PROGRAM facts

U.S. Department of Energy
National Energy Technology Laboratory
Office of Industrial Technologies

Strategic Center for Natural Gas

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Advanced Turbine Systems Program

Description

The Advanced Turbine Systems (ATS) Program was initiated by the U.S. Department of Energy (DOE) in 1992 to produce 21st-century gas turbines — systems that are more efficient, cleaner, and less expensive to operate than today's turbines. DOE's National Energy Technology Laboratory in the Office of Fossil Energy, and the Office of Industrial Programs in the Office of National Energy Technology Laboratory and the Office of Energy Efficiency and Renewable Energy share responsibility with their industrial partners for development of these revolutionary systems. Expectations for the program are to meet or exceed 60-percent system efficiencies in the utility market, and to increase efficiencies of industrial turbines by 15 percent. ATS technology emits far less nitrogen oxides, carbon dioxide, and unburned hydrocarbons than current gas turbine systems.

Two classes of gas turbines are being developed under the ATS Program. Simple-cycle industrial gas turbines, less than 20 megawatts (MW) in capacity, are being developed for distributed generation, industrial, and cogeneration markets. Combined-cycle-system gas turbines, greater than 20 MW, are being developed for large baseload, central-station, electric power generation markets. Turbines smaller than a nominal 3 MW are not covered by the ATS Program. The technology is designed to be fuel-flexible, allowing a coal-derived gas or renewable biomass-based gas to be used as well as natural gas. This makes ATS available to a wider market and minimizes the economic impact if gas prices increase.

Projects in the ATS Program are organized under two major activities: (1) major-systems development, and (2) technology-base development. ATS Program participants in major-systems development are turbine manufacturers actively participating in developing an ATS. Technology-base research consists of projects that support major-systems development and evaluate future advancements for gas turbine systems. Academic and applied research not currently targeted for incorporation into ATS demonstrations is supported.

Financial support for the ATS Program is provided by DOE and individual ATS Program participants. The level of cost-sharing required from participants increases as technology risk decreases.

Goal

The ATS Program emphasizes reducing the cost of generating electricity with gas turbines, increasing their efficiency, and lowering emissions. ATS turbines are projected to enter the pre-commercial demonstration stage by 2000; commercialization is expected by 2002.

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ATS WEBSITES

www.ornl.ms.doe.gov/ats/

www.netl.doe.gov/research/power/ats.html

STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

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ADVANCED TURBINE SYSTEMS PROGRAM

Status

Industrial System Development

Allison Engine Company's research is based on their extensive aircraft gas turbine experience. Increased efficiency for their simple-cycle engine is achieved by raising the turbine inlet temperature to 2,400°F and the pressure ratio to 30:1. Allison's approach is to develop a "core" ATS engine that will serve multiple applications (5 to 15 MW), with an overall cycle efficiency of nearly 41 percent. The Allison team has made significant progress towards the design of their advanced simple-cycle engine, which will be marketed commercially as the Allison 701-K.

Solar Turbines, Incorporated's research uses a recuperated cycle. The Solar concept takes advantage of their proprietary primary surface recuperator, which has an effectiveness exceeding 90 percent and has demonstrated long-term performance and reliability. Solar's cycle provides 43-percent efficiency at a more modest turbine inlet temperature of 2,200°F and pressure ratio of 9:1. Under the Ceramic Stationary Gas Turbine Program, Solar Turbines, Incorporated is testing a Centaur 50S engine that incorporates monolithic ceramic first-stage blades and a ceramic composite com-bustion liner. The Solar ATS is the Mercury™ 50, which is a single-shaft recuperated 5-MW turbine system that is designed for power-generation applications.

Utility System Development

Utility-scale ATS developers, General Electric Company, and Siemens-Westinghouse Power Corporation, are both developing large gas-turbine combined-cycle systems greater than 400 MW. Each of these systems incorporates a unique closed-loop cooling concept that improves system efficiency and maintains lower environmental emissions. Closed-loop steam cooling utilizes the superior (to air) heat-transfer characteristics of steam, and also enables better integration between the gas turbine and steam turbine cycles. Technology readiness and validation testing have been completed for utility-scale compressors, combustors, and turbine components. Full-speed no-load testing of the utility ATS is scheduled for the year 2000.

General Electric Company's (GE's) ATS, the gas turbine system MS7001H, is a 400-MW combined-cycle system that has an overall efficiency in excess of 60 percent lower heating value (LHV). The high system efficiency is achieved by increasing the turbine inlet temperature to 2,600 °F and by incorporating many advances from GE's aircraft gas turbine business. An 18-stage compressor, scaled up from GE's CF6-80C2 aircraft engine, is capable of delivering 1,230 lb/s of air at a pressure ratio of 23:1.

Siemens-Westinghouse Power Corporation is also developing a combined-cycle ATS system (the 501 ATS engine) that is capable of producing 420 MW at an overall system efficiency in excess of 60 percent LHV. The Siemens ATS operates with a turbine inlet temperature of 2,750°F. A high-efficiency, 20-stage compressor, capable of delivering 1,200 lb/s of air at a 29:1 pressure ratio enables Siemens to achieve its ATS target.

Technology Base Development

The *Advanced Gas Turbine Systems Research (AGTSR) Program* is a collaborative university-industry R&D consortium that is managed by the South Carolina Institute for Energy Studies. The AGTSR is a nation-wide consortium dedicated to advancing land-based gas turbine systems to improve future power-generation capability. The consortium supports the technology-research arm of the ATS Program and targets industry-defined research needs in the areas of combustion, heat transfer, materials, aerodynamics, controls, alternative fuels, and advanced cycles. Presently, 95 performing member universities and 8 cost-sharing U.S. gas turbine corporations make up the consortium. Fifty-one research projects have been completed or are currently underway at member universities in the areas of materials, combustion, heat transfer, and aero-dynamics. Nine workshops have been organized and hosted by the consortium, and 48 university student interns have been placed at the member ATS companies.

The materials and manufacturing element of the ATS program is a national laboratory program managed by Oak Ridge National Laboratory (ORNL) to develop airfoil manufacturing technologies and thermal barrier coatings (TBCs). Single-crystal casting production capability has been demonstrated with reduced sulfur levels and no grain defects. TBCs are being developed with enhanced oxidation resistance, improved environmental performance, and a longer life.

The *National Energy Technology Laboratory* (NETL) combustion group supports the AGTSR Program and provides technical evaluation of novel concepts generated by small businesses as well as from internal sources. The problem of combustion oscillation has emerged as a critical problem for all ATS engine developers. NETL is using their combustion laboratory facilities to develop techniques to characterize and mitigate this problem. Fuel flexibility and humid air combustion are also being addressed by the NETL combustion group.