

Advanced Process Engineering Co-Simulation of the FutureGen Power and Hydrogen Production Plant

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Presentation Outline

- **Vision for Energy Plants of the Future**
- **DOE FutureGen Project**
 - Concepts and features
 - Process description
- **FutureGen Modeling and Simulation at NETL**
 - Goals and objectives
 - Advanced Process Engineering Co-Simulator
- **APECS FutureGen Demonstration**
- **Summary**



Vision for Energy Plants of the Future

- Remove environmental concerns associated with the use of fossil fuels for production of electricity, transportation fuels, and chemicals through technology development
- Characteristics of future energy plants
 - “Near-zero” emissions (coal as clean as gas)
 - CO₂ sequestration-ready
 - Flexible (Feed stocks, co-products, and siting)
 - Highly energy efficient
 - Affordable (competitive with other energy options)
 - Industrially ecological (waste into by-products)
 - Reduced water requirements
 - Timely deployment of new technology
 - **Sustainable**



Electricity



Hydrogen



Chemicals

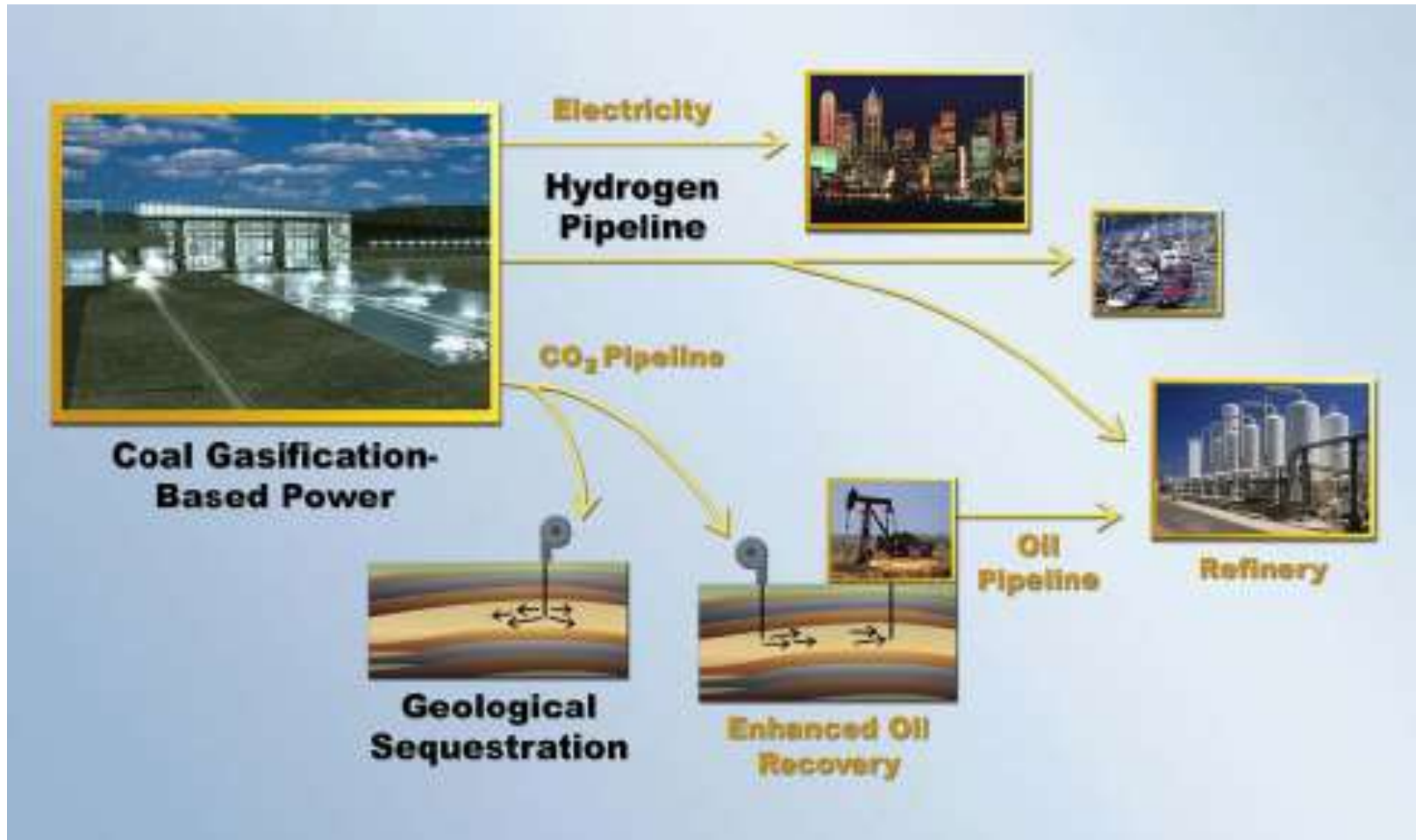


FutureGen

- **One-billion dollar, 10-year U.S. DOE project to create world's first coal-based, near-zero emission electricity and hydrogen plant**
- **Addresses four Presidential Initiatives focused on the environment and sustainability**
 - Hydrogen
 - Clear Skies
 - Climate Change
 - Clean Coal Power



