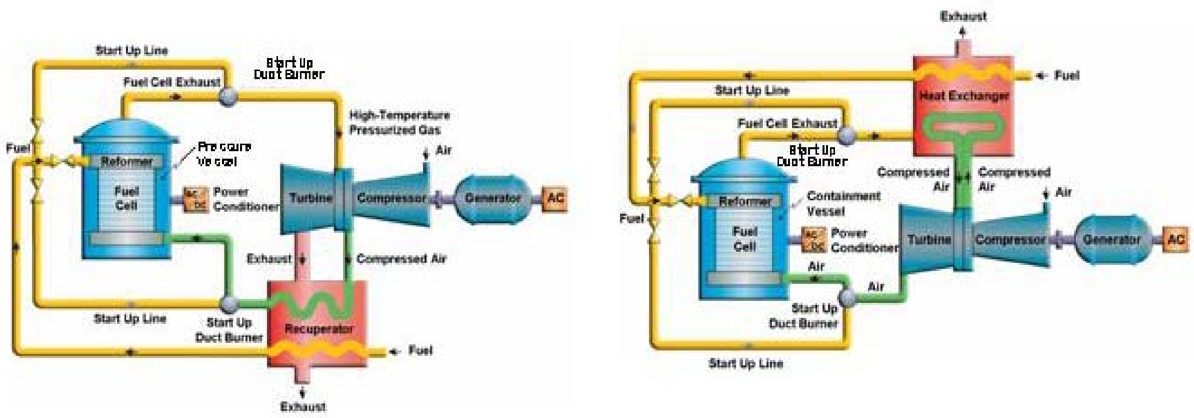
2.1.3 DISTRIBUTED GENERATION/FUEL CELLS

Technology Description

Fuel Cell Hybrid Cycles



Direct Fuel Cell Turbine Cycle

Indirect Fuel Cell Turbine Cycle

The ultimate goal of this technology is to develop fuel cell and/or hybrid systems that use natural gas or hydrogen (from coal, natural gas, or other sources) for highly efficient power generation. This also includes standalone applications of small to medium gas turbine systems, as well as advanced turbine systems for cogeneration application. Near-zero CO_2 emissions could be achieved with the integration of CO_2 capture.

System Concepts

- Hybrid systems that combine fuel cells and gas turbines to create a high-efficiency power module with near-zero emissions for central power or grid support applications.
- Unique fuel cell turbine hybrid cycles that incorporate intercoolers, humidified air cycles, and high-pressure ratios to achieve the highest efficiency.
- High-efficiency coproduction (electricity and hydrogen) energy systems, utilizing waste heat for making hydrogen from natural gas.
- Integration in the long term of CO_2 capture technologies with all of the above systems.
- Integration of fuel cells with other heat engines (reciprocating engines, Stirling engines, etc.) to create highly efficient and clean power modules.
- Fuel cell systems, including high- and low-temperature units.

Representative Technologies

- Low- and high-temperature fuel cells.
- Optimized gas turbines with higher-pressure ratios, intercoolers, oil-less bearings.
- Smart control systems.
- Hydrogen separation membranes.
- Natural gas reforming.
- CO_2 capture.
- Membrane separators for air, hydrogen, and CO_2.
- Ultra-high temperature steam turbines.

Technology Status/Applications

- Two different fuel cell turbine hybrid power systems (300 kW) have been designed, built, and operated (Siemens Westinghouse and FuelCell Energy Inc.). Both prototype systems logged more than 6,000 hours of operation each and achieved efficiencies of approximately 52% with near-zero emissions.

- The Solid State Energy Conversion Alliance (SECA) is in the fourth year of an eight-year program to develop low-cost (< $400 / kW) fuel cell modules for stand-alone and hybrid applications.
- High-temperature fuel cells – such as molten carbonate and tubular solid oxide – are engaged in commercial-scale demonstration tests, but not yet competitively on the market.
- Various elements of high-performance cycles need to be developed to integrate long-term CO_2 capture, membrane separation, optimized turbines, low-cost high-performance SECA fuel cells, and ultra-high temperature steam turbines need extensive development.

Current Research, Development, and Demonstration

RD&D Goals

- By 2010, demonstrate a gas-aggregated FC module larger than 250 kW that can run on coal syngas, while also reducing the costs of the Solid-State Energy Conversion Alliance fuel cell power system to $400/kW.
- By 2012-2015, the program aims to (1) demonstrate a megawatt-class hybrid system at FutureGen with an overall system efficiency of 50% on coal syngas, (2) demonstrate integrated fuel cell and turbine systems achieving efficiencies of 55% on coal; and (3) integrate optimized turbine systems into zero-emission power plants.

RD&D Challenges

- Low-cost, high-performance materials.
- Pressurization
- Scale up
- Aggregation
- Simpler manufacturing process and materials in fuel cells to lower costs.
- Grid interconnection.
- Fuel cell turbine control system for steady-state and dynamic operation.
- Developing new components required by long-term cycles integrating CO_2 capture.

RD&D Activities

- High-temperature fuel cell performance advancement for FCT hybrid application.
- Systems integration and controls for hybrid FCT application.
- Hybrid systems and component demonstration.
- Low-cost fuel cell systems.
- Develop hydrogen separation, transport, and storage.
- Develop methods for CO_2 sequestration and/or capture.
- Develop high-performance materials, catalysts, and processes for reforming methane.
- Develop membranes for separation of air, hydrogen, and CO_2.

Recent Progress

- Siemens-Westinghouse has demonstrated a nominal 300 kW fuel cell turbine direct-cycle hybrid for more than 3,000 hours and achieved an electrical efficiency of 53%.
- FuelCell Energy Inc. (FCE) has demonstrated a nominal 300 kW fuel cell turbine indirect cycle hybrid for more than 6,000 hours and achieved an electrical efficiency of 52%. FCE is currently building a fully integrated version of their 300 kW hybrid.

Commercialization and Deployment Activities

- Fuel cells are becoming viable in niche applications, and increased production rates are expected to lower capital costs.
- About 300 fuel cell units (mostly 200-kW size) have been installed worldwide.
- Currently, there are six industrial teams in the SECA program developing low-cost (< $400/kW) solid oxide fuel cell technology. The SECA program is supported by a significant core technology program to resolve technical issues. Three of the six SECA industry team have shown significant interest in developing fuel cell turbine hybrid products.
- Energy losses and cost are expected to decline with system refinements.