FutureGen: Pathway to Near-Zero Emissions and Sustainable Energy

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This presentation will highlight the U.S. Department of Energy's (DOE) FutureGen project – a $1 billion government-industry partnership to design, build, and operate a near-zero emissions coal-fueled power plant. The lead organization for the FutureGen initiative is the National Energy Technology Laboratory (NETL), a multi-purpose laboratory operated by the U.S. DOE's Office of Fossil Energy. NETL has a mission to conduct R&D from fundamental science to technology demonstration for resolving the environmental, supply, and reliability constraints of producing and using fossil energy resources. The commercial-scale FutureGen R&D facility is a pathway toward future fossil-energy power plants that will produce hydrogen and electricity while nearly eliminating emissions, including carbon dioxide. The 275-megawatt FutureGen plant will initiate operations around 2012 and employ advanced coal gasification technology integrated with combined cycle electricity generation, hydrogen production, and carbon capture and sequestration. Low carbon emissions would be achieved by integrating CO2 capture and sequestration operations with the power plant.

The FutureGen plant will be based on cutting-edge integrated gasification combined cycle (IGCC) technology as well as advanced carbon capture and sequestration systems. The centerpiece of the project will be coal gasification technology that can eliminate common air pollutants such as sulfur dioxide and nitrogen oxides and convert them to useable by-products. Using oxygen from an air separation unit (ASU), gasification will convert coal into a highly enriched synthesis gas comprised of mostly hydrogen and carbon monoxide. After exiting the gasifier, the syngas is cleaned and shifted to produce a concentrated gas stream of hydrogen, steam, and CO_2. Following separation of these three species, the captured hydrogen will be used primarily to power turbines that will generate electricity. Alternatively, the hydrogen in the synthesis gas can be used in a fuel cell to produce ultra-clean electricity, or fed to a refinery to help upgrade petroleum products. Carbon sequestration will also be a key feature that will set the FutureGen plant apart from other electric power plant projects. The initial goal will be to capture 90 percent or more of the plant's carbon dioxide emissions, virtually eliminating coal-related greenhouse gas concerns at a rate of one million tons of carbon dioxide per year. Once captured, the carbon dioxide will be permanently stored in deep-geologic, saline formations.

The FutureGen project would be a R&D facility as well as the cleanest coal-fired power system in the world. The facility would incorporate cutting-edge research as well as the development of promising new energy-related technologies at a commercial scale. Advanced technology candidates include:

- Advanced Transport Reactor
- O2 Membranes
- Raw Gas Shift Reactor
- H2 Membranes, "Clathrate" CO2
- Ultra-Low NOx Hydrogen Turbine
- SECA Fuel Cell ($400/kW Design)
- Sequestration Technology
- "Smart" Dynamic Plant Controls and CO2 Management Systems
- "First of a Kind" System Integration

The FutureGen Alliance, a non-profit consortium of some of the largest coal producers (> 40% of U.S. coal production, representing all major coal types) and electricity generators (> 20% U.S. coal-fueled electricity production), was formed to partner with the DOE on the FutureGen project. The active role of industry in this project ensures that the public and private sector share the cost and risk of developing the advanced technologies necessary to commercialize the FutureGen concept. The FutureGen Alliance members are dedicating $250 million toward the project's costs and bring valuable technical expertise and power plant engineering and construction experience to the project. Performance and economic test results from the FutureGen Project would be shared among participants, industry, the environmental community, and the public.

In July 2006, the FutureGen Alliance announced its short list of candidate sites for the FutureGen plant following an extensive technical review. Of the 12 competing sites in seven states, the Alliance concluded that four sites in two states are best suited to host the FutureGen facility. The four sites currently being considered as reasonable site alternatives are: 1) Mattoon, IL, 2) Tuscola, IL, 3) Jewett, TX, and 4) Odessa, TX. Final site selection is currently scheduled to be made in the fall of 2007.

The construction period for the FutureGen plant would begin in 2009 with initial startup of the facility anticipated in the 2012 timeframe. DOE sponsored activities would include construction and four years of plant operation, testing, and research. In 2016, the DOE will follow up with two years of additional geologic monitoring for the sequestered CO2. After DOE-sponsored activities conclude, the Alliance or its successor would manage and operate the power plant.

At NETL, research engineers are using the Advanced process Engineering Co-Simulator (APECS) to develop high-fidelity process/computational fluid dynamics (CFD) co-simulations for analysis of potential FutureGen plant configurations. In a recent demonstration case, the FutureGen co-simulation combines a plant-wide Aspen Plus simulation with two FLUENT CFD-based equipment models, one for the entrained-flow gasifier where fluid dynamics strongly affect syngas quality and carbon conversion and one for the gas turbine combustor where the blending of air and fuel is at the heart of gas turbine combustor performance and efficiency. Using APECS, Aspen Plus controls the co-simulation and automatically executes the gasifier and combustor CFD models as needed to converge the tail gas recycle loop and a design specification on the gas turbine inlet temperature. The design specification is met by manipulating the synthesis gas split between power production and hydrogen production. The co-simulation results illustrate how APECS can help engineers understand and optimize the coupled fluid flow, heat and mass transfer, and related phenomena that drive overall FutureGen plant performance.

The ultimate goal for the FutureGen plant is to show how new technology can eliminate environmental concerns over the future use of coal – the most abundant fossil fuel in the United States with supplies projected to last 250 years. FutureGen is an opportunity for public and private sectors to share cost and risk of "zero emissions" technology development by:

- Supporting a technology-based, climate change mitigation strategy, which reduces the risk of climate change while protecting the environment
- Validating the cost and performance of an integrated "zero emissions" coal-fueled power plant
- Creating the technical basis to retain coal in global energy mix with long-term goal of zero emissions

FutureGen's co-production of power and hydrogen coupled with carbon capture and storage will serve as a pathway to an environmentally sustainable energy future.