PROGRESS REPORT

Pleasant Prairie Carbon Capture Demonstration Project Oct. 8, 2009

PLEASANT PRAIRIE, Wisconsin.

We Energies, Alstom and the Electric Power Research Institute (EPRI) announced today that a pilot project testing an advanced chilled ammonia process has demonstrated more than 90 percent capture of CO_2 from the exhaust stream of a coal-fueled power plant in Wisconsin.

ALSTOM

EPRI ELECTRIC POWER RESEARCH INSTITUTE

INTRODUCTION

The CO_2 Capture Challenge

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It is estimated that about one third of U.S. greenhouse gas emissions today originate from electricity generation. That's why companies like Alstom, We Energies and the Electric Power Research Institute (EPRI) are advancing the science of carbon capture.

The three companies joined forces to demonstrate the technical feasibility of Alstom's chilled ammonia process at the We Energies power plant in Pleasant Prairie, Wisconsin. This report summarizes the key research findings at the Pleasant Prairie demonstration project. It is written for a non-technical audience and intended to provide a broad overview rather than a detailed analysis. As the data and results from the project are fully analyzed, Alstom and EPRI will publish technical reports on the project. But because the next steps in advancing these technologies to commercialization already are under way, the participants in the Pleasant Prairie carbon capture project want to summarize the results to date now.

The R&D process for advancing a new technology from the laboratory to commercial scale involves a series of progressively larger demonstration projects, culminating in a commercial offering with the standard guarantees that the technology will work as expected. This process applies to CO_2 control technologies as much as it does to any other new technology. For the chilled ammonia CO_2 capture process, the first of those stages was a series of laboratory tests, including the construction of small models in a controlled laboratory environment. From there, Alstom plans a series of field pilots, validation pilots, and commercial demonstration projects.

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Pleasant Prairie is a field pilot designed to validate the 'proof of concept.' This pilot captures approximately 40 tons of carbon dioxide each day. The project started in early 2008 and will wrap up later this year. As the next step in demonstrations at increasing size, the first of two product validation facilities recently began at the American Electric Power (AEP) Mountaineer Plant in New Haven, West Virginia. It will capture more than 330 tons of carbon dioxide per day, which is more than 110,000 tons per year. The site of a commercial demonstration project is still being determined. When commissioned, that project, at the final demonstration stage, is expected to capture 1-1.5 million tons of carbon dioxide per year and use it for enhanced oil recovery or store it in an underground formation.

The Pleasant Prairie Pilot Project

In early 2006, Alstom and EPRI set out to jointly develop a field pilot to demonstrate the chilled ammonia carbon capture process. EPRI's support is provided through 37 U.S. and international members who formed a collaborative, which not only helped to offset the costs of the project but also gave power generation owners and operators an inside look at a promising new technology under development.

Alstom and EPRI first conducted a comprehensive screening process to select a plant suitable to host the field pilot. From among several candidates, they chose the We Energies Pleasant Prairie Power Plant ("P4 Plant"), a state-of-the-art power generation facility that operates with extremely high environmental performance. Units 1 and 2 recently were retrofitted with selective catalytic reduction (SCR) systems to control emissions of nitrous oxides (NOx) and wet flue gas desulfurization (FGD) systems to control sulfur dioxide (SO_2) emissions - two pollutants which contribute to the formation of smog, acid rain, and fine particulate matter. This retrofit also included the construction of a new chimney (typically called a "stack").

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The chilled ammonia pilot system withdraws about 1 percent of the exhaust gas (also known as flue gas) between the outlet of the Unit 1 or Unit 2 FGD and the stack. The gas is first cooled to condense and remove moisture and residual pollutants before it enters the CO_2 absorber. There, the CO_2 is absorbed by an ammonia-based solution, separating it from the flue gas. In a successive step, the CO_2-laden solution is heated, releasing a very pure stream of CO_2. In a commercial application, this CO_2 stream would be compressed and transported for use in industrial processes, such as enhanced oil recovery, or for injection and storage in a suitable underground geological formation. In this research pilot plant, however, the CO_2 is remixed with the treated flue gas after process discharge sampling measurements. The entire extracted gas volume then is reintroduced into the FGD outlet transition duct where it is mixed with the FGD exhaust gas. At maximum capacity, the pilot system has been designed to capture nearly two tons CO_2/hour (equivalent to 15,000 tons/year at full capacity).

Alstom, We Energies, and EPRI executed funding and site agreements in early 2007. Construction of the carbon capture facility commenced in July 2007, and commissioning began in April 2008. Following a planned outage of the power plant, operations and testing commenced in June 2008 and have continued to the present day.

LESSONS LEARNED AT PLEASANT PRAIRIE

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The field pilot at Pleasant Prairie was the first opportunity to test different unit operations as a fully integrated process in a continuous mode, capturing CO_2 from actual flue gas. It took several months of work to resolve the various issues that arose during initial operations. However, after some initial modifications to the process design, the project achieved most of a series of operational objectives and met the fundamental research objectives. In short, the project provided what the participants needed to know.

