The in Salah project in Krechba. Photo: Øyvind Hagen/Statoil Hydro

Carbon capture and storage: risky but inevitable

The European Commission has embraced the development of carbon capture and storage (CCS), paving the way for a technology pull that is intended to make CCS work on a commercial basis within twelve years. Greenpeace objects, but most industry experts regard CCS as a necessary weapon in the fight against climate change.

by Rembrandt Koppelaar

The European Commission has proposed that all new coal power plants built after 2020 in the EU must be equipped for CCS, and all new plants built before 2020 must be able to be retrofitted with capture and storage technologies after 2020. This is a very ambitious goal from a technological and economic perspective, given that not a single power plant size demonstration project with CCS is in place today. But the Commission regards the contribution of coal to the fuel mix as unavoidable from the perspective of energy security and affordability.

According to the International Energy Agency, coal-fired power generation with CSS is the cheapest route to lower CO_2 emissions, with CCS adding 2-3 eurocents per kWh to the basic costs of 3-4 eurocents per kWh for coal-generated power. The next best option in terms of costs is onshore wind energy at 6-11 cents per kWh, depending on the site.

There is, however, a risk to relying heavily on CCS for decreasing CO_2 emissions. If large delays were to occur in implementing CCS, it would become extremely difficult to reach the European goal of 20% reduction in CO_2 emissions by 2020. This fact is recognised by the Commission, which states in its communication on CCS of 23 January: 'A delay of 7 years in demonstration leading to the same delay in the global introduction of CCS can mean over 90 Giga-tons of avoidable CO_2 emissions being released by 2050 worldwide, equivalent to over 20 years of current overall EU emissions of CO_2.'

This downside risk is substantial enough for some environmentalist groups to reject CCS. Greenpeace, in particular, advocates a total phasing out of coal-fired electricity generation in a time path up to 2050. In its 'energy revolution scenario' for the EU, it opts for sharp increases in renewable generation capacity, large sweeping efficiency increases and a phase-out of both coal and nuclear. 'In general, Greenpeace does not support CCS, due to the critical risks, limitations and uncertainties associated with the technology', says Mahi Sideridou, Climate & Energy Policy Director of Greenpeace Europe. 'We are opposed to any financial or political priority given to CCS at the expense of the real, available solutions to climate change in the energy sector: the promotion of renewable energy and energy efficiency.'

> *Brussels leaves the subsidizing of CCS largely to the individual member states*

But the question is whether a policy relying solely on renewable energy and energy efficiency is feasible. Consider that of the 179 GW of installed coal power capacity in the EU-25 as of January 2006, 90 GW is older than 30 years, according to the EU-25 power plant database maintained by the Chalmers University of Technology in Sweden. This capacity needs to be replaced in the coming decades. While it is possible to decrease CO_2 emissions by replacing this capacity with renewable energy, it will be extremely costly since the added costs are double those of CCS. It is also questionable whether alternative forms of power generation such as solar and wind are able to meet such substantial amounts of electricity demand in the near term future given the difficulties involved in solving the intermittency issue.

This is not to say that the implementation of CCS will be easy. The capture technology has already been applied on a small scale in several industries but not in combination with storage and not on the scale that will be needed.

A coal power plant of 500 MW emits approximately 2 million tons of CO_2 per year. It is possible to store such a large flow. This has been demonstrated by three of the biggest storage projects in operation, Sleipner in Norway, which is run by Statoil, In Salah in Algeria, run by BP, Sonatrach and Statoil, and Weyburn in Canada, a project supported by a number of regional governments and a large consortium of energy companies from across the globe. In each of these projects more than 1 million ton of CO_2 per year is stored. However, this CO_2 does not come from capture technologies but from associated CO_2 in natural gas production in the case of In Salah and Sleipner and CO_2 as a by-product of synthetic methane production from coal in Weyburn.

