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The Canadian Boiler Society Newsletter

COAL CELL - The gasifier will supply the fuel; and an electrochemical reaction will generate the power.

By: Jeffery Winters, Associate Editor ASME Mechanical Engineering Magazine, Dec. 2003 Issue

It's a cliché in discussions about energy generation that coal is the dirtiest fuel around. And, sure, there's a lot of evidence around to support that view. Coal mining is incredibly disruptive, and coal is heavy and bulky, involving rumbling freight trains to transport it. And most of all, to make electricity, coal is burned in boilers, with the exhaust vented through smokestacks and the ash carted to landfills.

The idea that fuel cells are every bit as clean as coal is dirty is just as widespread. Fuel cells, after all, take hydrogen and oxygen, and combine those elements to make electricity and water. Because it is a combustionless reaction, there are no byproducts such as nitrogen oxides, and the whole process promises to be far more efficient than burning fuel. So, what would you get if you could combine coal and fuel cells? Which attribute would dominate—dirtiness or cleanliness? That's the question about to be answered in a power plant in Indiana as part of a pilot program, sponsored by the U.S. Department of Energy. The Wabash River Coal Gasification Repowering Project in West Terre Haute is preparing to receive a two-megawatt fuel cell system designed to convert gasified coal into electricity.

The cells were fabricated by FuelCell Energy of Danbury, Conn., at a 65,000-square-foot facility in nearby Torrington. They are scheduled to be installed at the Wabash River plant by the end of the month and run for one year. If the concept lives up to its promise, it might well revolutionize the way we think about coal as a fuel. Coal isn't generally thought of as being compatible with fuel cells. But the coal at the Wabash River plant is first turned into a hydrogen-rich gas. Coal gasification is hardly a new technology. The first instances of gasifying coal date to the late 1700s, when it was part of a method for making tar. By 1812, commercial companies were supplying coal gas for heating and lighting London. (The famous "gaslights" were powered by coal gas.) By the start of the 20th century, most major cities in the developed world had gasworks, which often dominated skylines with their towering tanks. To get coal gas (also known at the time as "town gas," and today as "syngas"), coal or another hydrocarbon was pulverized and placed in a sealed container. The fuel was heated to over 1,500F until compounds, such as carbon monoxide, methane, and hydrogen, separated from heavier tars and solid coke. In many ways, gasification can be thought of as a type of fuel-rich, low-oxygen combustion.

The process was not without its problems. Coal is a complex fuel, with sulfur, metals and other impurities, and the residue from the gasification process was often toxic. Former gasworks sites are often contaminated with hazardous wastes. Another critical concern was efficiency: Early gasification methods delivered only 25 percent of the coal's original energy content into gas form. Often, gasification was viewed primarily as a means to produce coke rather than gas. Gasification technology improved in the 1920s and 1930s, yielding more gas and less coke. But by then, natural gas was being piped into industrial areas. Cheaper and cleaner than coal gas, natural gas began to dominate the market wherever they competed head to head. In places such as Germany, where coal is plentiful and natural gas is rare, gasification

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Editors: David Frost, Richard Barnes and Louise McColeman

NEWS FROM THE PRESIDENT - RICHARD BARNES

The CBS meeting with TSSA October 10, 2003, was a great success. It was a success for CBS because our members who attended were able to express their concerns directly to the management of TSSA.

The result was quickly felt by our members. Reports received from members on the CBS Board of Directors indicate that TSSA began to act immediately to solve the issues. They offered guidance for the resolution of problems requiring a quick solution.

The meeting was also beneficial for TSSA as they are very client focused. This enabled them to receive first hand feedback, act to resolve concerns, and improve their response to the clients. The end result was a win/win experience.

The CBS Board of Directors at its last meeting started to search for other opportunities to have similar meetings in other areas of interest to CBS members.

I encourage all CBS members to forward all experiences with TSSA both positive and negative to the CBS office care of lmc@anric.com, with a date and a time. This will help to build on the relationship between all CBS Members and TSSA. Please forward any suggestions of interest for future meetings.

remained an important technology. In recent years, coal gas has been produced in the United States for niche applications, such as raw material for chemical plants.

The energy crisis of the 1970s brought an upsurge in interest about portable fuels from coal and other minerals. But the spike in oil prices was too short-lived, and the push for alternative fuels died out. The technological development continued, however, and by the 1990s, the Department of Energy began funding coal gasification research as a possible pathway to reduce carbon dioxide emissions from power plants.

Transforming Wabash River

The program, called the Clean Coal Technology Program, was, in part, an effort to promote commercial-scale integrated gasification combined-cycle, or IGCC, coal power plants in the United States. Two such plants came online in the mid-1990s. The first was a 1950s-vintage pulverized coal-burning boiler in western Indiana, the Wabash River plant, operated by Global Energy of Houston.

The plant was rated at 90 MW and ran at 33 percent efficiency. As part of the demonstration project, the plant was gutted and connected to an advanced gasification system.

