Coal-to-gas: part of a low-emissions future?

Its proponents say that underground coal gasification combined with carbon capture could allow the continued use of coal — without unacceptable emissions. **Kurt Kleiner** looks at whether the technology is likely to live up to expectations.

Early next year a small Canadian company plans to start producing fuel by gasifying underground coal and extracting the combustible gas out of a well. It's an old trick with a new twist — the company will remove half of the carbon dioxide from the gas, creating a fuel that it says will be cheaper and cleaner than natural gas.

Laurus Energy of Montreal is one of a handful of companies around the world now exploring the technology, called underground coal gasification (UCG). Proponents claim that when UCG is combined with carbon capture and sequestration, it is potentially the most efficient and cost-effective way to use the world's vast coal reserves without emitting unacceptable amounts of carbon into the atmosphere.

"It's an extremely attractive technology both from an economic standpoint and a carbon management standpoint," says Julio Friedmann, a geologist and the head of the carbon management program at Lawrence Livermore National Laboratory.

Though there are no operational sites with both technologies yet, combined they could meet the twin grand challenges of reducing dependency on foreign oil and slashing greenhouse gas emissions, said scientists at the American Association for the Advancement of Science meeting held February 14–18 in Boston.

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> Julio Friedmann

Earlier in February 125 researchers and representatives of companies interested in UCG met in London for the 3rd International Conference on Underground Coal Gasification. Participants heard about UCG projects being developed in Europe, India, South Africa, China and elsewhere. Michael Green, a director of the UCG Partnership, which sponsored the conference, says this was the largest conference to date.

"A surge of interest is developing that's going to stimulate some significant projects," Green says.

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Coal is plentiful but dirty. UCG is among the most promising technologies for extracting energy from coal without overloading the atmosphere or breaking the bank.

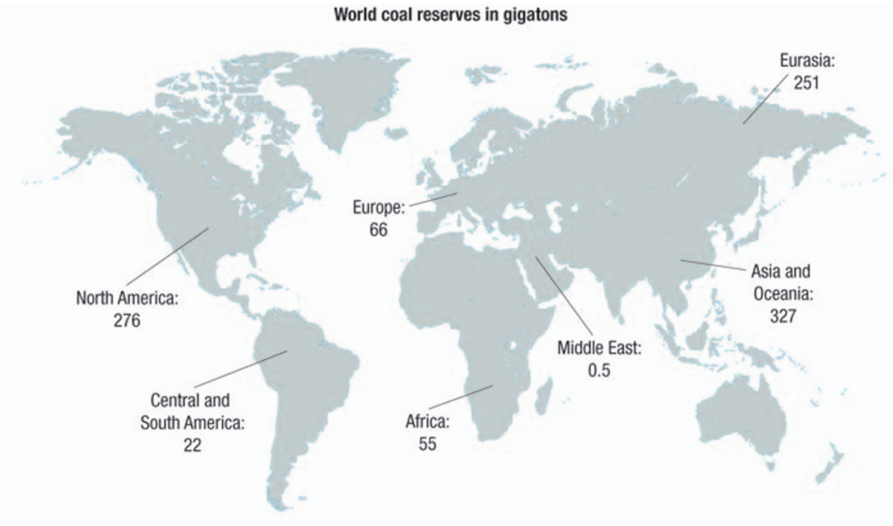
CLEANING UP COAL

Advocates of clean coal technologies maintain that increasing coal use is inevitable. Coal is a cheap fossil fuel — it costs just US\$1.69 to generate a million British thermal units of energy with coal, compared with US\$6.94 for natural gas and US\$6.23 for petroleum[1]. And there's plenty of it.

North America holds one-quarter of all known coal reserves in the world, and there are also significant reserves in China and Europe. Proven recoverable reserves total 998 gigatons (905 gigatonnes), according to the US Energy Information Administration (EIA)[2]. The World Coal Institute says that's enough to last 147 years at current production levels[3].

The problem with coal is that it's dirty, emitting twice as much carbon dioxide per unit of energy delivered as natural gas. Globally, coal accounts for more than 37 percent of all carbon dioxide emissions[4]. And that figure is projected to rise to 43 percent by 2030, according to the EIA, owing in part to increasing coal use in India and China[5]. China alone is constructing the equivalent of two 500-megawatt coal-fired power plants per week, each of which will produce 3 million tons per year of the potent greenhouse gas[6].