FutureGen Project Concept

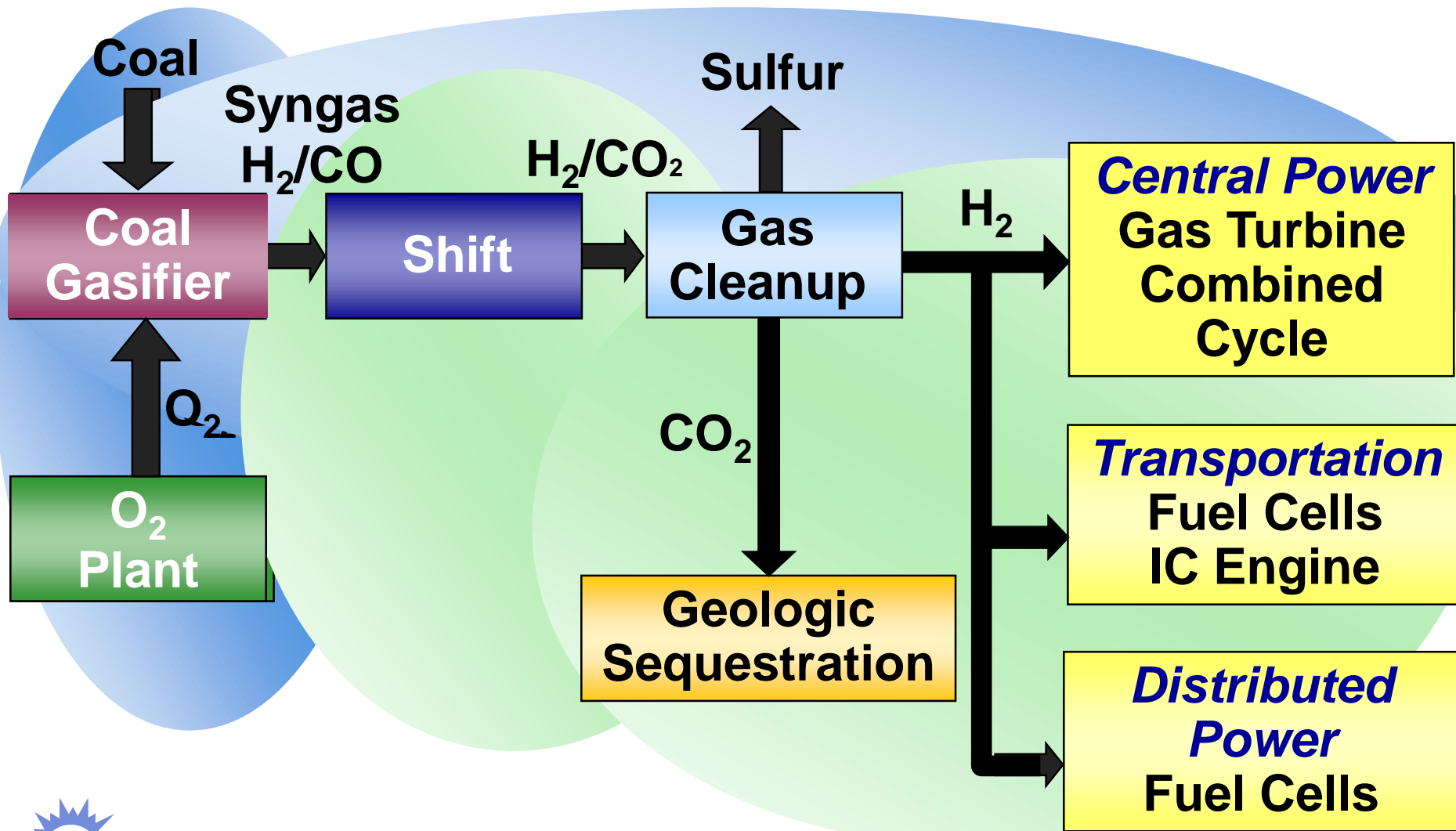


Features of the FutureGen Project

- **Coal-fueled gasification process that co-produces electricity and hydrogen – 275 MWe**
- **Near-zero emissions**
 - Capture and sequester > 90% CO₂ with potential for 100%
 - > 99% sulfur removal
 - < 0.05 lb/million Btu NO_x emissions (~5ppm)
 - <0.005 lb/million Btu particulate emissions
 - > 90% mercury removal
- **1 million tons/year of CO₂ captured and sequestered**
- **High-efficiency performance**
- **Platform for testing advanced technology components and integration concepts**