The coal is first slurried, then combined with pure oxygen and subjected to high temperatures and pressure. This not only partially oxidizes the slurry, but also melts the coal ash, enabling it to flow out of the gasification chamber.

The remaining gas moves into a second stage gasifier that enhances its heating value. After the gas is cooled, it's scrubbed of chlorides and sulfides, leaving a mostly pure fuel stream to be piped into a gas turbine.

"We've been running on petroleum coke since 2000," said Phil Amick, director of gasification technology at ConocoPhillips and former project manager of the Wabash River Plant. "It's cheaper than coal, but it's 5.5 percent sulfur. A conventional utility boiler would never have enough gas cleanup to run on a fuel with that much sulfur."

At the Wabash plant, sulfur is transformed from a problem to an asset. "We make about a railroad tank car a day of sulfur," Amick said. "We sell that to a broker, and it ends up in fertilizer."

The system, which included a heat-recovery steam generator, started operations in 1995 and proved to be 40 percent efficient over a four-year demonstration period. What's more, the plant (now rated at more than 260 MW) captured sulfur with more than 99 percent efficiency and generated undetectable amounts of particulate emissions.

Another DOE demonstration project, the Polk Power Station near Tampa, Fla., rated at 250 MW, was started from scratch. The Polk Power Station uses a slightly different gasification technology, but turned out to be every bit as clean; in fact, both plants lay claim to being the cleanest coal-fired generators in the world.

The success of these gasifiers in electrical generating facilities has spurred the DOE to push for more uses of the technology. Gasifiers are seen as potential sources for mass-producing hydrogen for transportation uses. And in February, Secretary of Energy Spencer Abraham unveiled plans for building a billion-dollar prototype fossil fuel power plant that would combine electricity and hydrogen production with the virtual total elimination of harmful emissions, including greenhouse gases.

Such a plant, called FutureGen, would have a gasifier at its heart.

"Gasification is the cleanest way to make power from coal," Amick said. "And since you've converted all the energy to a gas and put it in a pipe at pressure, you can even remove the CO2. It's still expensive, but it's easier with a gasifier than with anything else."

Coal gas traditionally is made of a mixture—mostly hydrogen and carbon monoxide. Hydrogen can be used in a number of applications, from gas turbines to fuel cells. Carbon monoxide is a bit trickier to deal with. It burns just fine, though it doesn't have as high an energy density as other fuels. But carbon monoxide can foul many fuel cells. It gloms onto the catalysts and destroys their ability to catalyze chemical reactions. For cells such as proton exchange membranes or phosphoric acid fuel cells, CO must be scrubbed from the fuel stream at all costs.

Removing carbon monoxide is not a large problem. It requires making it react with high-temperature steam to make hydrogen and carbon dioxide. But it comes at a price in terms of energy consumption and complexity. Researchers at Ohio University in Athens are working to develop a fuel cell system that can run on normal coal gas.

Professor David Bayless is experimenting with small stacks of planar solid oxide fuel cells, or SOFCs. "With the planar SOFCs, carbon monoxide is not a poison," Bayless said. "It's not as good a fuel as hydrogen—it doesn't have the energy content—but planar SOFCs can use it."

The question, Bayless said, is how many impurities—such as hydrogen sulfide and metals such as mercury—the SOFCs can handle. The greater tolerance they have for impure fuel streams, the cheaper and easier it will be to connect them to coal gasifiers.

"If this is going to be viable in the long term," Bayless said, "the cost of the fuel cell has to be competitive with other energy conversion systems."

In fact, Bayless envisions gasifiers and fuel cells as pieces of a revamped rural energy system. Coal gas can be separated into two streams: pure hydrogen, which can be used for transportation purposes, and carbon monoxide mixed with trace impurities. If this second stream can be converted directly into energy, it could make rural coal not just a cheap fuel, but a clean and efficient one as well.

"The efficiencies of coal plants right now are about 37 percent," Bayless said. "With fuel cells, you're talking about a theoretical efficiency of 70 percent. So right there, you're almost doubling the energy conversion rate. And if you are using SOFCs, it's hot enough to make steam or to convert into another industrial process, so you have the potential for much higher energy utilization.

"This is good for coal, long-term. If you are using it more efficiently, it makes it a more valuable fuel. And less input for the same usable output just has to be good for the environment."

A FuelCell Energy power plant like this one will soon convert coal gas into electricity. Such future combinations could provide zero-emission energy.

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Canadian Boiler Society News

2004 Annual General Meeting Montréal, Québec, May 30 - June 1, 2004

The Spring 2004 AGM is fast approaching. The **theme of the 2004 AGM** is **LOW EMISSION TECHNOLOGY FOR LARGE BURNER APPLICATIONS.**

There will be presentations delivered by **NATCOM and TODD Burners.**

The tour will be hosted by a member company, **Le Groupe Simoneau Inc.**

THIS AGM IS ONE NOT TO MISS!

