1.4 INDUSTRY

1.4.1 ENERGY CONVERSION AND UTILIZATION

Technology Description

Energy conversion and use account for a large share of carbon emissions from the industrial sector. An integrated systems approach to energy conversion and utilization incorporating the best technologies could significantly reduce greenhouse gas (GHG) emissions and improve industrial competitiveness. Many opportunities exist for improving the efficiency of energy generation, including advanced combustion technologies (burners, boilers), gasification technologies, and innovative energy delivery and conversion systems. Energy utilization gains can also be achieved through the increased adoption of existing technology for cogeneration of power and heat, referred to as combined heat and power (CHP), which provides higher thermal efficiency than purchased electricity. In addition, opportunities exist to reduce energy use and GHG emissions through economic recovery and use of both high- and low-level waste heat.

System Concepts

- The industrial sector could significantly reduce GHG emissions by improving energy utilization efficiency; gasifying waste materials to create useful fuels and materials; and using high-efficiency cogeneration technologies with lower-associated GHG emissions.
- Modern design techniques, advanced technology, and an integrated systems approach to mill or plant design could maximize the use of waste heat streams that are not currently recovered and reused.

A revolutionary super boiler now under development should substantially reduce energy use and carbon emissions throughout industry.

Representative Technologies

- Energy conversion technologies include high-efficiency burners and boilers; advanced steam cycles; innovative energy-conversion systems; and gasification of in-plant process streams, wastes, biomass, or combinations of these fuels. As an example of DOE-supported technology, ITP is working with the Gas Technology Institute and other industry partners to develop a revolutionary super boiler that could save more than a hundred trillion Btu of energy annually and reduce emissions (see inset).
- Energy utilization technologies include on-site combined heat and power systems, waste heat-recovery systems, advanced heat-exchanger designs, and innovative furnace technology (e.g., isothermal melting).

Technology Status/Applications

- Technologies with higher efficiencies have been demonstrated in several applications, but have not been uniformly adopted by industry.
- Energy-generation technologies currently used by industry typically have thermal efficiencies ranging from 25% to 55%; the next generation of energy-generation technologies promises substantially higher thermal efficiencies, perhaps ranging from 45% to 80%. This efficiency improvement would significantly reduce the amount of fuel required for industrial heat and power, thus reducing GHG emissions. Additionally, aggressive development and deployment of on-site generation technologies could reduce transmission and distribution losses, which average approximately 7%.
- Use of in-plant wastes and residues from production processes to generate energy is a promising area for reducing energy intensity and GHG emissions. RD&D is needed to increase the use and cost-effectiveness of technologies such as gasification.

Current Research, Development, and Demonstration

RD&D Goals

- The overall research program goal in this area is to contribute to a 20% reduction in the energy intensity (energy per unit of industrial output, as compared to 2002) of energy-intensive industries by 2020.
- By 2006, demonstrate a greater than 94 percent efficiency; and, by 2010, the packaged boilers will be commercially available with thermal efficiencies of 10%-12% higher than conventional technology.
- By 2008, in the pulp and paper industry, demonstrate high-efficiency pulping technology that redirects green liquor to pretreat pulp and reduce lime kiln load and digester energy intensity.
- By 2011, demonstrate isothermal melting technology – which could improve efficiency significantly in the aluminum, steel, glass, and metal-casting industries.

RD&D Challenges

- Entirely new technologies and increased understanding of thermal processes will be needed to facilitate development of advanced systems for improved energy recovery.
- Technical advances are required in gasification technology to make it economical, particularly for gas clean-up, construction materials, and conversion to viable chemical products.

RD&D Activities

- DOE is developing and demonstrating advanced, high-efficiency combustion systems, advanced furnace designs, waste heat-utilization technologies, and gasification technologies.
- RD&D activities related to this pathway are sponsored by DOE, the Environmental Protection Agency, and other Federal agencies. This pathway will work closely with these programs and also leverage past investments.

Recent Progress

- The UltraBlue burner was developed to maximize fired-heater efficiency and help the petroleum and chemical industries meet stringent environmental regulations. By 2020, advanced heaters incorporating ultra-high efficiency and ultra-clean combustion burners have the potential to save more than 84 trillion Btu/year and reduce NOx emissions by 150,000 tons annually. By late 2003, more than 1,300 UltraBlue burners had already been sold to the petroleum industry alone.
- Waste heat was tapped at two refineries to power absorption refrigeration units. The power generated was used to chill waste fuel streams that contained substantial amounts of propane or heavier hydrocarbons. With chilling, the refineries were able to condense and recover about half of the valuable hydrocarbons in the waste streams for increased profits; and, at the same time, reduce the amount of gas flared off as waste, reducing carbon dioxide emissions to the atmosphere.
- A dilute oxygen combustion system was developed and is now operating in two steel mills. The system increases the maximum production rate without additional capital investment, and significantly reduces fuel use.
- A high-efficiency, high-capacity, low-NOx combustion system integrated with an innovative, low-cost, vacuum-swing-adsorption oxygen system has been developed and demonstrated. This system uses a novel air-oxygen-natural gas burner that provides 30% higher furnace productivity and 40% energy efficiency improvements with low NOx emissions relative to air-fuel burners.

Commercialization and Deployment Activities
• Industry is already making substantial investments in commercializing and deploying economical technologies: combusting wastes and residues, employing oxy-fuel combustion, efficiently generating electricity and heat on-site, and energy cascading from high temperature to lower temperature uses within plants. Availability of capital and competition for R&D and demonstration funds will impact deployment of new technology. Cost competitiveness with existing technologies will be achieved when the newer technologies have completed their R&D cycles.
Market Context
• Markets include all manufacturing industries that use boilers or process heating. In 1998, process heating and boiler fuel accounted for about 10 quads of fossil energy consumption in the manufacturing sector alone. Significant potential also exists for additional or more efficient on-site generation of electricity in a number of industry sectors, including chemicals, petroleum refining, food processing, pulp and paper, cement, and equipment manufacture (transport, heavy machinery).