The international race for CO_2 capture and storage: And the winner is...?

Heleen de Coninck

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Ever since CO_2 capture and storage (CCS) has gained prominence among greenhouse gas reduction alternatives, researchers, policymakers, and industry have speculated about who would become the technology leader in this field. Will it be a technology that follows in the footsteps of solar and wind energy and sees European companies as market leaders benefiting from an early mover advantage, strengthened by a favorable internal market? Will the enormous investments of the U.S. government in R&D combined with its greater entrepreneurial power and better investment climate pay off? Or will other countries – like Australia which is very active in this area, or maybe China – become the world's market leader in CO_2 capture installations, a highly capital-intensive technology?

Given exploding world energy demand, climate-friendly technologies will be indispensable for stabilizing greenhouse gas concentrations. Thus, countries being able to develop and maintain themselves as technology leaders are likely to benefit from the deep reductions in CO_2 emissions that we will need to achieve in the near future.

Different technologies at different development stages

CCS is not a single technology. It consists of several components and is applied differently in different sectors. For the power sector alone, post-combustion, pre-combustion, and oxyfuel technology are alternative technologies for capturing CO_2. In addition, there is capture from low-cost, high-CO_2 sources, such as gas processing and fertilizer plants, refineries as well as coal-to-liquid facilities. There are various types of reservoirs in which CO_2 can be stored, such as depleted oil and gas fields as well as saline formations. All these different options for capture and storage are in various stages of technological maturity.

Technologically and politically, the United States has taken the lead early on. It has been investing in CCS R&D since the early nineties. It has many decades of CO2 storage experience in lucrative Enhanced Oil Recovery (EOR) projects, and in piping CO2 over very large distances for use in EOR. In 2003, even before the IPCC

published a Special Report on CCS and put the technology firmly on the policy agenda, President Bush launched the Carbon Sequestration Leadership Forum (CSLF), an international political forum primarily aimed at the exchange of CCS information between countries (CCS is often called "carbon sequestration" or "carbon capture and sequestration" in North America). The U.S. administration invited a number of like-minded countries to meet regularly under American leadership to align CCS activities. The initial group of CSLF parties included China, India, the United Kingdom, and Italy, and at the very last moment also the European Commission. By now, membership counts 22 countries, including Saudi Arabia and South Africa.

Successful American leadership?

Although at first it seemed like a good idea to coordinate activities in the field of CCS internationally, the results of the CSLF have been disappointing. While its membership quickly increased from the original 13 to 22 parties, only a small group of experts attended the meetings. Since most of them were policymakers, this made it hardly relevant for the exchange of knowledge among researchers. For policymakers, however, the mandate that implicitly excluded structural implementation of the technology made the agenda very short.

The CSLF would have been a good opportunity to coordinate large-scale demonstrations of CCS, but the leadership of the US failed at this point. Its flagship demonstration, FutureGen, suffered from a lack of support from budgetary commissions and is currently shelved. The process to provide existing R&D and demonstration projects with a "CSLF-approval stamp" was quickly ignored by many serious CCS project developers, and differences over how to address climate change affected the openness of information exchange throughout. The United States is the largest contributor to CCS research, but its budget so far has been spent on relatively small-scale CCS demonstrations. It has failed initiating efforts to seriously commercialize CCS.

The EU's inclusion of CCS in its Emission Trading Scheme

The European Union currently seems to have better cards for assuming the leading role in the field of CCS. The European Commission has recently proposed legislation for including CCS in the EU Emissions Trading Scheme (ETS). Current forward prices of around €25 (US$ 39) per ton of CO_2 for the trading period 2008-2012 would in theory provide a sufficient incentive for some CCS deployment in attractive places (i.e. in areas with low capture costs, short transportation distances, and easy storage). In the ETS, however, price volatility has been high so far and the sufficiency of such an incentive

for a relatively new technology like CCS is questioned in economic studies from both sides of the Atlantic. On the other hand, the Commission's policy package is straightforward insofar as it sets firm 2020 targets, proposes stronger rules for allocation (including auctioning in the power sector, which has the largest potential for CCS), and includes a strong legal framework for licensing safe CCS operations. This is something that is still absent in the United States where only a few states have issued legislation allowing for experimental CCS and, of course, EOR.

In a communication, published early 2007, the European Commission, advised by its expert Zero Emission Technology platform, proposed to build ten to twelve full-scale CCS demonstration installations in order to bridge the gap between CCS in the R&D stage and the commercial stage. There is broad agreement that the technology needs these demonstrations in order to be able to benefit from the price signal of the ETS. Unfortunately, so far it has not been possible to raise the €6-9 billion which are the estimated cost of those demonstration projects so that the fate of the overall proposal is uncertain.