FutureGen Based on Integrated Gasification Combined-Cycle (IGCC) Technology



NETL Office of Science & Engineering Research

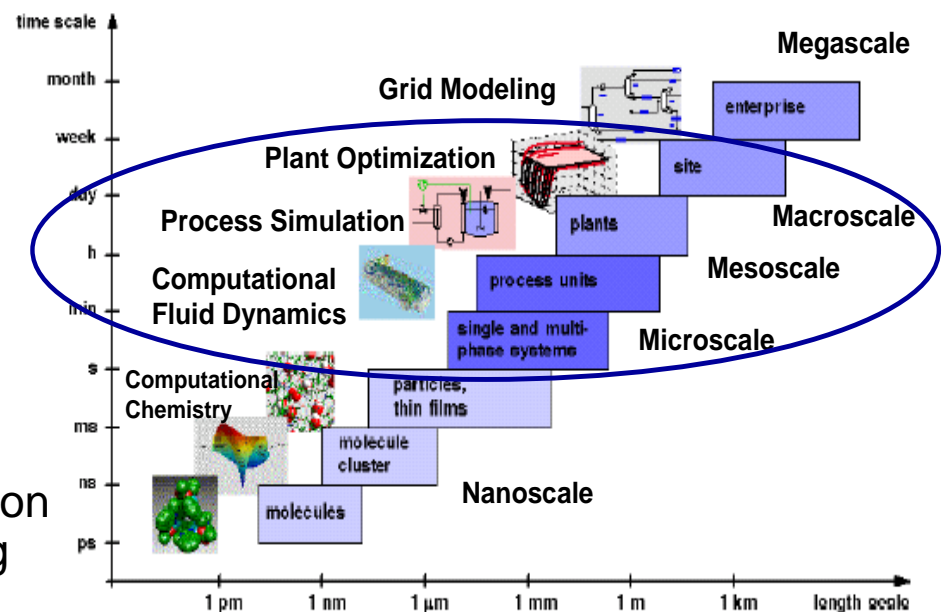
FutureGen Plant Modeling and Simulation

• Goal

- Reduce the time, cost, and technical risk of developing the FutureGen plant using advanced modeling and simulation technology

• Objectives

- Apply wide range of modeling and simulation technology
 - Process simulation, CFD, PDE multiphysics
- Develop integrated, multiscale simulation capabilities
 - Co-simulation frameworks
 - Open standards
- Couple with advanced visualization and high-performance computing
- Demonstrate virtual power plant simulations



