A cleaner future

How commercializing gasification technology may save the environment—and the coal industry

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In Canada, we have a source of energy that can meet demand for clean electricity—a reliable source with hundreds, and perhaps thousands, of years of relatively easy availability.

It's called coal.

That may come as a surprise to people who view coal as a grimy holdover from the industrial revolution. Yet thanks to a process that has been around for more than a century, Canada's vast, accessible coal seams hold the key to a cleaner future.

The technologies at the heart of this vision are known collectively as Integrated Gasification Combined Cycle (IGCC). When combined with carbon capture and storage, IGCC makes it possible to produce electricity with virtually no air pollution or greenhouse gas emissions.

IGCC brings together two existing technologies: a chemical gasification process, which converts hydrocarbons such as coal or petroleum coke into pure streams of hydrogen and waste gases; and, combined cycle power operations, which use the hydrogen as the fuel for electricity production and capture waste heat from both the gasification and power production processes to increase efficiency.

Gasification has roots stretching back more than a hundred years, when some European communities used converted energy from biomass to power street lights. In the twentieth century, gasification was primarily used by economies that lacked access to oil supplies, including Germany during the Second World War and South Africa during Apartheid-era sanctions. Today the focus has shifted to gasification's environmental benefits.

Nearly 40% of global electricity production comes from coal combustion, and coal is one of the primary sources of power for some of the world's largest and fastest-growing economies (World Coal Institute, 2005). Addressing carbon emissions from coal combustion is, therefore, critical to corporate, national, and international plans to reduce greenhouse gas emissions.

The gasification process does not combust coal—it uses coal as a feedstock for the creation of hydrogen. In the process, the system is engineered to separate a pure stream of carbon dioxide which can then be captured and sequestered. Sequestration options that are being studied include long-term storage in saline aquifers and use in enhanced oil and gas recovery, where CO_2 is pumped down low-producing wells to build up pressure, which in turn increases the amount of oil brought to the surface.

Just as significant, IGCC power plants would dramatically reduce emissions of nitrogen, sulphur dioxide, and particulate matter. Consider sulphur, for example, which is also captured during the gasification process. A typical vintage coal-fired power plant releases about 2.5 kilograms of sulphur oxides for every megawatt hour of electricity produced. Today's best coal-fired power plants reduce those emissions to 720 grams. But at an IGCC facility sulphur emissions would be just 19 grams per megawatt hour—a 99.25% reduction.[1]

The environmental performance of IGCC power plants has led proponents such as the FutureGen Alliance to call IGCC a "near zero emissions" technology (FutureGen, 2008). And because coal gasification relies on an abundant natural resource that is widely geographically dispersed, it is also highly reliable and secure.

The benefits go beyond power generation. Gasification plants can produce more than one product. This is known as polygeneration. For example, the synthesis gas (or "syngas") produced by the gasification process can be used as a fuel or a petrochemical feedstock, or can be further processed for use by bitumen upgraders and crude oil refineries. The range of products immediately obtainable from syngas includes substitute natural gas or bulk chemicals such as ammonia and methanol. Gasification may even supply a source of hydrogen to power hybrid and electric cars.

There are more than a hundred syngas plants around the world, but only four IGCC operations that produce electricity (in Florida, Indiana, Netherlands, and Spain). However, with clean coal initiatives taking hold around North America, there are now several projects on the drawing board.[2]

Although IGCC technologies exist, they haven't been proven at a utility-scale operation—with CO_2 capture—for baseload power production. Demonstration plants in other countries have been expensive to build and operate and have as much as 50% higher operating costs compared to conventional plants (Jacobs Engineering, 2006). There have also been problems with reliability associated with coal feed systems, gasifier refractory repairs, burner nozzle replacements, and the general integration of all systems to improve efficiency.

To successfully commercialize IGCC technology, two sets of barriers need to be overcome: the first set are technological in nature, and the second relate to project economics and risk-sharing.

The technological barriers remain formidable. First, the technology required for the gasification process must be compatible with the coal being used. The design of an IGCC power plant also presents a challenge. The front-end engineering and design of a 500 megawatt (MW) IGCC plant must address a myriad of issues: how will the facility remove emissions of concern? What is required for commercial-scale geological storage of carbon dioxide? How will the design be adapted for construction and operation in a northern climate? And what operating and capital cost estimates can project partners rely on to make their investment decisions?

Moreover, different technologies must not only be economical, but also customized to suit the type of coal within a region. In North America, the quality, character, and performance of coal can vary considerably depending on geography.

There is plenty of risk. Early estimates put the cost of a different utility-scale clean coal technology, oxy-fuel combustion,[3] at more than $3 billion[4] per facility. Based on that estimate and on an urgent need for new power, the government of Saskatchewan postponed its clean coal initiative in September 2007 in favour of investment in proven technologies that could be brought online faster and cheaper.

On January 30, 2008, the US Department of Energy withdrew from the high profile FutureGen clean coal project, citing cost overruns (*The Washington Post*, 2008, Feb. 16). The public-private partnership involving 13 utilities and coal companies was struck in 2004 with a goal to design, build, and operate a coal gasification, near-zero emissions power plant with CO_2 capture and storage. Now, instead of backing one major project, the US Energy Department will support several groups working on carbon capture and sequestration technology.

It is unlikely that any single proponent of IGCC will proceed with a utility-scale IGCC venture on its own. The scale of investment and the risk associated with next generation technologies will require multiple partners.