A number of technologies are being explored to capture and sequester some



Abundant supplies mean continued use of coal fuel, say energy experts. Map shows total recoverable coal reserves according to a 2005 EIA report[2].

or all of the carbon before it reaches the atmosphere. In one approach, the carbon dioxide is captured after the coal has been burned in a power plant but before it escapes into the atmosphere. Although plants are being built with this technology, it is expensive, with studies estimating it would increase electricity prices by anywhere between 42 percent and 81 percent[7].

Another latent clean-coal technology is called integrated gasification combined cycle (IGCC). In an IGCC power plant, coal is transported to the plant and converted to a gas. The carbon is then removed from the gas and transported away for sequestration, and the rest of the gas is burned to power a turbine. There are at least 50 IGCC coal power plants in the planning stage around the world. But it's also an expensive technology and could add 20 to 65 percent to the cost of electricity[7].

UNDERGROUND BURN

The attractive thing about UGC is that it could do the same thing as an IGCC power plant at a much lower cost. The coal doesn't have to be mined: it is converted to a gas in the ground and extracted through a well. And since the converted coal leaves space in the ground, the captured carbon can be pumped back to where it was taken from.

Gasifying coal underground involves drilling two wells into a suitable coal seam, igniting the coal at one well and pumping in air or oxygen[8]. Because the amount of oxygen available is limited, only part of the coal is used to provide heat that converts the rest to combustible gases, including hydrogen, butane, methane, carbon monoxide and carbon dioxide.

This syngas is removed from the second well. It can be burned as it is, but is a relatively dirty fuel in its raw state. It is also possible to remove all of the carbon from the gas, producing pure hydrogen. But that option is relatively expensive. Instead, plans are to remove about half of the carbon, which should produce a fuel that is fairly cheap and still cleaner than natural gas.

CHEAP EXPLOITATION

UCG without carbon capture has a fairly long history, starting in the former Soviet Union in the 1930s. But only lately has there been a resurgence of interest in its potential. A more recent UCG project began in July 1999 in Chinchilla, Australia, and gasified 35,000 tonnes of coal over a three-year period — the largest operational UCG project in the western world to date.

Michael S. Blinderman, director of Ergo Exergy Technologies, Inc., in Cote St. Luc, Canada, worked on the Chinchilla project, and he says it shows that UCG can be a low-carbon option. He estimated that syngas produced by UCG with carbon capture would emit only about 380 kilogrammes of carbon dioxide per megawatt-hour of electricity produced, 26 percent less than the next-cleanest option, a natural gas combined-cycle power plant[9].

In a study he conducted in 2003 of greenhouse gas emissions in Canada, he estimated that converting all coal-fired electricity generation to syngas produced using UCG would reduce Canada's carbon dioxide emissions to 83.1 megatonnes per year by 2010, 7 percent below the country's Kyoto Protocol target. In contrast, Canada would emit 154.8 megatonnes per year under a business-as-usual scenario, which would place them 73 percent over the target by the same date[10].

Because the technology avoids the costs of mining and transporting the coal and the additional costs of transporting the captured carbon dioxide, it is cheaper than above-ground gasification and sequestration. Friedmann says that initial studies at Lawrence Livermore suggest the final cost of producing the syngas is likely to be somewhere around the price of natural gas.

The process also provides a way to access coal reserves that are too deep for conventional mining. Green says the technique could make an additional billion tonnes of coal affordable to exploit globally.

READY FOR PRIME TIME?

Environmentalists, however, remain sceptical about the technology, and about

MICHAEL GREEN, UCG PARTNERSHIP

A UCG trial facility at El Tremedal in northeast Spain in 1998.

clean coal technology in general. "There are a slew of technologies being proposed as a way of continuing to meet our energy needs, including coal gasification with carbon capture. Our response is that it's not ready for prime time yet. We need the answers today," says Bruce Nilles, the national coal campaign director for the Sierra Club.

He points out that it's still not clear how well underground carbon sequestration will work. Carbon could leak out, or it could cause environmental problems, such as groundwater contamination. Nilles says that research should continue but that the promise of clean coal should not slow down efforts to conserve and to develop renewable fuels.

Gary Stiegel, a coal gasification expert at the US National Energy Technology Laboratory in Pittsburgh, says that UCG has potential but that surface gasification technology is more developed.

"The lack of large demonstration projects out there makes the economics speculative at this time. I think ultimately down the road underground gasification will probably make sense. But what the commercial potential is at this point in time, it's hard for me to say," Stiegel notes.

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But Friedmann at Lawrence Livermore is more optimistic. "It may be one of the few credible technologies we have. We have to be able to demonstrate we can get the same economic value out of the coal without paying an economic penalty for the carbon capture. It's a tall order. So far, I like the odds," Friedmann says.

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