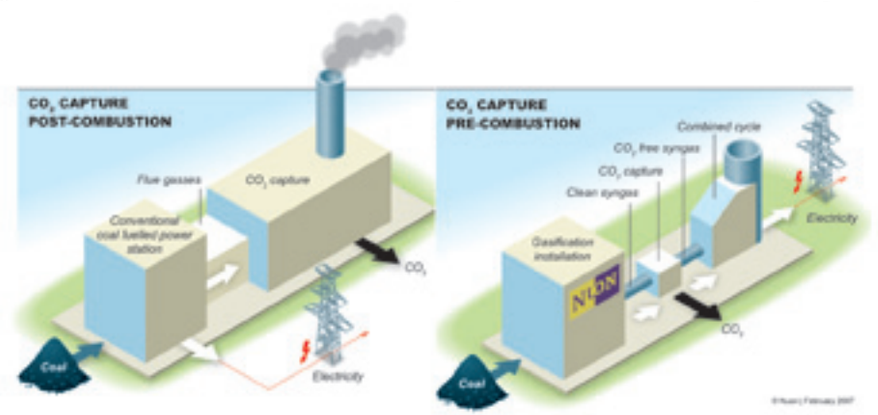
The only project to date in the world where CO_2 is captured from an operational power plant is Esjberg in Denmark, operated by Dong Energy. Marking the start of a new era, this EU funded CO_2 capture pilot project was inaugurated in March 2006 and now captures 9000 tonnes of CO_2 per year from the flue gasses of coal incineration by means of post combustion. With pre-combustion and oxyfuel-technology, post-combustion is one of the three methods of capturing carbon dioxide from power plants (see box). Esjberg is part of the EU funded R&D project Castor, coordinated by the Institut Français du Pétrole. The goal of Castor is to reduce the costs of post-combustion CCS in the coming 15 years from 2-3 cents per kWh to 1-2 cents per kWh. The largest part of the costs is due to the high energy input needed for the process of CO_2 separation, which leads to a lower efficiency of the power plant. The results of Castor so far are promising. Niels Rökke, CCS expert at the Scandinavian research institute Sintef which is a partner in Castor, says 'In the Castor project we have succeeded in increasing efficiency 2.5 percentage points by finding a better solvent to separate the CO_2 from the flue gasses.'

Larger pilot projects intended to further refine the technology will start in the coming three years. These will capture on average 100,000 tons of CO_2 per year. If this stage is successful, CCS can then be applied in the 10 to 12 large-scale demonstration plants that Brussels aims to have operational by 2015. Because the technologies that can be employed to capture CO_2 in power plants vary, the Commission wants to see a substantial number of demonstration plants set up. Many of them are already on the drawing board. In addition, power companies have plans to build more than 20 power plant designs to be equipped with CCS between 2013 and 2016. These plans have not been finalized, since the additional upfront investment costs of capture, transport and storage boil down to 300-500 million euro for a single demonstration plant. The companies are therefore looking for support to the EU and their national governments.

The European Commission, however, has made it clear in its communication of 23 January, that it has few funds available for direct support. Brussels leaves the subsidizing of CCS largely to the individual member states. Some power companies are not happy with this decision. Julia Scharlemann, spokesperson of RWE, regrets that the European Commission 'has not made clear what specific incentives there will be to cover the economic costs for CCS'. RWE-rival Eon takes a more sanguine view. 'Government support is important but it is not at all an obstacle in pursuing CCS for us since this technology is in our own interest and we want to take our responsibility as a company', says Christian Drepper, spokesperson for Eon.

> *'Companies need to remain liable for a CCS site over hundreds of years'*

The response of the national governments to Commission's appeal will likely vary. 'In Germany the government has shown a positive stance to CCS in general but it has been reluctant in discussing the issue of covering the additional costs', notes Scharlemann. In France and the Netherlands, the situation is quite similar. Poland, the coal country of Europe, has shown more enthusiasm. 'In Poland the Ministry of Environment and the Ministry of Economics are very supportive of CCS', says Adam Wòjckicki, from power company PGB, who is the Polish representative on the Castor project. 'They are considering supporting several smaller demonstration projects by 2015 in addition to the pilot plant that will be built by Vattenfall which has already secured support.'



To create a nearly pure stream of carbon dioxide at the power plant for storage there are three distinct possibilities. Firstly, in the process of Post-combustion the mixture of CO2 and flue gases is separated after combustion by using a liquid solvent. Secondly, in the process of Pre-combustion the fuel is treated with steam and air prior to combustion. Thirdly, in the process of Oxyfuel combustion (not displayed) pure oxygen is used instead of air in the combustion process resulting in flue gas that contains mainly water vapour and CO2.

Another country that has made a firm decision to give financial support to a large demonstration project is the United Kingdom. The UK government is willing to contribute to the capital investment of the CCS part of a single several hundred megawatt post-combustion plant. The company with the best offer will be selected in a competitive bidding round that began in November 2007. In addition to capital investment, operational costs will also be supported if the project is successful.

Interestingly the UK government has decided to support only post-combustion technology, since it considers this method the most promising in the current phase of development. Power companies will also usually choose one method over the other, often depending on their own past experiences. Dutch power company Nuon for instance has pre-combustion, RWE has opted for post-combustion. Very few companies are considering oxyfuel technology, since this technique is still inits infancy. It has so far been applied in two test plants in the world. It is an interesting method, however, because it combines a clean incineration process with a high efficiency potential. The most aggressive in pursuing oxyfuel is Vattenfall, which has a small 30 MW pilot plant starting operation in 2008 and a large demonstration project on the drawing board.

