1.4 INDUSTRY

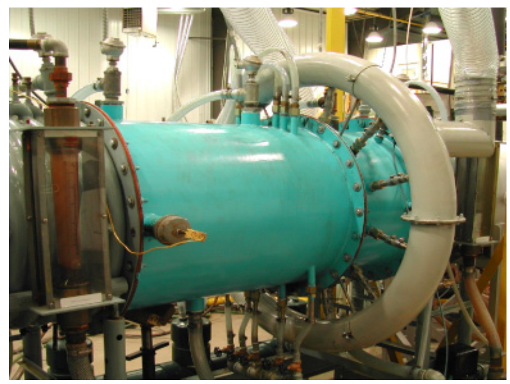
1.4.1 ENERGY CONVERSION AND UTILIZATION

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. Energy utilization gains can be achieved through the increased adoption of existing technology in the areas of combined-cycle power generation and cogeneration of power and heat, referred to as combined cooling, heating, and power (CHP). Many opportunities also exist for improving the efficiency of energy generation, including advanced combustion technologies, fuel cells, gasification technologies, and advanced steam cycles. GHG reductions also can be achieved through increased use of fuels with low or no net GHG products, such as biomass and hydrogen. Opportunities in energy utilization include making economical use of waste heat and minimizing generation of low-level heat.

System Concepts

- The industrial sector could significantly reduce GHG emissions by improving energy utilization efficiency; switching to low-GHG fuels; gasifying waste materials to create useful fuels; and using high-efficiency, distributed generation technologies with low-GHG emissions (such as fuel cells).
- Modern design techniques and an integrated systems approach to mill or plant design could minimize the generation of low-level heat that cannot be used economically.



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; oxy-fuel combustion, with or without flue gas recirculation; gasification of in-plant process streams and cofiring of biomass with fossil fuels; hydrogen-enriched combustion and fuel cells; and reforming of liquid and gaseous fuels to hydrogen, combined with carbon management. 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 several hundred trillion Btu of energy annually and reduce emissions (see inset).
- Energy utilization technologies include on-site combined heat and power systems and waste heat-recovery systems.
- Advances in heat exchangers and furnace design also will allow for the more efficient utilization of energy.

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 distributed on-site generation technologies could avoid 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 this technology.

Current Research, Development, and Demonstration
RD&D Goals • Effect an aggressive transition to highly energy-efficient, on-site generation technologies, such as CHP systems, improved boilers and furnaces, and low- or zero-carbon fuels such as natural gas, biomass, or hydrogen to support the overall DOE Industrial Technologies Program goal of contributing to a 30% reduction in the energy intensity (Btu per unit of industrial output as compared to 2002) of energy-intensive industries by 2020. Reductions in energy intensity could significantly reduce industrial GHG emissions. • By 2006, demonstrate a >95% efficient packaged boiler; by 2010, packaged boilers will be commercially available with thermal efficiencies 10%-12% higher than conventional technology. • Continue to focus technology development efforts on key energy-intensive industries, which collectively account for three-quarters of energy use by the industrial sector. • Assist industry efforts to develop advanced glass technologies that will reduce the gap between actual melting energy use (more than 11 million Btu to melt a ton of glass as measured in 1996) and the theoretical minimum (2.5 million Btu per ton) by 50% by 2020. • Develop technical advances in gasification technology and non-combustion, high-efficiency power generation techniques such as fuel cells (requiring advances in fuel reforming technologies). **RD&D Challenges** • Better understanding of enabling technologies will allow developments of processes and equipment for improved energy recovery. • Advanced, low- or zero-GHG-emission, power-generation technologies must be made economically competitive. • Technical advances are required in gasification technology and noncombustion, high-efficiency, power-generation techniques such as fuel cells (requiring advances in fuel-reforming technologies). **RD&D Activities** • DOE is developing and demonstrating advanced, high-efficiency combustion systems, waste heat-utilization technologies, a systems approach to mill or plant design, and gasification technologies. • RD&D activities related to this pathway are sponsored by DOE, the Environmental Protection Agency, the National Institute of Standards and Technology's Advanced Technology Program, and other Federal agencies. This pathway will work closely with these programs and also leverage past investments.
Recent Progress
• The forced internal recirculation burner is beneficial to all industries that generate steam from natural gas burners. This new technology combines several techniques to dramatically reduce NO_x and carbon monoxide emissions from natural gas combustion without sacrificing boiler efficiency. • 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 high-luminosity, low-NO_x burner for oxy-fuel fired glass furnaces was developed to reduce NO_x formation by up to 50% and also increase heat transfer compared to conventional burners. The technology has been demonstrated in both fiberglass and float glass plants.

Commercialization and Deployment Activities
• Industry is already making substantial investments in commercializing and deploying economical technologies: combusting wastes and residues, fuel switching in combustion systems, employing oxy-fuel combustion, 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 at least 6.8 quads of fossil energy consumption in the manufacturing sector alone. Significant potential exists for additional or more efficient on-site generation of electricity in manufacturing.