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KyotoPlus - Papers

Carbon Capture and Storage - Solution to Climate Change?

by
Niko Supersberger, Andrea Esken, Manfred Fischedick, Dietmar Schüwer
Wuppertal Institute, Research Group on Energy, and Mobility Structures

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Corresponding author: niko.supersberger@wupperinst.org
Editor: hermann.ott@wupperinst.org

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Introduction

Technologies for carbon capture and storage (CCS) are gaining more and more acceptance for mainly two reasons:

- CCS as a low-carbon solution is considered as an option for climate protection together with the utilisation of renewable energies and energy efficiency; and
- CO_2 can play a role in increasing fossil fuel production in the form of enhanced oil recovery, contributing to the generation of revenue.

If CCS proves large scale practicability it could be introduced in developed countries and in fast growing developing countries as well, therefore it is discussed not only in general terms in the climate regime, but as well in combination with the Clean Development Mechanism CDM (see below). Injection of carbon dioxide for boosting oil production is applied in some cases already, but capture of CO_2 in the power generation sector is still in its infancy.

There are various open questions. Among them are the temporal availability of efficient large scale capture technologies with long term stability, public acceptance, and infrastructural requirements.

This paper presents the current set of players of the CCS debate, as well as their rationale. CCS will then in brief be compared with other climate protection options, concentrating on renewable energies. Discussion of national and international importance of CCS is followed by the last section, which sets CCS in the context of international legal frameworks, analysing its possible role in the climate regime.

Drivers and Rationale in CCS policy

There is a broad spectrum of actors engaging in carbon capture and storage as an instrument to curb carbon dioxide emissions. For the sake of simplification, there are mainly two types of actors following two rationales that can be discerned: economic considerations and climate protection.

Among those energy companies investing in carbon capture and storage, British Petroleum (BP) is one of the most prominent players. Its natural gas field In-Salah in Algeria combines fossil fuel production with carbon dioxide storage: CO_2 from the gas field, which has to be separated from the methane, is not vented into the atmosphere but stored in a geological formation. The rationale in this case is in large parts the economic benefit (meeting export requirements in terms of allowable CO_2-content of natural gas) combined with gaining experience in CO_2 handling in the context of CCS.

Another economic motivation is the utilisation of CO_2 for enhanced oil recovery (EOR). Various players are considering CO_2 as useful for these purposes: the gas is injected into boreholes in order to increase pressure within the reservoir and to reduce the viscosity of oil to increase production rate. EOR with CO_2 is practised already, e.g. in the Weyburn-Oilfield/Canada but not yet on a global scale.

Other energy companies are mainly driven by climate protection reasons, like e.g. Vattenfall or RWE of Germany. Both of them are seeking a solution for coal fired power generation with significantly lower impact on climate.

In general CCS seems to be an option to bring as yet sceptical stakeholders closer to climate protection. The Organization of Petroleum Exporting Countries (OPEC), for example, stated in its Long Term Strategy of 2006 that CCS can be a promising instrument to curb CO_2 emissions for climate protection. This has to be seen in the light of OPEC's attempts to gain wider acceptance in the climate regime.

The Asia-Pacific Partnership on Clean Development and Climate (APCDC or AP6) is an international agreement between Australia, India, Japan, the People's Republic of China, the United States of America and South Korea (http://www.dfat.gov.au/environment/climate/ap6/). Together they account for almost half of the world's greenhouse gas emissions. These countries seek to reduce CO_2 emissions without, however, legally binding emission targets. Furthermore, no timetables for achieving goals and no incentives for governments or corporations to actually reduce greenhouse emissions were fixed. Apart from the general aim to reduce greenhouse gas emissions, the APCDC has agreed on the following aims (selection):

- Development, deployment and transfer of existing and emerging clean technologies; and
- Meeting increased energy needs and exploring ways to reduce the greenhouse gas intensity of economies.

