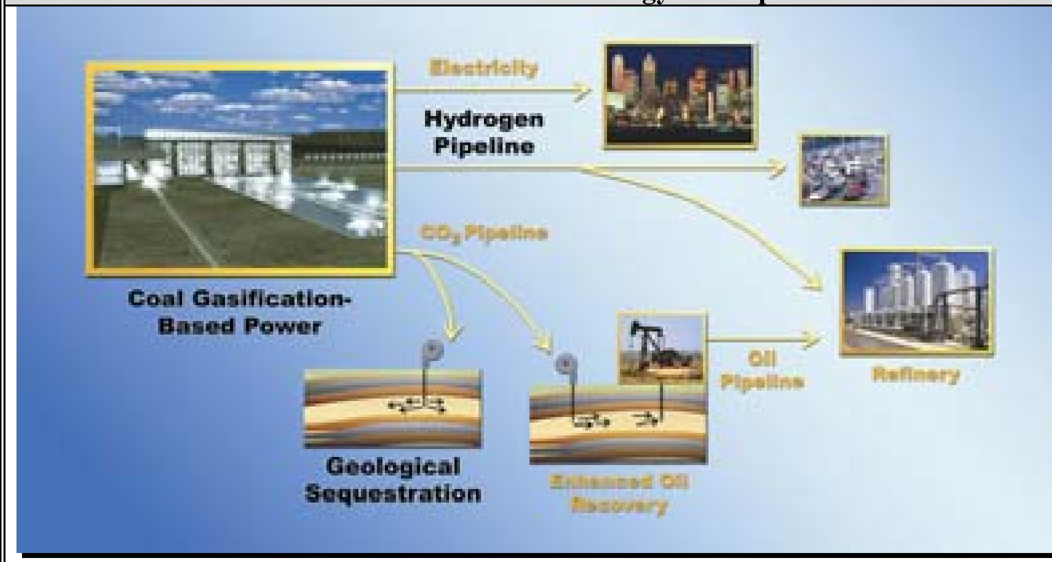
2. REDUCING EMISSIONS FROM ENERGY SUPPLY

2.1 LOW EMISSIONS FOSSIL-BASED FUELS AND POWER

2.1.1 COPRODUCTION/HYDROGEN

Technology Description



FutureGen Power Plant

Coproduction technology focuses on developing plants that coproduce electricity and hydrogen for a transportation fuel from fossil and/or fossil/biomass blends with very large reductions in CO_2 emissions compared to present technologies. Two approaches may be developed. Both approaches employ synthesis gas generated from natural gas reforming or coal gasification. Carbon emissions are reduced in the near-term approach principally by improving process efficiency (e.g. warm gas cleanup, separation membranes); and in the longer term, via more advanced system components such as high-efficiency fuel cells. In both the near and long term, incorporating CO_2 collection into the process, followed by permanent sequestration will be required to achieve zero emissions.

System Concepts

- Synthesis gas is used from a variety of feedstocks including coal, petroleum coke, biomass, opportunity fuel, and natural gas. For solid feedstocks, the initial processing involves gasification followed by gas cleanup (particulate matter, sulfur, nitrogen compounds). For natural gas feed, the initial step is partial oxidation reforming. All new technologies to be developed for the long-term approach of coproduction will work equally well with solid or gas feedstocks.
- The core approach is to employ water gas shifting of syngas to maximize production of hydrogen and carbon dioxide, which allows carbon capture prior to combustion.
- Nominal carbon capture for the near-term approach (including both net power and fuel production) is 90% of feedstock carbon used for conversion. For the long-term approach, carbon capture will be more than 99%.
- Power production is via combustion turbine/steam turbine combined cycle in the near-term approach. Power production is via solid-state fuel cell combined cycle in the long-term approach.
- The near-term approach accomplishes carbon capture by absorption from shifted syngas into a physical solvent such as Selexol. Use of a physical solvent instead of chemical solvents such as amines yields energy savings in CO_2 recovery.
- The principal fuel product anticipated with the near-term approach is Fischer-Tropsch diesel fuel, a premium fuel or blending stock with ultra-low sulfur and aromatics. The principal fuel product with the long-term approach is high-purity hydrogen.
- The long-term approach will employ ceramic membranes for oxygen separation and for hydrogen separation.

