoided. In addition to generating electricity from coal, liquid fuels such as hydrogen can be created from coal. Such coal-derived fuels could be used not only in transportation but also in meeting domestic heating and cooling demands. Because their manufacture from fossil fuels is energy-intensive, however, such new fuels would end up contributing to human-induced climate change unless CCS is employed.

Figure 1: The Carbon Dioxide Capture and Storage Process



There are four major possible storage sites for the captured CO_2: i) depleted oil and gas reservoirs; ii) still operational oil and gas fields with the CO_2 being used for enhanced oil (or gas) recovery; iii) saline formations, which are porous rocks that currently contain very salty water; and iv) unmineable coal beds, in which the CO_2 attaches via a chemical reaction to the coal's surface. The first three types of storage can be located onshore or offshore. Coal beds are more commonly onshore.

The capacity of potential reservoirs globally is not known with any degree of accuracy but is likely to be sufficient to allow CCS to play a major role in reducing CO_2 emissions in many countries. For example, in the UK the storage sites examined in detail have a large enough capacity that they can store all of the CO_2 arising from electricity generation (at present levels) for at least the next 50 years. For Norway and the Netherlands, similar numbers have been published.

Much work is underway on assessing the risks arising from potential leakage of CO_2 from the geological storage sites. Such risks are site-specific and detailed risk assessment on a site-by-site basis will be necessary. Natural gas and CO_2 have remained trapped in geological formations for millions of years, so there are good reasons for believing that storage sites can be chosen that would hold CO_2 for the very long timescales required for climate change mitigation purposes. Questions remain regarding the integrity of existing borehole seals and more research will be required to better understand the risks. An appropriate regulatory regime will include site-specific requirements for monitoring during and probably also following injection. Very minor leakage might be tolerated both in terms of local environmental impacts and global climate change impacts, but this depends on the careful assessment of risks to human health and safety and ecosystems arising form leakage from sites.

Costs

It is nearly always more expensive to use CCS than to allow the CO_2 to escape to the atmosphere. This is because the capture of the CO_2 requires a large installation and uses up energy – a so-called 'energy penalty' - for the separation and compression of the CO_2. The only reason to implement most applications of CCS therefore is to reduce CO_2 emissions to limit climate change. The capture installation can remove 85 to 95% of the CO_2 from the flue gas. Taking into account the energy penalty of 10 - 40%, which varies greatly depending upon the CO_2 capture method, the power plant design and age and other local conditions, the CO_2 reduction drops to 80 to 90% per unit of output. A summary of the costs of CCS is provided in Table 1. Expressed as the cost of avoiding a tonne of CO_2 emissions, the additional costs for most of these CCS technologies are in the same order of magnitude as many renewables and new nuclear build. The cost of electricity with CCS would increase by approximately 2 to 3 cents per kWh. Depending on the price paid by the end-consumer, this represents an increase in price of between 20 and 80%.

Table 1: Range of total costs for CO_2 capture, transport and geological storage based on current technology for new power plants (in € *2002)*

Power plant with capture and storage	Pulverised coal power plant	Natural gas combined cycle plant	Integrated coal gasification combined cycle plant
Cost of electricity ***without*** CCS per MWh (in €)	43-52	31-50	41-61
Cost of electricity per MWh ***with*** CCS (in €)	63-99	43-77	55-91
Electricity cost increase per MWh (in €)	19-47	12-29	10-32
% increase in costs with CCS	43-91%	37-85%	21-78%
Cost per tonne CO_2 avoided (in €)	30-71	38-91	14-53

Source: adapted from Table 8.3a, page 347, IPCC (2005)

Incentives

Because electricity generation with CCS always costs more than equivalent generation without it CCS will only take place if there are specific financial incentives. The one exception to this is where cheap CO_2 capture can be combined with Enhanced Oil Recovery, though this is likely to be limited to a relatively few locations. Furthermore many companies will require financial incentives which take account of the relatively high business risk associated with the implementation of CCS due to, e.g., technological, market and policy uncertainties. The EU Emissions Trading Scheme is one such incentive scheme but the price it gives for a tonne of CO_2 abatement (between 10 and 30 euros per tonne CO_2) is lower than the (current) real cost of CCS per tonne of CO_2 especially when there is no guarantee that those prices will be as high over the entire lifetime of the CCS project. Hence some further incentive is likely to be required. The following incentive mechanisms have been proposed.