CCS is one of the major technologies the Asia Pacific Partnership is highlighting and fostering. Climate protection scenarios which have been developed for the USA, for example by the Department of Energy (DoE), state that already a stabilisation of CO_2-emissions would require a significant contribution of CCS.

Besides of this coalition of countries, the European Union also promotes carbon capture and storage as an instrument which could in the future contribute to the reduction of CO_2 emissions, among other climate protection instruments such as energy efficiency and renewable energies.[1]

[1] http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/05/42&format=HTML&aged=1&language=EN&guiLanguage=en.

In general, the European Commission emphasises the need to accelerate actions to tackle climate change at its roots, i.e. by reducing the emission of greenhouse gases. Even with significant emission reductions over the coming decades, however, the climate system will continue to change. Globally societies have thus to prepare for and adapt to the consequences of inevitable climate change.

Carbon Capture from a system analytical point of view

Economical analysis and life cycle assessment show that it does not suffice to propose CCS technologies a priori as a "CO_2-free" solution to solve the climate problem. From a system analytical point of view, emphasis should be given to the whole process chain. Recently conducted investigations came to following conclusions[2].

The current thinking only considers the reduction of CO_2 from the operation and emissions of the power stations themselves. There are, however, also emissions along the process chain that must be taken into account: The emissions of the pre-processes (e.g. coal production and transport to the power plant) as well as transport and storage of CO_2 are not irrelevant. By analysing the whole process chain a CO_2 reduction of nominally 88% (oxyfuel: 99.5%) directly at the power plant results in net CO_2 reductions of only 72% - 79% (oxyfuel: 90%). It is therefore not justified to use the term "CO_2-free" power plants. Furthermore, according to the Kyoto Protocol not only the CO_2 emissions, but also other greenhouse gases have to be taken into account. A CO_2 emissions' removal rate of 88% (oxyfuel: 99.5%) accordingly results in a reduction of greenhouse gases by around 65% - 79% (oxyfuel: 78%). Gases emitted additionally are e. g. SO_2 and NO_x.

Using this fully-fledged analysis frame it has to be noted that the least efficient power plant *with* CCS (pulverized hard coal with 274 g CO_2-equ./kWh) causes only 45% less emissions than the cleanest power plant *without* CCS (natural gas combined cycle, 400 g CO_2-equ./kWh).

Economical assessment results reveal a steadily growing trend towards renewable energies, even when only moderately increasing fuel prices are taken into consideration. Whichever price scenario is used, it is clear that climate protection measures using fossil energy technologies are always depending on fuel price development, whereas a relevant advantage for renewables is that their "fuel" mostly comes for free. But it should be noticed that the price development of renewable energy carriers will only become reality with ambitious expansion of renewable energy utilisation (using economies of scale) - a pre-condition for mass market effects and technology improvements and therefore a cost decrease.

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[2] Viebahn, P. et al, Comparison of carbon capture and storage with renewable energy technologies regarding structural, economical and ecological aspects in Germany, GHGT, Norway, 2006.

From an energy economic perspective the development of electricity generation and the resulting demand for new plants over time is the crucial factor determining the potential for CCS. Looking at Germany as a specific case study the main impact factors are average operation time of the power plants, availability of CCS technologies for the power plant market, nuclear energy policy, resulting electricity demand, and last but not least the fossil fuel mix. Regarding an ambitious sustainable electricity scenario with ecologically optimized extension of renewable energy utilization[3] the option CCS might come too late for Germany or can only be seen as additional factor.

National and International Relevance of CCS

The national scenario analysis for Germany mentioned above indicates that CCS is not indispensable to reach the 80% emission reduction goal for industrialized countries by 2050, even with the phase-out of nuclear energy at the same time. Strong efforts in utilising all options of energy saving and energy efficiency combined with a large share of renewable energies in the overall energy mix could pave the way for the ambitious reduction targets.