Objectives

1.) Demonstrate full system operation on flue gas from a coal-fueled boiler, including:
- Flue-gas cooling using heat recovery/exchange and chilling;
- Removal of residual pollutants;
- CO_2 separation from the flue gas (absorption by the ammonia solvent); and
- Production of a high-purity CO_2 and regeneration of the solvent

Results: Over time, pilot performance steadily improved to the point that stable absorber operation at 100% of design flue gas flow was established in April 2009. From this point, the pilot has demonstrated the ability to meet all the key performance metrics in this objective.

2.) **Prove the process concept:**

- High-efficiency removal of CO_2 ($\geq$ 90%)
- Minimize ammonia slip (release) (< 5ppm)
- Produce high-purity CO_2 which can be re-used or safely stored underground

Demonstrated > 90% CO_2 removal at design conditions

Results:

- CO_2 removal - Demonstrated > 90% CO_2 removal at design conditions
- Ammonia release - During operations at design gas flow, we have consistently measured less than 10 parts per million (ppm) and normally less than 5 ppm ammonia released
- CO_2 purity - Produced high-purity CO_2 with low ammonia (< 10 ppm) and water content (< 2,500 ppm); other impurities require further testing/ evaluation.

3.) **Begin to identify operational procedures for routine operation, startup and shutdown, and begin to establish system reliability.**

Results: The pilot has operated for more than 7,000 hours and, since September 2008, it has reliably operated 24 hours per day, 7 days per week. During this period, there were only two unplanned outages for pilot plant maintenance.

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The experience in operating the field pilot has been invaluable, as the Alstom operations and project validation teams have refined startup and shutdown procedures and gained experience troubleshooting issues with process operation.

Validation of the total energy consumption of the process was not a key objective of this project. This is because total energy consumption can only be validated on an efficiently designed system that is demonstrated at a commercial scale and fully integrated with the power plant. However, the heat of reaction and heat of vaporization, which are dictated by the process chemistry, could be validated at the pilot scale. Alstom and EPRI were interested in measuring the energy consumption of the process, comparing the results with initial estimates, and incorporating the data into techno-economic studies that estimate the total energy consumption for a commercial scale process.

The team collected empirical data for these two key parameters driving energy consumption, and compared the data to original Alstom estimates. The results:

- These values compare favorably with values determined in the laboratory setting;
- The results validate the figures used to size the validation pilots;
- The results validate the figures being used in commercial feasibility studies.

The fundamental lesson learned at Pleasant Prairie was that it is possible to operate a chilled ammonia carbon capture system on the flue gas from an operating power plant and in a typical plant environment. The project achieved the vast majority of its research objectives and demonstrated the fundamental viability of carbon capture by this process.

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The fundamental lesson learned at Pleasant Prairie was that it is possible to operate a chilled ammonia carbon capture system on the flue gas from an operating power plant and in a typical plant environment. The project achieved the vast majority of its research objectives and demonstrated the fundamental viability of carbon capture by this process. Technology that worked in laboratory experiments proved viable in real-world conditions like hot and cold weather, the inevitable starts and stops of a large power plant, and the environmental challenges that go along with using any chemical process. Moreover, the project achieved key research metrics around hours of operation, ammonia release, CO_2 removal levels, and CO_2 purity.

The few objectives that weren't completely accomplished can be addressed more effectively in later stages of the R&D cycle. For example, key questions around energy consumption – a key driver of cost – and other important technical issues will be addressed as larger-scale demonstrations work to fully optimize the technology.

WHAT'S NEXT?

The R&D process for carbon capture technologies is expected to move through progressively larger stages designed to validate different issues, with a goal of optimizing the technology before it is brought to market.

EPRI is supporting Alstom and AEP on the next phase of demonstrating the chilled ammonia technology pioneered at Pleasant Prairie. That project is the first to capture CO_2 from a pulverized coal-fueled power plant and inject it into a permanent storage site, more than 8,000 feet underground. The data collected and analyzed by that collaborative will support efforts to advance CCS technologies to commercial scale and provide information to the public and industry on future advanced coal generation options.

A 20-megawatt electric capture system has been installed at AEP's 1,300-megawatt Mountaineer Plant, where it will remove up to 110,000 tons of CO_2 emissions annually from the flue gas stream of the plant. The captured CO_2 will be compressed, transported by pipeline and injected into two saline reservoirs located under the plant site.

After the Mountaineer project, Alstom plans to develop a third and final phase commercial-scale demonstration project that will be designed to capture between 1.0 – 1.5 million tons of CO_2 per year. Alstom currently is working with AEP, TransAlta – a Canadian energy company – and other parties to successfully develop this demonstration project.

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Successful completion of these two projects will pave the way for a commercial offering. Alstom has committed to have a commercial offering for a carbon capture technology available by 2015 and believes the progress made at Pleasant Prairie keeps it on track to meet that commitment.