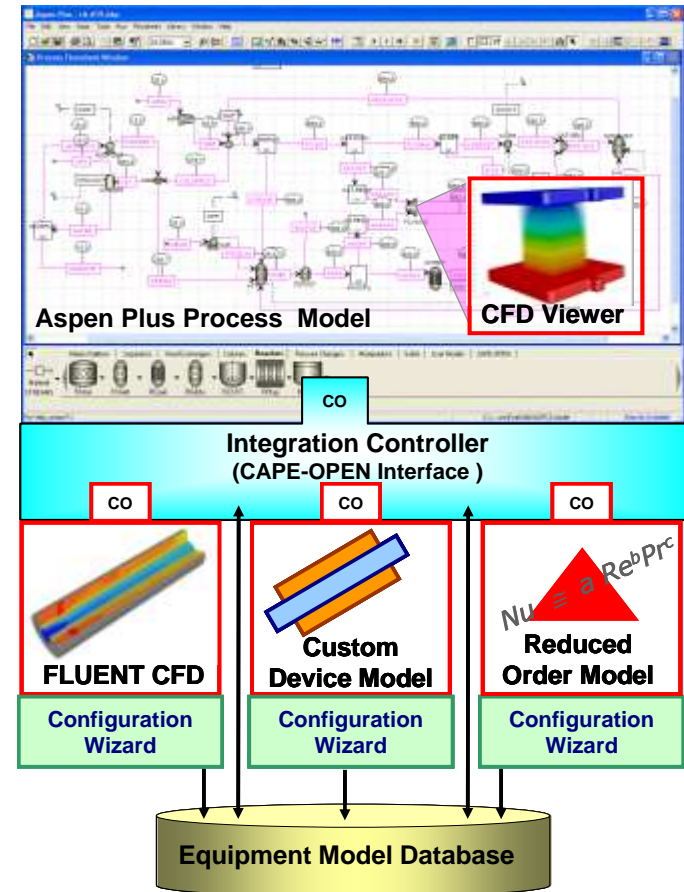
Multiscale Modeling and Simulation





Advanced Process Engineering Co-Simulator (APECS)

- Combines process simulation with custom engineering models and computational fluid dynamics (CFD)
- Complies with the process industry CAPE-OPEN software standard
- Offers fast reduced order models (ROMs) and parallel computing for improved performance
- Exploits advanced visualization for equipment and process analysis
- First of a kind development by NETL and its R&D technology partners
- Recognized with 2004 R&D 100 Award

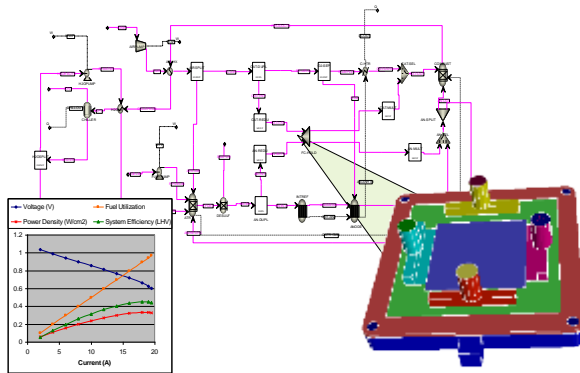


APECS Software Integration Framework

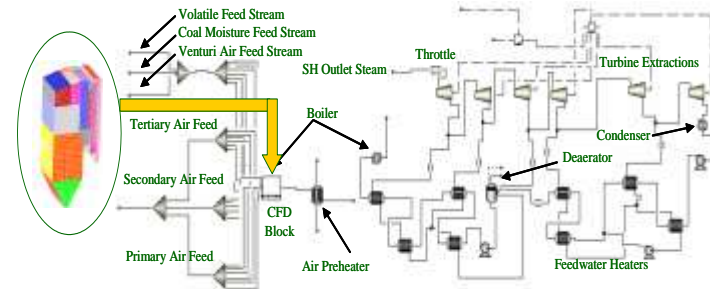


APECS Power Generation Applications

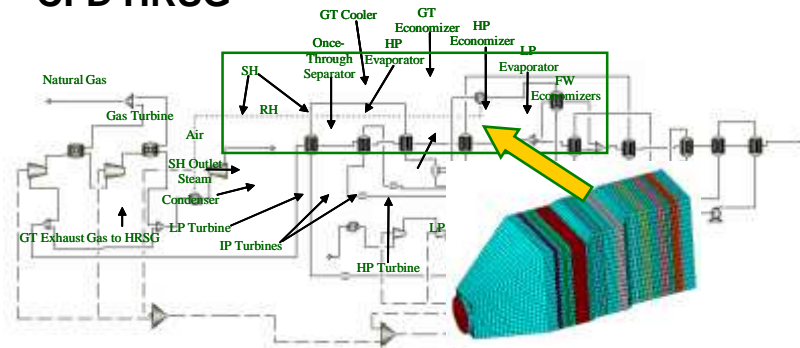
- Fuel Cell Auxiliary Power Unit (APU) with 3D CFD SOFC



