Research and Development Projects—Cogeneration and Advanced Turbine Systems

DOE's Office of Technologies Reports on New Studies

Gas turbines are improving steadily, keeping pace with increasingly stringent emissions requirements, new capacity needs, and growing competitive pressures to improve efficiency. So far, technological improvements to keep up this momentum have mostly come from the private sector. But federal assistance is also available to stimulate R&D.

Some of the new activities stemming from DOE's Office of Technologies, specifically in the areas of in advanced turbine systems and cogeneration, are given here.

CERAMIC RETROFIT GAS TURBINE

The performance of current gas turbines is limited by the temperature and strength capabilities of the metallic structural materials in the engine hot section. Much progress has been made in the development of ceramic components for various high-temperature environments; now attention is focusing on integrating such components into stationary gas turbines such as those used by industrial cogenerators and electric utilities. Using ceramic components would allow higher turbine inlet temperatures without cooling, thus improving the thermal efficiency of gas turbines.

Because of their superior high-temperature strength and durability, OIT is currently sponsoring a cooperative program with industry to develop uncooled ceramic components such as nozzles, blades, rotors, and combustor liners for gas turbines. When combined with

innovative turbine designs, these advantages translate into a significant improvement in thermal efficiency, considerably lower NO_x emissions than the best domestic equipment currently available, a major reduction in emissions of CO and VOCs, and lower capital costs. The technology could be used to retrofit an existing 15,000 MW of capacity as well as be used for new capacity additions. The program is attempting to help U.S. gas turbine manufacturers to become the first to commercialize this technology and capture a major share of the $100+ billion worldwide market.

PARTNERS:	Solar Turbines, AlliedSignal, DuPont Lanxide, Kyocera, ANL, Norton Advanced Ceramics, Sundstrand Power Systems, Carborundum, NGK, ARCO, University of Dayton, Caterpillar, Babcock & Wilcox
OIT COST:	$14,000,000
INDUSTRY COST-SHARE:	$5,000,000
ENERGY SAVINGS:	36.6 trillion Btu/yr in 2010
ENVIRONMENTAL BENEFITS:	2.1 million tons waste/yr in 2010
COST SAVINGS:	$175 million/yr in 2010
EMPLOYMENT:	930 jobs (new base) in 2010
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HIGH-PERFORMANCE STEAM SYSTEM

Steam turbine systems are used as both stand-alone systems and with gas turbines in combined-cycle systems for industrial cogeneration. The efficiency of these systems has changed little since temperature and pressure limits were set in the 1950s. These limiting conditions are mostly a result of the corrosion and erosion problems that occur when conventional steam system components are operated at high temperatures. If these problems could be overcome, however, steam temperature and pressure could be raised, resulting in increased generating efficiency (and thus power output). To address these long-standing limitations, OIT is sponsoring the development of a high-performance steam system (HPSS) for industrial cogeneration application.

The HPSS technology is based on using two advanced steam-cycle components. One is a high-temperature boiler whose tubes are made from Inconel 617, an exceptionally strong nickel alloy that is capable of withstanding high temperatures without wearing out. The second component is an efficient, high-speed steam turbine that incorporates state-of-the-art turbine blade materials technology borrowed from gas turbines. A system based on HPSS technology can handle steam with a pressure of 1500 pounds per square inch and a temperature of 1500°F, compared with current maximum conditions of about 900 pounds per square inch and 1000°F. This translates into an increase in conversion efficiency of more than 50% and an increase in electricity generation of more than 20%—both increases achieved using the same amount of steam. Compared to the typical industrial practice of operating with conditions as low as 600 pounds per square inch and 750°F. the HPSS will more than double both power output and turbine efficiency.

PARTNERS:	Solar Turbines, Innovative Steam Technologies, INCO, Precision Cast Parts, Fischer Valves
OIT COST:	$1,893,000
INDUSTRY COST-SHARE:	$300,000
ENERGY SAVINGS:	68.1 trillion Btu/yr in 2010
ENVIRONMENTAL BENEFITS:	6.2 million tons waste/yr in 2010
COST SAVINGS:	$132 million/yr in 2010
EMPLOYMENT:	880 jobs (new base) in 2010
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ADVANCED TURBINE SYSTEM

OIT is developing advanced turbine systems with DOE's Office of Fossil Energy (FE), the Electric Power Research Institute, the Gas Research Institute, the Environmental Protection Agency and others in response to the Energy Policy Act of 1992, Section 2112 ("Heat Engines"). The goal for advanced turbine system efficiency is a 15% improvement over today's best gas turbine systems; reduced emissions of NO_x, CO_2, CO, and UHC; and a 10% reduction in the cost of generating electricity for both utility and nonutility power generators by 2002. FE is developing the utility gas turbines. Initial advanced turbine systems will be natural-gas fired; these gas turbines will be capable of burning coal, biomass, or other solid fuels. The OIT program is targeting the development of a new industrial-application turbine with a power-generating capacity of less than 20 MW.

The advanced turbine system will need to operate at higher firing temperatures and higher pressure ratios to achieve higher efficiency. Higher firing temperatures will require manufacturers to

incorporate such features as ceramic components and better turbine blade cooling techniques. Operating at these temperatures alone will not meet the desired efficiency goals; however, manufacturers will need to make innovative cycle changes using compressor cooling, heat recovery, turbine reheat, and moisture injection technologies. The advanced turbine system will use advanced low-NO_x burners, thereby eliminating the need for costly emissions control equipment.

PARTNERS:	Solar Turbines, Allison, Howmet, AlliedSignal, DuPont Lanxide, ORNL, EPRI, Indianapolis Power & Light, GRI, U.S. Turbine, Fluor Daniel, Others
OIT COST:	$15,289,000
INDUSTRY COST-SHARE:	$10,000,000
ENERGY SAVINGS:	81.6 trillion Btu/yr in 2010
ENVIRONMENTAL BENEFITS:	4.6 million tons waste/yr in 2010
COST SAVINGS:	$293 million/yr in 2010
EMPLOYMENT:	2440 jobs (new base) in 2010
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These R&D advances, and many others in the technical field which aim toward improving energy and environmental efficiencies, are reported in a volume published recently by DOE's Office of Industrial Technologies, "Enhancing the Competitiveness, Efficiency, and Environmental Quality of American Industry Through Technology Partnerships."

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