Oxyfuel carbon capture plant at Schwarze Pumpe Photo: Vattenfall

Capturing that Carbon

If our economies cannot do without coal-fired power, the climate must be saved with carbon capture and storage (CCS). The good news is, the techniques for CCS are all in place. The bad news is they cost a lot of money.

by Chris Cragg

It does not seem surprising that the general public is cynical about the idea that carbon dioxide can be captured and stored in the ground. The idea sounds crazy and possibly dangerous. First, the gas needs to be separated. Then it needs to be piped to a suitable storage site and stuck in the ground. How can it be taken out of the combustion equation? How do you get it into storage and what, ask the sceptics, if it all starts bubbling out again? And in any case, carbon capture and storage (CCS) is an untried and untested technology, isn't it? Best then to get on with the business of banning coal combustion because of global warming.

Leaving aside the obvious, that the Wright Brothers' airplane was 'untried and untested' before it left the ground, this objection is just plain wrong. The oil industry has been injecting CO_2 into oil wells for over 30 years, while the chemicals industry has been streaming out CO_2 from combustion for equally long, if not longer. There are four well known ways of doing it, either before or after combustion. Admittedly, the oil industry uses the techniques for enhanced oil recovery, not because of climate change.

Governments are increasingly backing the idea that industry should apply these techniques to the problem of greenhouse gas emissions. They know what's at stake. The sudden removal of fossil fuels from the power supply is inconceivable because of the sheer size of the global demand for energy. Not only is coal the fastest growing fuel worldwide, it is also the single largest reserve of stored energy on the planet, amounting to 133 years supply at current levels of production. It is also India's and China's largest local source of fuel for electricity.

But the consequences of burning all this coal are now apparent. Hardly a day goes by without another warning from climate change scientists and the trend is to demand ever-greater cuts in emissions. The world is between a rock and a hard place. The choice appears to be one between dying in the dark with a collapsed economy, or suffering catastrophic shifts in climate.

CSS to the rescue

Therein lies the fascination with the idea of CCS and the growing support by governments for research. In the US, funding for CCS research even made it into the $700 billion bank rescue measures. Funds are also coming from the Texas and Illinois state governments. In Alberta, Canada, the government sees CCS as fundamental to the survival and expansion of the oil shale business. Earlier this year, the Australians started pumping 100,000 tonnes of CO_2 into a depleted gas field in the Otway Basin in a government-backed experiment.

In the EU, there is a proposal to assign €12 billion to 12 demonstration plants. The UK is willing to finance a 300-400 MW demonstration plant with CCS and is currently holding a competition for a post-combustion system, which could be retrofitted. In Germany, Vattenfall has started up the 30 MW Schwarze Pumpe power station, which streams out 10 tonnes of dense CO_2 per hour for storage. EU Energy Commissioner Andris Piebalgs has bluntly stated that 'climate change cannot be combated without CCS.'

Logistics

How is the 'new' technology put together? All the components already exist: separation, transport and capture. It is merely a question of putting them together. The first is the separation of CO_2 from either the fuel or the flue gas. The simplest method is post-combustion. It involves running the flue gas through a scrubber. This consists of an amine solution, which is subsequently removed and boiled, releasing the CO_2 and re-using the solution. This is a method that is similar to flue gas desulphurisation (FGD), which has been used for sulphur removal for many years to avoid acid rain. Such systems can be retrofitted.

The alternative is pre-combustion capture, which is more complex, but has a number of advantages. Instead of removing the CO_2 from the flue gas stream, it effectively changes the combustion process. One process, called oxyfuel combustion, effectively removes oxygen from the air and combusts the fuel in a stream of pure oxygen. As a consequence, the fuel gas is a near pure stream of CO_2 in the exhaust, which can be easily separated out. The advantage is that there is considerable potential for improving combustion efficiency.

An additional method talked about for years has some surprising advantages. Integrated Coal Gasification Combined Cycle (IGCC) has been around since the coal industry started looking for ways to compete with the efficiency advantages that combined cycle turbines gave to gas-fired electricity generation. Few stations have actually been built up to now due to the high capital costs, but the technology is well understood. Indeed, prior to the use of methane in gas networks, town gas was used, and that's been around for a century.

This method effectively involves heating coal or oil to produce a syngas containing hydrogen and carbon monoxide. It can then be reacted with water vapour to produce a mixture of hydrogen and CO_2. The unexpected advantage here is that the process provides a potential route via coal towards the hydrogen economy. It solves the mystery of where hydrogen comes from, since the use of renewable electricity to produce it, through the electrolysis of water, is unlikely to produce sufficient quantities to run the transport sector.