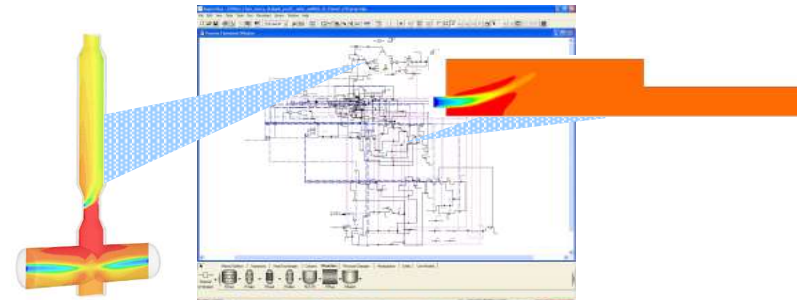
- ALSTOM Conventional Steam Plant (250MWe) with 3D CFD Boiler



- ALSTOM NGCC (250MWe) with 3D CFD HRSG



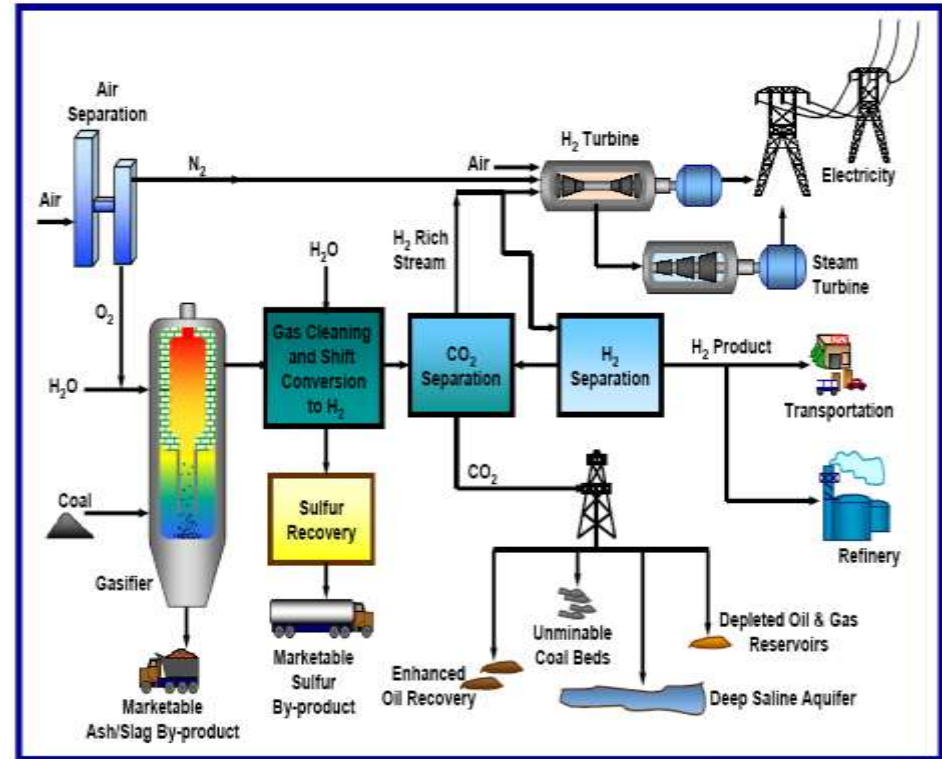
- FutureGen Plant (250MWe) with 3D CFD Gasifier and 2D CFD Turbine Combustor





FutureGen Power/Hydrogen Production Plant

- **IGCC with CO₂ capture and H₂ generation**
 - Air separation unit (ASU) integrated with gas turbine
 - Entrained-flow, coal-slurry, oxygen-blown gasifier
 - Water gas shift
 - Gas cleanup for particulates, Cl₂, and S₂
 - Selexol for CO₂ capture with compression to liquid
 - Pressure-swing adsorption (PSA) for generating H₂
 - GE 7FB gas turbine
 - Steam cycle with three pressure levels and HRSG