The fact is that while coal is a relatively inexpensive feedstock, the IGCC process is relatively expensive. Its combined operating and capital cost is estimated to be comparable with existing nuclear technologies, greater than electricity from new natural gas or coal-fired plants, and likely more expensive than renewable sources other than solar (although most renewables cannot be used for baseload power production).[5]

The growth in baseload power generation from each of these options is constrained by market forces and public policy. For example, additional baseload generation from natural gas is constrained by fuel availability, price volatility, the existence of higher-value uses for the commodity, and uncertain, possible future pricing for carbon emissions. Large hydro is constrained by the limited number of locations for development (both in total number and in their regional distribution), distance to market, and environmental concerns. And additional coal-fired generation without carbon capture is becoming constrained by public policy.

Given these costs, if the public and policymakers agree that there is a public interest in accelerating the commercialization of IGCC technology with carbon capture, then it will require development of a model—perhaps similar to government investment in common transportation infrastructure—to fund the pipelines required for large-scale carbon dioxide capture and storage, and allocate the increased cost of power generation itself.

Moreover, the technology cannot be implemented overnight. Given the three years required for front-end engineering and design, and a three to five-year construction timetable, the first IGCC plant could begin operating by 2015. Others would follow based on increased demand, or to replace older coal-fired plants as they are retired. This process of capital stock turnover is key to long-term emissions reductions, which is why realistic policymakers are focused on 20, 30, and 40-year targets. In the interim, it is essential that industry and government continue to push to reach incremental gains by employing the best available technology economically achievable at the time.

These notes of realism—about the scale of the technological challenge, the need to develop new models for sharing the increased risk and cost associated with commercializing new technologies, and the likely timeline for implementation—should not dampen our enthusiasm for the benefits that gasification technology can offer.

Coal is the world's most abundant fossil fuel. In Canada, it represents 66% of energy reserves (Stobbs, 2006). Commercializing gasification technology so that we can leverage this resource into clean, reliable, and secure power—both for ourselves and for the developing world—is a worthy challenge for the twenty-first century.

Notes

1 The figure for vintage plants is based on the average emissions for Alberta-based coal-fired power generation in 2005 (EPCOR, 2005). Figures for emissions from current technology are based on the design standard for Genesee 3, which features super-critical combustion technology and clean air technologies (EPCOR, 2005). Emissions figures from IGCC facilities are estimates by the Canadian Clean Power Coalition (CCPC, 2004).

2 EPCOR Utilities Inc. (EPCOR), which is headquartered in Edmonton, is in the early

stages of development of two Canadian IGCC projects: one at its existing Genesee site west of Edmonton, and another as part of the proposed Sherritt Dodds-Roundhill project near Ryley, Alberta. EPCOR has a Memorandum of Understanding (MOU) with the Carbon Development Partnership (CDP), a general partnership, indirectly and equally held by Sherritt International Corporation and the Ontario Teachers' Pension Plan, that could see EPCOR construct, own, and operate facilities to provide power generation, water, and wastewater treatment services to CDP's Dodds-Roundhill coal gasification project near Ryley, Alberta. The Dodds-Roundhill project will be Canada's first commercial coal gasification project.

3 Oxyfuel technology involves removing nitrogen from all of the combustion air in order to operate the boiler in the absence of nitrogen. With this process, gasses leaving the boiler are relatively easy to purify, compress, and deliver for enhanced oil recovery with ultimate geological sequestration. The technology nearly eliminates emissions of combustion by-products, including greenhouse gas emissions.

4 With respect to postponing its clean coal project, SaskPower Senior Vice President Gary Wilkinson said the project capital costs soared from $1.7 billion to $3.8 billion (*Globe and Mail*, 2007, Sept. 7).

5 Costs provided are internal EPCOR estimates.

References

Canadian Clean Power Coalition [CCPC] (2004). *CCPC Phase I Executive Summary: Summary Report on the Phase I Feasibility Studies conducted by the Canadian Clean Power Coalition*. <http://www.canadiancleanpowercoalition.com/Customer/ccpc/ccpcwebsite.nsf/AllDoc/4D3C1EB172F9282C87256EAF005B1ECA/$File/CCPC%20PHASE%20I%20EXEC%20SUMMARY%20-%20WEB%20MAY%2004.PDF!OpenElement>.

EPCOR Utilities Inc. [EPCOR] (2005). Genesee 3, Canada's Most Advanced Coal-fired Unit, Declared Operational. News release (March 1). <http://www.epcor.ca/About/Media+Room/News+Releases/2005archive/Mar0105.htm>.

FutureGen Alliance (2008). *About FutureGen*.<http://www.futuregenalliance.org/about.stm>. Last updated January 2008.

Globe and Mail (2007, September 7). SaskPower Shelves Clean-coal Project.

Jacobs Engineering (2006). CCPC Gasification Optimization Study Phase 2. Unpublished paper.

SaskPower, Air Liquid, and Babcock & Wilson Canada (2006). *Media Fact Sheet: Clean Coal Project Technology Announcement* (October 30). <http://www.saskpower.com/pdfs/clean_coal_media_fact_sheet_Oct30-06.pdf>.

Stobbs, B., Canadian Clean Power Coalition (2006). Current Status of Clean Coal Technologies. Unpublished speech, presentation to National Energy Board, Calgary, Alberta, June 12, 2006.

The Washington Post (2008, February 16). The Demise of FutureGen: The Cancellation of a Clean-Coal Project Shows There's No Silver Bullet for Climate Change.

World Coal Institute (2007). *Coal Facts 2007*. <http://www.worldcoal.org/pages/content/index.asp?PageID=188>. ◻

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