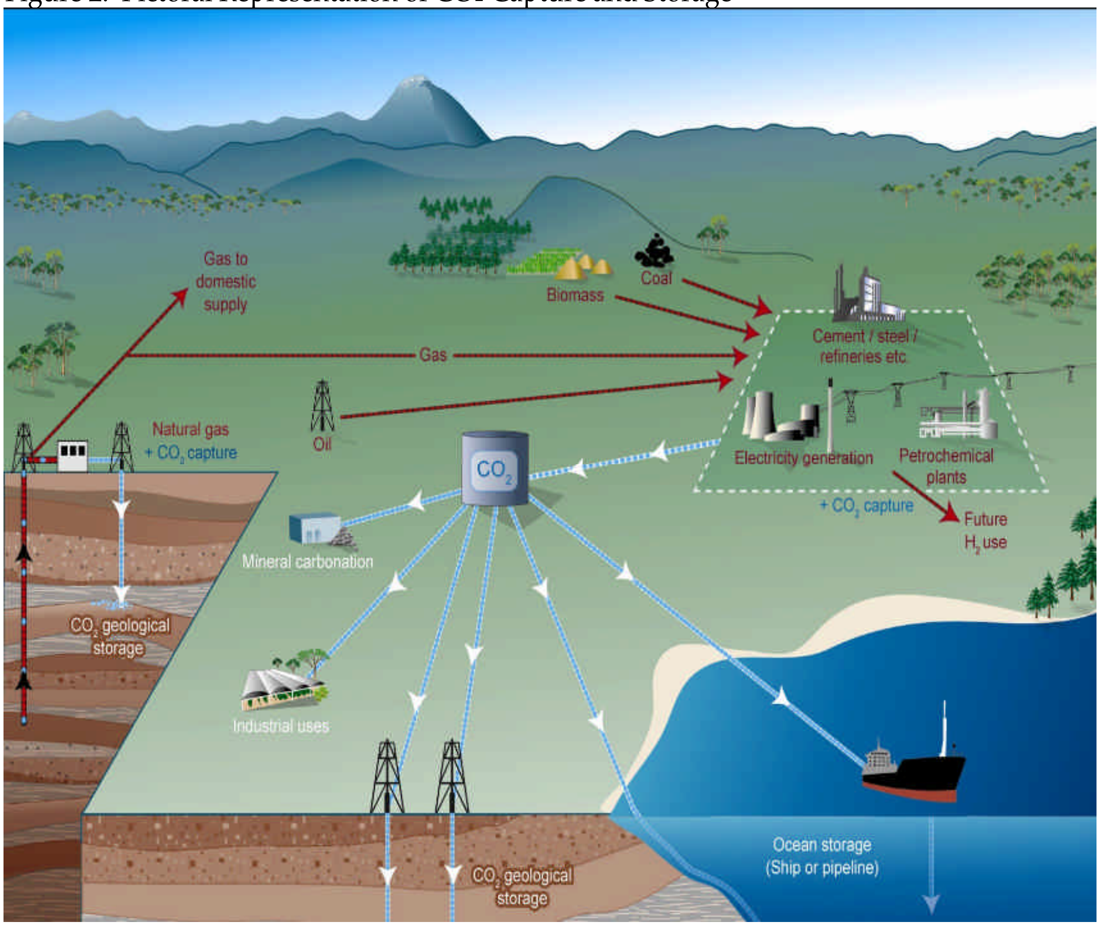
a) A subsidy scheme whereby producers of electricity using CCS are provided with the additional cost of CCS from public finances (e.g. through a guaranteed feed-in tariff for electricity generated with CCS which reflects the real costs of implementing CCS).
b) A requirement or obligation scheme whereby electricity producers are required to produce a certain proportion of their electricity using CCS (comparable to Renewable Portfolio Standards or a Renewables Obligation) or a similar requirement, but without specifying the low- or zero-carbon electricity source.
c) A capital subsidy support scheme, whereby public finance is used to subsidise the initial capital costs of a CCS project.
d) An economy-wide carbon tax, whereby end-users of carbon-based fuels and electricity pay a tax per unit of CO_2 emitted. This would mean that domestic, commercial and industrial users of gas, electricity and petroleum-derived fuels would pay a tax based upon the carbon content of the fuel so providing an incentive for the development of low- or zero-carbon sources of energy such as CCS.
e) An extension of the EU Emissions Trading Scheme with tighter emission caps: the EU ETS could be extended beyond 2012 and tighter national emissions quotas could be negotiated, so pushing up the permit price of a tonne of CO_2. The EU ETS could also be extended to all energy users, not just medium- to large- energy producers.
f) Public support for Research, Development and Demonstration projects.

Legal Issues

The London Convention regulates the dumping of wastes at sea. OSPAR is a regional treaty for the North East Atlantic and similar to the London Convention. Dumping is defined widely to include any deliberate disposal or storage at sea of wastes or other matter. No dumping of wastes is permitted except for those listed and CO_2 is not presently included on the list. Exceptions are permitted such as placement of wastes rather than disposal and disposal related to seabed mineral exploitation. Amendment of the London Convention and OSPAR treaties is probably necessary before CO_2 storage in saline aquifers and oil and gas fields can take place offshore and this could take several years, especially as little is known about the impact of leaks of CO_2 into the marine environment. Clarification and modification of the legal framework will be necessary before CCS can become an established carbon abatement technology. Companies are unlikely to initiate major investments in CCS technology where there are potential conflicts with the provisions of the London and OSPAR Conventions. A process is now underway to modify the

London Convention and a proposed amendment is to add CO_2 to the annex so allowing it to be dumped provided: that it is stored in sub-seabed formations (not in the water column); that it is overwhelmingly CO_2 and does not contain additional wastes.

Figure 2: Pictoral Representation of CO_2 Capture and Storage



Source: IPCC Special Report on *Carbon Dioxide Capture and Storage*