Only gas processing plants are currently equipped with CCS technology

Nevertheless, European activity seems to yield some results. By far most of the existing and planned CCS demonstrations at essential scale are in Europe or operated by European companies. Already since 1996, Statoil operates the Sleipner field in Norway, a gas processing facility with storage in a saline formation. Recently, Statoil started operating a similar facility at Snøhvit. BP runs the In Salah project in Algeria, based on a similar project concept as the Statoil facilities, and is planning a number of Decarbonized Fuel (DF) projects for power generation around the world. In a joint venture, Shell, Statoil and NorskHydro announced a large gas-fired power plant operation with CO_2 storage in Norway. Shell is also working on capturing CO_2 from one of Europe's largest refineries, in Pernis, the Netherlands, in order to store it in a depleted gas field nearby. Nuon, a Dutch electricity company, owns one of the few mid-size, commercially operating high-efficiency coal-fired Integrated Gasification Combined Cycle (IGCC) plants in the world. It announced plans for a highly innovative and full-scale multi-fuel IGCC with CCS, the Magnum plant, in the north of the Netherlands.

It should be noted that none of the projects currently in operation feature CO_2 capture from power plants. Instead, they are all in relatively easy and cheap gas processing activities, where capture of CO_2 needs to happen anyway as too much CO_2 makes the gas unsuitable for the market. Power plant-based CCS projects are currently only in the planning phase.

Technologic, economic and public concerns

There are more proposed projects, often introduced with a lot of media attention. Many of them, however, have not made it through the feasibility study. This indicates that technological challenges, economics, the legal framework, and public acceptance are still critical concerns, despite the EU-proposed legal framework and incentives through the Commission's climate package. BP's Petershead project in Scotland, for example, the first DF project, was cancelled because of the eventual lack of support from the UK government. Likewise, the second and third BP-led DF projects, in California and Australia, are currently on hold because of economic problems.

The Californian installation has also been met with public resistance in the region where the CO_2 would be stored. Environmental Justice groups managed to delay the approval of the legal framework in California (BP insists that this did not affect the project). The Shell/Statoil/NorskHydro project was also put on hold after geological surveys cast doubt on the suitability of the reservoir for EOR. The coal-fired part of the Magnum plant was cancelled altogether; here, rising steel prices played an important role in the decision. In the EU, contrary to the United States, parts of the NGO community are actively discouraging CCS.

What are Australia, China, and the Middle Eastern countries doing?

Outside of the United States and Europe, Australia, China and a number of oil-producing countries in the Middle East are candidates for a leading role in CCS. Australia considers CCS as an essential part of its climate and energy strategy. The continent is planning mid-size demonstration projects and has passed a legal framework, even if the latter is not as comprehensive as the EU's. China has entered several cooperative research and demonstration projects with the EU, the United States, and Australia. It has a significant low-cost potential in coal-to-liquid operations, but is refuses to invest in CCS on its own.

Saudi Arabia and other countries in the Middle East are highly interested in CCS in general, and in EOR technology in particular. BP is currently planning its fourth DF project, this time in the United Arab Emirates. There are a few more countries that are active in CCS, such as Brazil and South Africa, but concrete plans for large-scale demonstrations have not yet been officially announced. For developing countries, the inclusion of CCS in the CDM would be a powerful incentive, but currently this area is a controversial point in the negotiations among the Kyoto Protocol's parties, with no agreement in sight.

International cooperation for the benefit of all

Which country will be able to benefit from a first-mover advantage in structural, large-scale CCS deployment is at this point undecided. Currently, the EU seems to be better positioned because of its head start in legislation, considerable incentives, and an impressive list of globally active companies and proposed projects – yet it seems to be unable to raise the money required to fund the demonstration projects necessary to help CCS through the commercialization phase. The United States started with great ambition, but then political will turned out to be ambivalent. This may change once the country adopts emission caps, perhaps as early as in 2009. Even if it does, however, it is uncertain that the United States gets a cap-and-trade system right from its early beginnings and avoids the birth deficiencies the EU experienced with its ETS. The U.S. approach, in its initial phase, might also generate low carbon prices and thus insufficient incentives for CCS.

After all, there is no need for a single winner. Instead, it may be better to cooperate rather than compete on CCS. The technology is diverse and promising enough to allow for more than only one single leader. While one country might take the lead in post-combustion, for instance, another one can excel in pre-combustion capture technology. Perhaps the U.S.-led CSLF was not such a bad idea after all and can be transformed into an effective international organization. Indeed, a strengthened version of the CSLF on CCS technology development could lower the barriers to full-scale demonstration projects and would allow for a multi-lateral learning-by-doing process. In that way, we might be able to realize what we all hope for: that CCS will be deployed worldwide in a responsible way, and Earth's climate will be the real winner.

Heleen de Coninck (deconinck@ecn.nl) works as a group manager in international energy and climate issues at ECN Policy Studies in the Netherlands. She was an editor for the IPCC Special Report on CCS.