After the demonstration phase ends, costs of CCS are envisioned to be covered by the Emission Trading Scheme (ETS) of the European Union. Robert de Kler, head engineering services of Nuon, notes: 'In the long term Nuon expects that taxes on the right to emit will become more expensive.' The industry hopes that the third round of ETS, between 2013 and 2020, will make investments in CCS viable by delivering a CO_2 price that is high enough to justify CCS costs. In the new rules proposed by the European Commission on 23 January, CO_2 captured and safely stored will count as 'not emitted' under the ETS. In the case of an existing power plant that is retrofitted, CO_2 credits do not need to be given up, and for a new power plant built with CCS no additional credits need to be bought.

European CO_2 capture and storage pilot projects

Company	Location	Capture technology	Power capacity with CSS (MW)	Capture capacity (tonnes of CO_2 per annum)	Date of CSS operation
Total	Lacq	Oxyfuel	35	150,000	2008
Vattenvall	Schwarze Pumpe	Oxyfuel	30	60,000	2008
Enel	Brindisi	Post-combustion	40	29,000	2008
Doosan Babcock	Renfrew	Oxyfuel	40	n/a	2008
Fwesa, Praxair, City Of Energy	El Bierzo	Oxyfuel	n/a	n/a	2009
Nuon	Buggenum	Pre-combustion	253	1,000,000	2009
Eneco, SEQ	Drachten	Oxyfuel	50	175,000	2009
RWE	Aberthaw	Post-combustion	1-25	n/a	2010
Enel	Brindisi	Oxyfuel	35-75	n/a	2012
PKE, ZAK Kedzierzyn	Lagisza	n/a	50-100	n/a	2012-2014
Eon	Maasvlakte	Post-combustion	30-60	n/a	2014
Eon	n/a	Oxyfuel	n/a	n/a	2014

EU Proposed CO_2 capture and storage demonstration plants

Company	Location	Country	Power plant type	Capture technology	Capacity (MW)	Date of potential CSS operation
Vattenvall	Lausitz	Germany	PC	Oxyfuel	250	2013-2015
Nuon	Eemshaven	The Netherlands	IGCC	Pre-combustion	1200	2013
ConocoPhilips	Immingham	UK	IGCC	Pre-combustion	450	2015
RWE	Tilbury	UK	PC (ASC)	Post-combustion	1600	2013
RWE	Nordrhein-Westfalen	Germany	IGCC	Pre-combustion	450	2014
Poweo	Le Havre	France	CCGT	Post-combustion	800	2015
ConocoPhilips	Immingham	UK	CHP	Pre-combustion	450	2012-2015
PowerFuel	Hatfield	UK	IGCC	Pre-combustion	860	2012-2015
Eon	Killingholme	UK	IGCC	Pre-combustion	500	2014
Eon	Kingsnorth	UK	PC (ASC)	Post-combustion	1600	2015
Centrica	Teeside	UK	IGCC	Pre-combustion	800	2012-2015
Scottish & Southern Energy	Ferrybridge	UK	PC (ASC)	Post-combustion	800	2015
Enel	Brindisi	Italy	PC (ASC)	Post-combustion	660	2014
Bot consortium	Bot initiative	Poland	PC (ASC)	n/a	800	2014
Dong	Lubmin (Greifswald)	Denmark	PC (ASC)	Post-combustion	1500	2012-2015
Siemens	Spreetal	Germany	IGCC	Pre-combustion	1000	2015
Statoil	Mongstad phase 1	Norway	CHP	Post-combustion	630	2010
Statoil	Mongstad phase 2	Norway	CHP	Post-combustion	630	2014
Statoil, Shell	Halten	Norway	CCGT	Post-combustion	860	2013
Gassnova, Naturkraft	Karsto	Norway	CCGT	Post-combustion	420	2012

Complete survey of CCS projects currently being planned in Europe. Source: European Commission.

Besides costs there are a number of legal issues that need to be sorted out before CCS can become successful. In 2008 an amendment will be made to EU legislation to allow the storage of CO_2 underground. The exact details still need to be worked out but by 2010 the EU guidelines to permit storage projects and the various regulatory aspects of monitoring, reporting and risk management should be in place. One issue that needs to be resolved is how long a company remains liable for the CO_2 stored underground. Opinions differ on this, due to the great uncertainties involved. According to Sideridou of Greenpeace, 'Given the fact that carbon dioxide needs to be stored safely for at least 100,000 years, companies need to remain liable for a CCS site over hundreds of years, to ensure that no carbon dioxide leakage occurs. For that reason, for a company to implement a CCS project it must also guarantee financing for post-closure monitoring over this period of time.' Such time horizons will definitely spark debate, since the survival of a company for several hundred years is a rare event. Hence, rules need to be established that define to whom the liabilities are transferred after a company ceases to exist. ■