Trailblazing power plant is first to bury its carbon

- 05 March 2014 by **Catherine Brahic**
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A coal-fired power station in Canada is launching carbon capture and storage on a commercial scale. Could this make burning fossil fuels guilt-free?

RISING above the endless plains of Saskatchewan, Canada's Boundary Dam power plant looks like any other: giant boxes, tall red-and-white striped chimneys, and a mess of pipes and power lines.

But appearances can be deceptive. In the coming months, it will become the first power plant to suck the carbon dioxide out of its flue before the gas reaches the air. It is blazing the trail for carbon capture and storage (CCS) around the world. Not bad for Canada's largest coal power plant.

Each year, Unit 3 of SaskPower's Boundary Dam plant emits 1.1 million tonnes of carbon dioxide. But from this summer, 90 per cent of that CO_2 will never see the light of day. Instead, the gas will be piped to the nearby Weyburn oilfield and Deadwater saline aquifer, and pumped several kilometres underground.

"The resulting 110 megawatts of power produced will be some of the world's most environmentally clean power from fossil fuels," says SaskPower's Robert Watson.

"2014 is a pivotal year for CCS," says Stuart Haszeldine of the University of Edinburgh, UK. "The technology is going from zero to something. It's terrific."

Boundary Dam is CCS's first big success story, and more must follow. The International Energy Agency (IEA) says that, to have a 50 per cent chance of avoiding 2 °C of global warming, which is probably too dangerous to adapt to, the energy sector can only emit 884 gigatonnes of CO_2 between 2013 and 2050 (*Redrawing the Climate-Energy Map*, 2013). Burning proven reserves of coal, oil and gas would release 2860 Gt. So we must leave two-thirds in the ground (*Technology Roadmap: Carbon Capture and Storage*, 2013).

Here's the rub: the IEA says we will build enough power plants by 2020 to burn our budget by 2050. "Climate change mitigation can and should start by lowering consumption and increasing energy efficiency," says Ruben Juanes of the Massachusetts Institute of Technology. "But the reality is that fossil fuels will continue to dominate the world's primary power for decades to come."

That is where CCS comes in. Exhaust from a power plant is passed through a solvent that binds to CO_2. While the rest of the gas is vented, the CO_2-rich solvent is drawn off and heated to release the gas. Then the CO_2 can either be used (see "Don't junk CO_2, turn it into bottles and glue") or pumped underground, beneath impermeable layers of rock (see diagram).

Boundary Dam will be the first CCS project built on a commercial-scale power station. The process is already up and running in 12 industrial installations like fertiliser factories and natural gas processing plants. Also, for some time the oil and gas industry has been injecting flue gas into old oil and gas seams to push out the last drops of fuel. But power stations are the big daddies. They are the single largest source of greenhouse gases, accounting for 26 per cent of our emissions.

Later this year, Kemper County power station in Mississippi will become the second CCS power station. It is a coal gasification plant, so will test CCS on a different energy source. And last week the UK announced funding to draw up detailed plans for full-scale CCS at the Peterhead power plant. That is a significant move: Peterhead is gas-fired and, while coal remains a major source of power in China, Europe and the US have been switching to gas.

"The success [of these projects] is very important for the future of CCS," says Howard Herzog of MIT.

A key question is whether there is enough room underground to safely store all that CO_2. "Curbing CO_2 emissions worldwide is a daunting task," says Juanes. We pump out 30 billion tonnes each year, which amounts to 60 billion cubic metres of compressed CO_2 under the typical conditions in Earth's crust, he says. "That's more than 10 times the volume of oil that is transported around the globe on a daily basis. Of course we don't expect that one single technology will take our emissions to zero, but this gives a sense of the scale of the problem."

Juanes and other experts say CCS is only a bridge technology. It could buy time to make the switch from fossil fuels to renewables. The question is, "how long is that bridge", and will it be enough?

He studied 11 US saline aquifers, geological formations that could store CO_2, and calculated that they could hold 100 years' worth of US emissions (*PNAS*, doi.org/rqs). The North Sea is said to have room for 100 years of European emissions.

