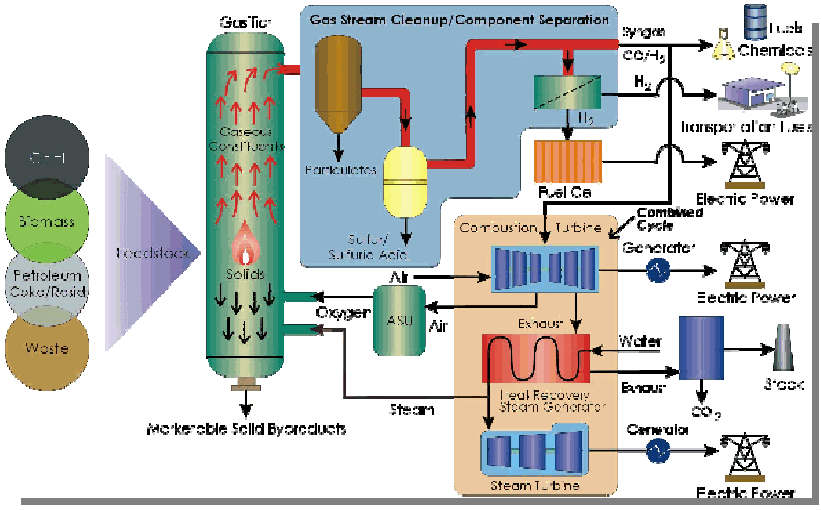
2.1.2 ADVANCED POWER SYSTEMS

Technology Description

Advanced Gasification System



Advanced coal-fired, power-generation technologies can achieve significant reductions in CO_2 emissions while providing a reliable, efficient supply of electricity. Significant improvements in reducing CO_2 and other emissions have been demonstrated via efficiency improvements and cofiring of coal and biomass. Achieving the efficiency improvements and reducing emissions must be accomplished in a cost-effective manner. While current power plant efficiencies are about 33%, increasing efficiencies ultimately to 60% or more will reduce CO_2 emissions by more than 50% per unit of electricity. Future development of CO_2 sequestration could reduce carbon emissions to near-zero levels.

System Concepts

- Gasification technology increases the coal power-generation cycle efficiency by combining two or more energy cycles, a high-temperature gas turbine, and a steam turbine. In a typical configuration, the gasifier converts coal into a low- or medium-BTU gas, which is burned in the combustion section of the gas turbine to produce electric power. The exhaust gases from the gas turbine are cooled in the heat-recovery steam generator. The steam is routed to the steam turbine, producing additional electric power. Depending on the quality of the gas produced, the gas also may be used as the feedstock to coproduce a variety of chemicals and fuels.
- Combustion technology, including chemical looping, may use oxygen separation coupled to a coal-fired power plant featuring oxygen combustion, carbon capture, and ultra-supercritical steam-cycle operation.

Representative Technologies

- FutureGen – the ultra-clean energy plant of the future.
- Integrated gasification combined cycle (IGCC).
- Advanced combustion systems.
- Unconventional combustion (e.g., use of chemical cycling for CO_2 enrichment).

Technology Status/Applications

- Current IGCC systems based on oxygen-blown, entrained-bed gasifiers are 40%-42% efficient.
- IGCC systems with efficiencies of 40%-42% are available for commercial deployment.
- Efficiencies of a portfolio of IGCC technologies are expected to average 48%-52% by 2010 and 60% by 2020.
- The cost of electricity for these technologies is expected to be 3¢/kWh (in 2003$) by 2015.

- Gasifier capital costs are expected to decrease to 90% of current costs as these technologies mature around 2012.
- Supercritical coal-fired technologies without carbon sequestration are available now with efficiencies of 42%.
- Ultra-critical steam cycles using coal-fired technologies with efficiencies in the 45% range are expected by 2010.
- Coal-fired technologies with significant potential for carbon capture are expected by 2015.
- Oxygen-fed, coal-fired power plants with near-zero CO_2 emissions are expected by 2020.

Current Research, Development, and Demonstration

R&D Goals

- The research program goal in the Advanced Power Systems area is to increase efficiency of new systems to levels ranging from 48% to 52% by 2010, and to more than 60% by 2020.
- By 2020, achieve an overall electricity production cost that is between 75% and 90% of current pulverized-coal-based power generation.

RD&D Challenges

- Long-term systems need to maintain relatively high temperatures between the combustion/gasification stage and the turbine stage to achieve efficiency goals.
- High-temperature materials that are stable and resistant to corrosion, erosion, and decrepitation are a primary technology development need.
- Advanced materials are needed for heat exchangers, turbine components, particulate filters, and SO_2 removal. Other challenges include the use of alternate working fluids and heat-exchange cycles, CO_2 capture methods, cycle optimization, environmental control technologies with low energy penalties, and solids handling.

RD&D Activities

- The portfolio of high-efficiency coal power systems under development through DOE is comprised of IGCC, pressurized fluidized bed combustion, and Vision 21 plants.
- DOE activities are supplemented by up to 50% cost share from the private sector.
- Current development encompasses a broad range of activities including major efforts by Boeing, Alstom, Southern Company Services, and others to develop a new class of gasifiers.
- Four IGCC clean coal demonstration projects are in various stages of completion.

Recent Progress

- Incorporating the results from technology studies and lessons learned at the Wabash River Integrated Gasification Combined Cycle (IGCC) power plant in Terre Haute, Indiana, Excelsior Energy Inc. and ConocoPhillips will construct and operate the 531-megawatt Mesaba Energy Project in Hoyt Lakes, Minnesota, to reduce costs and improve efficiency and availability for a next generation, oxygen-blown gasification plant using bituminous coal. Mesaba will advance such across-the-board performance to achieve criteria pollutant emission levels (SO_x, NO_x, mercury, and particulate) equal to or below the current LAER rates for coal-fired generation. Carbon dioxide emissions will be 15% to 20% less than most existing coal-fired power plants as well.
- A Demonstration Plant will be built in Orange County, Florida, and co-owned by Orlando Utilities Commission and Southern Power Company. It will gasify sub-bituminous coal and generate 285 megawatts (MW) of electricity (net) at a heat rate of 8,400 Btu/kWh (40.6% efficiency – higher heating value basis). The transport gasifier offers a simpler and more robust method for generating power from coal than other alternatives. The Demonstration Plant will use state-of the-art emission controls and will be the cleanest, most efficient coal-fired power plant technology in the world. Future units based on the plant design will be 600 MW-class units running at efficiencies near 41.5 %. This project is a continuation of successful work conducted at the Power Systems Development Facility (PSDF).

Commercialization and Deployment Activities
• The gasification technology is under development with several recent proof-of-concept greenfield and repowering installations. Existing plants may be repowered with higher-efficiency coal technologies at or below the price of the natural gas combined-cycle plants. Where natural gas is not available (a considerable portion of the United States and a major portion of the international market) or if gas costs stay above $4/mmbtu, high-efficiency coal plants will be the lowest-cost choice. • Internationally, where natural gas is not available, the market share for coal is expected to be much higher. **Market Context** • The market for new or repowered capacity from now until 2020 is estimated to be as much as 400 GW in the United States and more than that internationally. Domestically, the primary competition for this technology profile is expected to be natural gas combined cycle.