This is not just a pipe dream. ConocoPhillips has plans to introduce coal gasification technology at its expanding CHP station at Immingham in the UK. When finished in 2009, this plant, at 1,180 MW, will be one of Europe's largest CHP units. With coal gasification, it could become a hydrogen hub for either power generation or straight petrol engine vehicles. The project is currently on hold, but the position of

the plant on England's east coast is close to the UK's declining North Sea southern basin with its depleting gas fields.

In terms of transporting the captured CO_2, there is no challenge here to an oil industry that has been piping gases for decades. The use of CO_2 for enhanced oil recovery (EOR) has also been going on for decades. A 300-mile CO_2 pipeline already exists linking a gasification unit in North Dakota to Saskatchewan, where it is used for EOR. The need for extra CO_2 in Canada has led to the development of additional gasification units in the US to supply it.

In fact, it is experience with EOR that gives the CCS lobbyists cause for optimism. CO_2, if heavily compressed to supercriticality, behaves increasingly like a liquid solvent on the oil and can therefore be used for extra recovery. However, the oil industry is increasingly using it not for extra oil recovery, but simply to get rid of the CO_2. The porous rock simply absorbs it.

Success stories

The two most spectacular success stories in this area are BP's In Salah gas field in Algeria and StatoilHydro's Sleipner field in the Norwegian North Sea. In the case of Sleipner, CO_2 injection has been going on since 1996 and more than 10 million tonnes have now been stored. The gas is pumped into the Utsira, an enormous sandstone formation that covers a significant part of the North Sea. As for the In Salah field, CO_2 is also removed from the natural gas stream using amine and pumped back into the same ground structure as the original methane, but at a safe distance. This is removing 1.2 million tonnes of CO_2 a year.

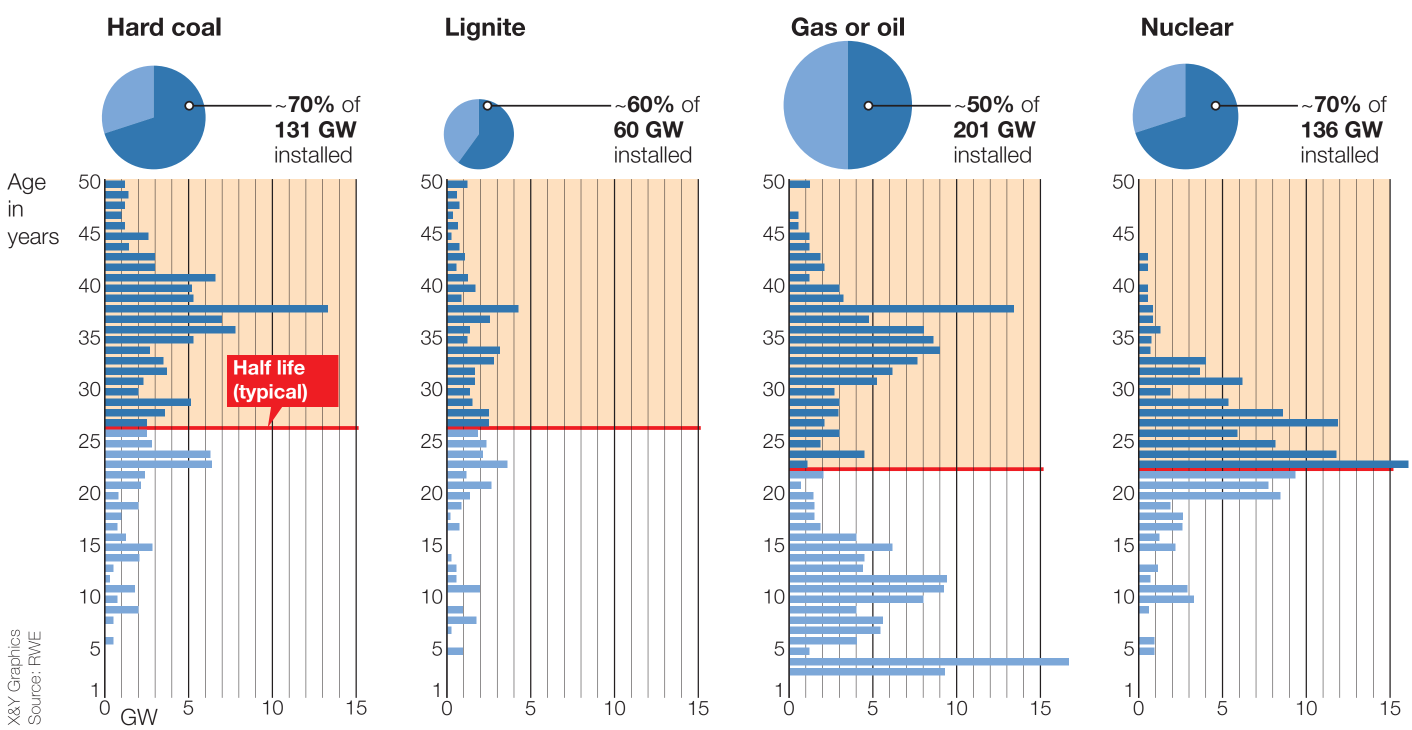
These are just two such projects all over the world. In Germany, the European CO_2SINK project has been observing the effects of pumping CO_2into a small reservoir since April 2004. In Abu Dhabi, Hydrogen Energy is planning to inject 1.7 million tonnes of gas from a 450 MW power plant into its oil fields, replacing the natural gas that is currently being used to improve oil uplift. Norway's government has allocated NOK 1.9 billion to CCS projects at Mongstad and Kårsto. The list goes on and on.