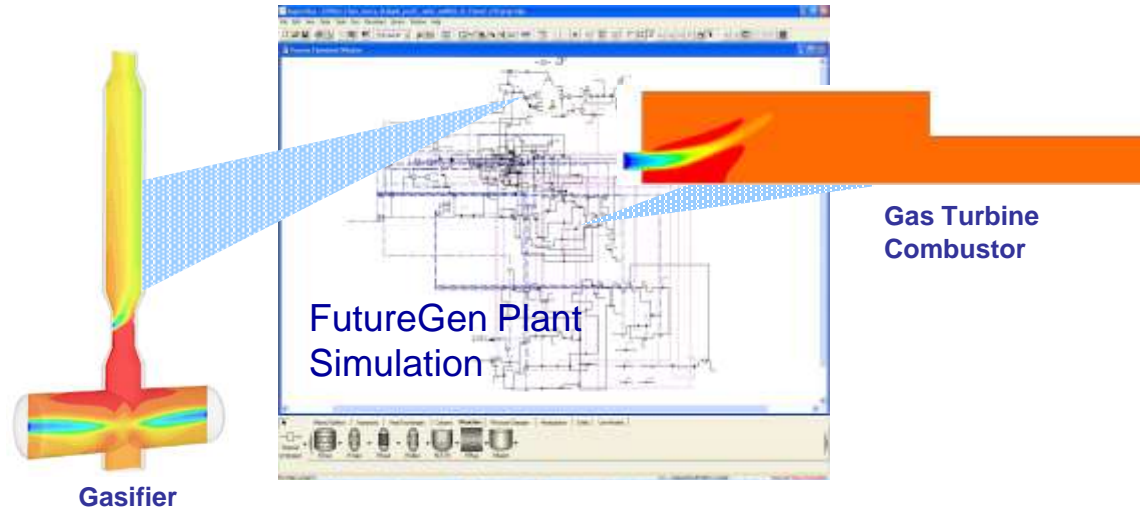


FutureGen Process Diagram

- **IGCC plant with advanced technology modules and aggressive integration, performance, and environment goals**



APECS FutureGen Plant Demonstration



- **FutureGen Plant Model**

- Aspen Plus® steady-state
- All major plant sections, over 250 unit operations
- Calculates M+E balances, power, efficiency, etc.
- Design specifications, e.g., gas turbine inlet temperature

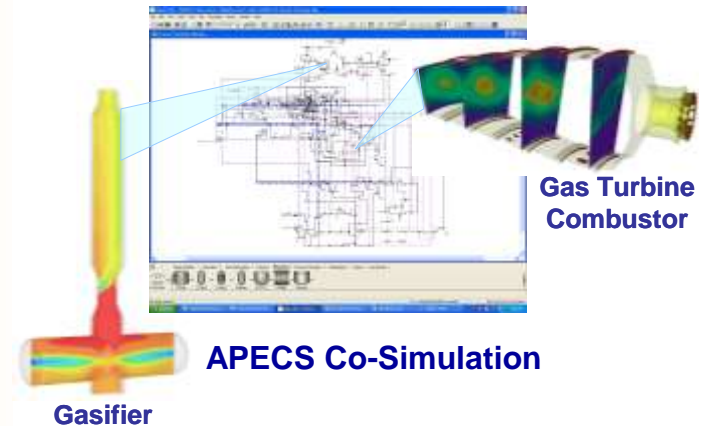
- **CFD Models**

- Entrained Flow Gasifier
 - FLUENT® - 3D
 - DPM for coal slurry
- Gas Turbine Combustor
 - FLUENT® - 2D / ROM
 - Embedded in design specification loop



Summary and Conclusions

- Described DOE's vision for energy plants of the future and the FutureGen Project
- Highlighted NETL's APECS system for coupling high-fidelity equipment models with process simulation
- Demonstrated application of the APECS technology to the FutureGen plant
- Illustrated how the APECS system:
 - Helps engineers better understand fluid dynamics and related phenomena that impact overall power plant performance
 - Provides necessary level of detail and accuracy essential for advanced power plant design and optimization
- Reducing the time, cost, and technical risk of developing high-efficiency, near zero-emission plants will speed the transition to a sustainable energy future



FutureGen Power Plant