The technology highlighted in this report – chilled ammonia – is one of three different technologies under development by Alstom (the other two are advanced amines and oxy firing). All three are being demonstrated in the field in pilot projects similar to the one at Pleasant Prairie. Alstom believes that each technology has the potential to distinctly serve the needs of different customers with different specific situations and needs.

TEAM MEMBERS' PERSPECTIVES

EPRI: Achieving a low-carbon future requires a full portfolio of technologies, including CCS

Carbon capture is important, but it is just one tool for reducing carbon emissions. EPRI has developed analyses, known as Prism and MERGE (available at www.epri.com, report # 1019563), that show a full portfolio of electricity sector technologies could simultaneously address the challenge of growing load demand while meeting carbon constraints and limiting increases in the cost of power.

The report shows that, under proposed emissions standards, the sector can reduce its CO_2 emissions by 62 percent by 2030 relative to the U.S. Energy Information Agency's 2008 reference case projection, but that will require sustained research, development and demonstration, and aggressive deployment of the full technology portfolio. The full portfolio includes coal-fueled generation with carbon capture and storage, renewable resources, and nuclear generation on the supply side, as well as significant efficiency improvements throughout the electricity production and delivery system, and reduced consumption through end-use efficiency.

The analysis calculates that a full portfolio could reduce the economic cost of reducing emissions in the United States by more than $1 trillion by 2050. Less than half of these savings would be achievable if the future electricity sector generation portfolio does not include advanced coal with CO_2 capture and storage or advanced light water nuclear reactors.

Alstom's carbon reduction strategy: Multiple technologies for multiple generation options

Alstom is pursuing three interrelated strategies to reduce CO_2 emissions. The first approach focuses on the technology mix. As indicated in EPRI's analyses, no single form of power generation will address the dual challenge of securing the supply of reliable and affordable energy and affecting a rapid transformation to a low carbon system of energy supply. It will take all types of generation technologies including fossil fuels, nuclear and renewables. Supported by the broadest product portfolio in the industry, Alstom strongly supports the push for renewables but at the same time acknowledges that fossil fuels (coal, oil and gas) will still represent more than half of electricity production in 2030.

Production efficiency and energy management are the second step. Alstom is looking for solutions not only for CO_2 emissions from new plants but also from existing units that increase the efficiency of these plants and the networks in which they operate. It follows that for every incremental increase in production efficiency, there is a decrease in emissions. Similarly, such increases in production efficiency have a direct effect on fuel consumption. The more efficient a plant is, the less fuel it consumes to produce the same electrical output – an area of increasing priority in a time where security of fuel supply is a growing concern. Alstom's comprehensive range of integrated retrofit solutions offer plant operators a varied and innovative range of products and services that can be applied to their existing asset base, increasing their efficiency, output and extending the plant life.

The third and essential solution to addressing the climate change challenge is the application of CCS technologies as discussed in this report. Alstom has a long-term program for developing and/or acquiring the best available technology that will provide optimum efficiency as well as environmental and commercial benefits to power plant operators, now and in the future. Alstom is developing a portfolio of technologies that will provide power plant operators with the optimum carbon capture solution that takes into account the costs of installation, overall efficiency and maintenance requirements.

All three steps are needed to achieve the most cost effective solutions for controlling carbon emissions from power generation. Nothing less is needed given the urgent and technology demanding challenge of climate change.

We Energies' environmental commitment: A mix of low-emissions generation

Participation in this project is consistent with We Energies environmental commitment to its customers and to the quality of life in the areas it serves. To curb greenhouse gas emissions, We Energies supports flexible, voluntary, market-based strategies that encourage technology development and transfer and strategies that include all sectors of our economy and all significant global sources.

Through the company's Power the Future plan, the company is retiring older, less efficient coal-fueled power plants and replacing that generation with newer, more efficient power plants. Upon implementation of Power the Future, We Energies will achieve a system-wide reduction of emissions by 65 percent while producing 50 percent more electricity.

The We Energies environmental commitment also includes a mercury removal demonstration project installed at the We Energies Presque Isle Power Plant in 2006. The $53 million project, co-funded by the U.S. Department of Energy and We Energies, works to reduce mercury emissions by as much as 90 percent through the EPRI patented TOXECON® process.

The company operates the largest wind farm in the state at the Blue Sky Green Field Energy Center. We Energies is also seeking approval for a second wind project of comparable size in Columbia County and announced plans to build a 50-megawatt biomass plant that will use wood waste as its main fuel source.

Renewable energy is nothing new for customers of We Energies. Created in 1996, Energy for Tomorrow was one of the first and continues to be one of the most nationally recognized customer-based voluntary "green-pricing" programs in the nation. Approximately 20,000 customers are currently enrolled in the program that provides customers the option to choose to have all or a portion of their electricity purchased to come from renewable energy sources.

FOR MORE INFORMATION

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