However, this is not necessarily valid in developing countries or countries in transition showing high growth rates. One example for such a fast growing economy with according rising energy demand is China. As a recent study reveals, the demand for electricity plant new builds is 950 gigawatt (GW) by 2020, calculated by the Chinese government – and the real demand could even be underestimated by about 30%[4]. If the economy keeps on growing by 6.5% p.a., 48 GW of new builds (which equal about 40% of Germany's total electricity production capacity) - will be required annually to cover the increasing electricity demand.

Under these conditions it is unlikely that China will be able and willing to meet its soaring demand with renewable energies and through an ambitious shift towards lower carbon fossil fuels like natural gas alone. Of course, significant improvements of the system energy efficiency would lower the demand, but it can not stop the increase totally. The share of natural gas in relation to the current total energy demand in China is only 3% and thus very low. The government intends to increase the share up to 8–10% in 2020, but experts believe that already after

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3 See e.g. the study „Ecologically Optimized Extension of Renewable Energy Utilization in Germany" by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Berlin 2004.

4 Capgemini: „Investment in China's Demanding and Deregulating Power Market." In association with Electricite de France (EDF) and China Electricity Council Senior Common, Berlin 2006.

2010 China won't be able to cover the demand by it's own resources[5] and nuclear energy is not a real and safe option at all.

Therefore, and because global reserves of natural gas are limited, China is expected to stay on the coal path that produces two thirds of electricity currently and probably in the future as well. Already today China is the world's largest coal producer and consumer and it is expected that the consumption of coal will double between 2001 and 2025. This would mean that the People's Republic will then be responsible for a quarter of the world's total CO_2 emissions, causing enormous environmental consequences that would not only have negative impacts on China itself (local and regional environmental damages) but on the whole global community.

Therefore Chinese energy supply is a challenge on a global scale and a challenge that may require carbon capture and storage (CCS) technologies to limit the problem of global warming. Not only the transfer of renewable energy and energy efficiency technologies may thus be required and essential, but also the transfer of low-carbon emission technologies for coal (or natural gas) fired power plants. Another pressing need for this type of international cooperation is created by long-term plans, e. g. in China and other fast growing economies, to substitute oil through synthetic fuels based on coal in the transport sector. Such a switch to CTL (Coal-to-Liquid) would further increase coal consumption and greenhouse gas emissions as well, if carbon capture and storage were not applied.

However, one should bear in mind that CCS is a cost-intensive end-of-pipe technology and will not be implemented in China without significant incentives from outside. So far industrialized countries should have an enormous interest to lower demand via fostering alternatives and accelerating market introduction of high-efficient technologies (e.g. high-efficient-cars).

Carbon capture and storage and the Clean Development Mechanism

One incentive for developing countries to implement CCS could come from the Kyoto mechanisms, in particular the *Clean Development Mechanism* (CDM). Through the CDM, industrialised countries with emission targets under the Kyoto Protocol may acquire Certified Emission Reductions (CERs) from climate protection projects implemented in developing countries and count them towards their targets. The CDM is supposed to provide additional revenue to low-carbon technologies and practices and thus promote their further dissemination.

CCS projects are currently not eligible under the CDM. CCS falls in between the two types of projects that are currently possible, namely emission reduction

5 Kreft, H.: „Neomerkantilistische Energie-Diplomatie - China auf der Suche nach neuen Energiequellen." IP S. 50-57 Februar 2006.

projects on the one hand and forestry carbon sequestration ("sink") projects on the other hand. CCS can be viewed as an emission reduction technology since the CO_2 does not actually enter the atmosphere, but it also has the sequestration component. Therefore, neither the CDM modalities for emission reduction projects nor the modalities for forestry projects are applicable. Moreover, it is a requirement for the acceptance of CCS in the CDM that CCS technologies prove their environmental „safety". So far, three methodologies for CCS projects have been submitted to the CDM Executive Board. The Board was tasked by the Kyoto Protocol's first Meeting of the Parties (MOP 1) in Montreal in December 2005 to review these submissions and make recommendations to MOP 2, due to take place in Nairobi in November, on whether and how to integrate CCS in the CDM.[6] In particular questions of the project boundaries, permanence, liability, responsibility and leakage are key issues that have to be addressed. These issues are currently being discussed by the Board's Methodology Panel.