In practice, there are four distinct geological formations that can work as carbon sinks. The simplest method is to pump CO_2 into sandstone-type formations as at Sleipner, where the CO_2 will be partially absorbed into a saline solution underground. Alternatively it can be used in EOR as in Abu Dhabi. Third, it can simply replace oil and gas in depleted reservoirs, of which there are enormous numbers. And finally, it can be used to displace coal-bed methane in coal-seams, with the added advantage that it operates as a method of inerting the coal and preventing the underground fires common in many coal areas.

But how can anybody be sure that carbon stored in this way will not leach out into the atmosphere? The short answer is that it will be buried very deep, at least a kilometre underground and effectively sealed in porous rock. The only way out is the way it went in, and the oil industry has decades of experience with much

Time to start building

Most power stations in Europe are beyond their typical half life point (2007)



Oxyfuel carbon capture plant at Schwarze Pumpe Photo: Stefan Schroeter

more dangerous fiery blow-outs. It also has decades of detailed geological information about the rock structures that are suitable for such storage. Those who are concerned about the possibility of escape have to ask themselves why, for example, North Sea gas did not make its way to the surface without the wells drilled there.

Cost vs. concern

The technology is readily available. However, as David Price of McCloskey Coal Information puts it: 'It's not the technology that is the problem, it's the cost.' As recently as September, the management consultancy firm McKinsey published a report suggesting that CCS has the potential to remove 3.6 Gt a year of carbon worldwide from the atmosphere by 2030. By then, the cost will have fallen as a result of experience and infrastructure growth to €30-45 per tonne from around €60-90 per tonne today. This, the consultancy maintains, will be 'in line with expected carbon prices' under the EU emissions trading scheme.

This is not to deny that there is an 'economic gap' in the building of demonstration projects which only governments can fill. This requirement is estimated at around €10 billion by European Parliament member Chris Davies, who is helping steer CCS legislation in the European Parliament. However, the EU Commission is putting forward its own proposals and the Council of Ministers is expected to make decisions on those in December.

Dr Jeff Chapman, Chief Executive of the London-based Carbon Capture and Storage Association (CCSA), is optimistic about the prospects. The association had a mere nine founding members in 2001; the list is now 63 members long, including most of the major oil and gas companies and power companies. There is even an association pooling information in the US as well. Chapman says that everybody important, including the politicians, is now on his side. His only regret is the delay in formulating policy given that the technology has been around for so long. The drive into wind energy has also been a distraction.

Chapman also points to another very important factor: Come 2009, the Kyoto Treaty will have to be renegotiated in Copenhagen. Any new American administration still won't bring the US to the party given the size and importance of its coal industry – unless CCS technology is included. The US has always been more inclined towards technical solutions to climate change than Europe, and CCS is right up there in terms of making environmental targets viable. Similarly, CCS makes it possible for both China and India to settle on their own targets.

In fact, however outlandish the CCS package may appear to the layperson, it increasingly looks like 'a no brainer' to the oil industry. With all its hard won expertise on rock structures, putting CO_2 back down depleted fields is merely the reverse of what it's been doing for decades. ■