The big hurdle for CCS is money. Adding chemical scrubbers to a power station uses about 20 per cent of its power output. Power companies are unlikely to pay that hefty cost without incentives.

For now the cost of electricity from a CCS power plant is higher than normal fossil fuels but close to wind energy, says Haszeldine. The most pricey bit is reheating the solvent to release captured CO_2. Researchers are now looking into scrubbing reactions that use less energy. If that works, power plants could use residual heat alone to drive the reaction.

That is still in the R&D phase, with tangible results 10 to 15 years away. But Haszeldine says a similar technology – scrubbing sulphur dioxide pollution from power station emissions – was once dismissed as impossibly expensive, but now runs on most power stations for little extra cost.

We need to do more than CCS to save ourselves from climate change. But, asks Juanes, how many technologies can vanish gigatonnes of CO_2each year? "The answer is none," he says. "I think CCS stands alone."

Don't waste CO_2, turn it into bottles and glue

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IF HUMANITY is to avoid dangerous climate change, we need to capture hundreds of billions of tonnes of carbon dioxide. But what to do with it all? There is no shortage of places to bury it (see "Trailblazing power plant is first to bury its carbon"), but we can at least put some of it to good use. A few start-up companies view CO_2 as a resource rather than a waste product. They are using CO_2 as the raw material for making products including superglue and fertiliser.

Liquid Light of Monmouth Junction, New Jersey, showed off its prototype CO_2 converter at the ARPA-E Energy Innovation Summit in Washington DC last week. About the length and width of a coffee table, and a few inches thick, the module is a layer cake of steel and plastic. Inside it are catalysts that can produce more than 60 carbon-based chemicals, from just CO_2 and electricity. By linking many of these devices together, a chemical plant could convert CO_2 into hundreds of thousands of tonnes of products in a year, says co-founder Kyle Teamey.

Helping chemical companies switch their feedstock to CO_2 does more than boost their green credentials. "Almost all of their expenses are based on buying oil or natural gas or biomass," says Teamey. So releasing it into the air is perverse. "It's not just pollution, it's actually losing the value of the stuff they bought in the first place."

Liquid Light's first product will be ethylene glycol, the raw material for making polyester fibre, plastic bottles and antifreeze. Teamey estimates the process would trap 31 million tonnes of CO_2 per year if the firm took over all global production. It would also avoid the emissions that current processes create, although that figure is not so clear-cut. The company has processes in the pipeline to make everything from superglue to Plexiglas.

Liquid Light is not alone in looking at CO_2 as a resource. Dioxide Materials of Champaign, Illinois, is a start-up spun out from the University of Illinois. It will focus on producing acetic acid, a chemical used to make products like paint and glue.

Dioxide Materials has partnered with 3M, the multinational firm that invented Post-It notes. 3M hopes to replace some of the expensive raw materials for its adhesive business.

"The CO_2 becomes the feedstock," says Laura Nereng, 3M's sustainability leader. "There are several materials we could make, but for us the most important area of interest is acrylic acid. It's used to make adhesives, and 3M makes a lot of adhesive. Therefore it's an important raw material to our company and we're always looking for lower cost routes to our most important raw materials."

Using CO_2 as a feedstock should help lower 3M's carbon footprint, especially if the company can capture and use its own. "The idea of us using our own CO_2 emissions to make something that we need is very appealing, but I don't know whether the scale will work out," Nereng says. "Even if it mitigates CO_2 at our supplier, that's also a net win."

Both Liquid Light and Dioxide Materials can already produce fuels from CO_2. But they will not be bringing them to market yet, as it is cheaper to break down crude oil into petrol and heating oil. That could soon change, though. Teamey says wind power is nearly cheap enough for it to be economic to use it to make fuel.

We won't be able to convert all the CO_2 we capture into products, says Pamela Tomski of the Global Carbon Capture and Storage Institute in Docklands, Australia. Liquid Light's 31 million tonnes a year would only use up a fraction. But if ethylene glycol proves successful, and new markets for CO_2 can be found, humanity may end up handling its emissions in a whole new way.