The hotel is beautifully located on Île Charron - Longueuil. It is the Hôtel Gouverneur Île Charron Montréal, 2405, Île Charron - Longueuil, Quebec, J4G 1R6. There is a block of rooms on reserve for all CBS members and guests. It is imperative to **book you room today! Call 450-651-6510 or 1·888·910·1111.** The hotel is only holding the rooms until May 1, 2004. The famous CBS golf tournament is scheduled for May 31, 2004 at the beautiful Club de Golf La Seigneurie, www.international-golf.com/seigneurie/. Don't miss out on the fun!

PLAN TO ATTEND!
MARK THIS DATE ON YOUR CALENDAR TODAY!
DON'T MISS THE CBS 2004 AGM!

Update from the 2003 Fall General Meeting Oct. 24, 2003

The Fall General Meeting was held on October 24, 2003 at the Holiday Inn Select Hotel in Mississauga, Ontario. The **Theme of the 2003 FGM was BURNER TECHNOLOGY.** Keith Farrell of RIELLO Burners, a member company, delivered the presentation. It was followed by an active discussion. **RIELLO Burners** generously hosted the tour of their facility. The CBS would like to thank Keith Farrell and RIELLO Burners for offering their time and facility to our members and colleagues.

New Member Company Profiles

The Canadian boiler Society is pleased to introduce…
CH LJUNGBERG INC.
(CBS contact - Marcel Kamutzki)

CH Ljungberg is a value added partner for engineers and manufacturers in the steam and power generation industries acting as a representative for custom industrial manufacturers. Our project experience ranges from small multi-stage boiler feed water pumps to 177 inch boiler draught fans to rotary air heaters over 30 feet in diameter.

We are an office of five technical specialists with extensive theoretical and practical experience offering equipment solutions in air and gas handling fans, Ljungstrom air heaters and other extended surface heat exchangers, diverter, isolation, and control dampers, expansion joints, stacks and stack silencers, process pumps and coolers.

Centrally located in Cambridge, Ontario, we are close enough to work with end users, contractors, and consultants to arrive at an optimal solution. Put our experience to work for you on your next project.

On behalf of all Company Members of the Canadian Boiler Society, we would like to welcome you and look forward to building new relationships and networking contacts.

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All members are welcome to vote and participate on the Board of Directors! The board of directors encourages you to become actively involved with the issues that concern you. Please contact our board members at any time!

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Please submit any company news you would like published in the next CBS newsletter by fax to 416-252-5335 or by email to info@canadianboilersociety.ca.

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The Wabash River plant in Indiana will start sending coal gas into a fuel cell early 2004.

Carbonate Design

The experiment in Indiana starting next year won't involve a solid oxide fuel cell, though. Instead, FuelCell Energy will be installing a molten carbonate fuel cell stack power plant.

One advantage of the carbonate design is in scale. Planar SOFCs are still somewhat experimental and available in stacks on the order of a few thousand watts. Molten carbonate fuel cell stacks routinely weigh in at 250 kilowatts. For the Wabash River demonstration, eight stacks will be combined for a total of 2 MW. George Steinfeld, director of systems development at FuelCell Energy, said it will be the largest carbonate fuel cell power plant operating on coal in the world.

FuelCell Energy has been planning for this sort of project for more than 20 years. "Fifty percent of U.S. power is generated from coal," says Hansraj C. Maru, FuelCell Energy's chief technology officer. "It's a large part of the market." And FuelCell Energy believes that its technology is well suited to coal gas since it can run directly on methane and carbon monoxide as well as just pure hydrogen. (A carbonate fuel cell needs a carbon fuel to provide the carbon dioxide needed on the cathode side of the cell.)

"The fuel is more dilute than pure methane," Maru said, "so we have to design the fuel cell system for this dilute stream."

One way to increase the energy density of the stream is by methanation. The two major components of coal gas, carbon monoxide and hydrogen, are reacted catalytically to make methane and steam. On the one hand, this adds a processing step and thus unwanted complexity. But the reaction is exothermic—and so is self-sustaining. And the extra heat can help drive other processes, including ones designed to remove trace levels of sulfur from the fuel stream.

Steinfeld said the project is aiming for efficiencies in the 48 percent range, a 20 percent improvement over the efficiency of the current IGCC plant at Wabash River. But that increase will be scarcely noticeable in the overall operation of the plant: The eight fuel cell stacks will be receiving less than 1 percent of the coal gas stream, with the rest being sent on to the turbines. And the cells will operate at times from natural gas rather than coal gas.

Still, if the demonstration proves successful, it might well lead to new plants along this model. (All parties agree that established plants are unlikely to convert to this technology.) This is especially true of new plants in built-up areas, where gas turbines have proven far more popular of late than coal-fired boilers. "The typical image of coal goes away when you combine it with a fuel cell," Steinfeld said.

Indeed, such a power plant probably wouldn't need a traditional smokestack. Trainloads of coal enter; electricity, carbon dioxide, sulfur and various trace metals leave—it sounds less like industry than like magic.