Representative Technologies

- Gasifiers for solid feedstocks.
- Partial oxidation reformers for natural gas feedstock.
- Shift reactors (both approaches).
- Hydrogen-fueled combustion turbines (near-term approach).
- Steam turbines for combined cycle power generation (near-term approach).
- Fischer-Tropsch reactors and product recovery train (near-term approach).
- Physical solvent-based absorption system for CO_2 recovery (near-term approach).
- Cryogenic oxygen separation (near-term approach).
- Ion transport membranes for oxygen separation and ceramic membranes for hydrogen recovery (long-term approach).
- Solid-oxide fuel cells (long-term approach).
- CO_2 compression and drying system (both approaches).

Technology Status/Applications

- The only technology module that needs to be developed for the near-term approach is the hydrogen combustion turbine. Major turbine manufacturers (e.g., GE, Siemens-Westinghouse) have performed design studies on the modifications that would be required on existing combustion turbines. Test results indicate the modifications are technically feasible.
- Absorption of CO_2 in a physical solvent has not been practiced commercially at the large scale that will be required at a central coproduction plant (about 5,000 tpd CO_2 for a 250-MW plant). All aspects of the technology are proven, however, so scale-up should be straightforward.
- Fischer-Tropsch conversion is a commercial process used in South Africa (Arge reactors) to convert both coal- and natural-gas-derived syngas to liquid fuels and chemicals. Fischer-Tropsch conversion is also used commercially by Shell in Malaysia to convert natural gas to diesel fuel, solvents, and wax products. In the United States, liquid-phase synthesis with unshifted coal-derived syngas has been practiced at the LaPorte, Texas, pilot facility, and at the Eastman Chemical Co. Clean Coal Technology demonstration project.
- Ceramic membrane reactor development projects for both oxygen separation and hydrogen recovery are underway with industrial partners as part of the DOE Vision 21 program. The Vision 21 roadmap calls for both technologies to be ready for commercial use by 2015.
- Compression, drying, and transport of CO_2 at supercritical pressures already are practiced in recovery and use of CO_2 from underground sources for tertiary oil recovery.

Current Research, Development, and Demonstration

RD&D Goals

- By 2010, design a near-term coproduction plant, configured at a size of 275-MW, which would be suitable for commercial deployment.
- By 2010, demonstrate pilot-scale reactors using ceramic membranes for oxygen separation and hydrogen recovery.
- By 2010, demonstrate a $400/kW solid-oxide fuel cell.
- By 2020, design a long-term coproduction plant at a scale of 275-MW or larger.

RD&D Challenges

- Hydrogen combustion turbine design modifications.
- CO_2 absorber demonstration at full scale.
- Plant integration issues for coproduction of Fischer-Tropsch liquids and power.
- Integration of coproduction plant with sequestration site planning.
- Ion transport membranes for oxygen separation.
- Long-term membrane reactor for hydrogen recovery.
- Low-cost solid-oxide fuel cells.
- Plant integration issues for coproduction of hydrogen and power.

RD&D Activities
• Ion transport oxygen separation membranes • Hydrogen separation membranes • Early-entrance coproduction plant designs
Recent Progress
• Air Products' liquefied petroleum methanol pilot plant at LaPorte, Texas, was scaled up to Eastman Chemicals Clean Coal Technology Project. • Eastman Chemicals Clean Coal Technology Project successfully produced 80,000 gpd of 97% methanol, and was selected for scale-up in Global's early-entrance coproduction plant design study for the Wabash River site.
Commercialization and Deployment Activities
• Early entrance coproduction plant projects begin with a Phase I plant design for eventual commercial scale demonstration in follow-up phases. **Market Context** • Coproduction plants like those described here address both the power and transportation sectors, providing energy with very large reductions in carbon intensity from large point sources of CO_2 (such as central generating stations) and could become the new world standard for providing environmentally responsible power and transportation.