Under the CDM, project boundaries would have to encompass sequestration, transportation, injection and storage. Open questions are whether to integrate CCS activities whose project boundaries would span international borders in the CDM and whether several projects should be allowed to share one reservoir.

Leakage, i.e. increased emissions which occur outside the project boundary and are attributable to the CDM project activity, is a matter of concern for example as regards the integration of EOR into the CDM. Crediting EOR under the CDM could provide an incentive for increased oil production which in turn would lead to increased emissions.

As regards the risk of impermanence of the sequestration, there is a debate on approaches and on whether acceptance of long-term responsibility and liability should be required of CCS host countries or from the owners of the CERs. Suggested approaches include liability insurance, temporary credits and a compensation fund to cover claims arising from physical leakage at storage sites.

The essential question, though, is whether or not a technology branch should be promoted in the context of the CDM which requires enhanced mining efforts and increased production of fossil fuels and associated environmental impacts. Moreover, next to cost-effective emission reductions the aim of the CDM is to promote the sustainable development of the host countries, but for CCS this criterion has yet to be proved. In fact, accepting Carbon Capture and Storage into the CDM may divert investments from renewable energy technologies and energy efficiency measures.

CCS may have the potential to reduce CO_2 emissions, but without appropriate safeguards and the establishment of a strong regulatory framework to minimize the risks for future generations and the environment, CCS could compromise the sustainable developments objectives of the CDM.

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[6] Decision 7/CMP.1: Further guidance relating to the clean development mechanism, FCCC/KP/CMP/2005/8/Add.1, 30 March 2006, pp. 93-99.

Legal aspects of carbon capture and storage

There are already a number of existing regulations for injecting chemicals underground that are applicable to geological storage of carbon dioxide (CO_2). Some countries have specified legal or regulatory frameworks for long-term storage. Long-term liability issues associated with the leakage of carbon dioxide to the atmosphere and local environmental impacts are, however, generally unsolved. Monitoring of geological storage sites may be required for very long periods.

In the short-term, governments should ensure that there is an appropriate national legal and regulatory framework for more storage demonstration projects. In the interest of time, and given the diversity of institutional setups and policy processes between States, working at the national and/or provincial/state level using existing legal frameworks might be the preferred route. Longer-term national frameworks should be formulated on the basis of adequate empirical knowledge about the conditions and risks of long-term storage. There are further open legal questions concerning CO_2 injection into the geological sub-sea bed or the ocean, especially as regards the compatibility with international law (London Convention and OSPAR). May be much more important though could be another aspect: CO_2-injection into the water column is opposed by all relevant NGOs, while in other cases (storage options) the position of the NGOs is differing related to the central motivation behind. Positive or negative positions towards CCS thus often depend on the national background

Conclusions

- Carbon capture and storage are not yet applied reliably in large scale facilities, be it in power plants, coal liquefaction plants or others, but some large scale projects are running or recently started enabling the gathering of experience. CO_2 injection is already applied for enhanced oil recovery on the North American continent and foreseen for Europe as well;
- Open questions are focussing on most parts of the CCS chain, be it technical solutions or long term storage stability as well as monitoring aspects;
- Legal framework needs to be established;
- If proving large scale applicability CCS could contribute significantly to greenhouse gas emission reduction;
- By calculating emissions reductions of CCS technologies, the whole process chain has to be analysed, energy intensity increase of CCS processes leads to higher emissions of greenhouse gases other than CO_2. within the process chain;

- There is controversial discussion on whether to accept CCS in the CDM, as some criteria of CDM don't match CCS technologies;
- NGOs are opposing injection of CO_2 into the ocean waters and favor renewable energies and energy efficiency in general, but don't completely reject CCS.