PROGRAM facts

DEPARTMENT OF ENERGY
FEDERAL ENERGY TECHNOLOGY CENTER &
OFFICE OF INDUSTRIAL TECHNOLOGIES

ADVANCED TURBINE systems

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ADVANCED TURBINE SYSTEM PROGRAM

Program Description

The Advanced Turbine System (ATS) Program was initiated by the Department of Energy 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 Office of Fossil Energy and the Office of Energy Efficiency and Renewable Energy's Office of Industrial Technologies share responsibility with their industrial partners for developing 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. Gas turbines, greater than 20 MW, used in combined cycles systems, are being developed for large baseload central station electric power generation markets. Turbines smaller than nominally 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 as it 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. The ATS Program participants under the major systems development activity are turbine manufacturers actively engaged in developing an ATS. The technology base research activity consists of projects to support the major systems development and evaluate future advancements for gas turbine systems. Academic research and applied research not currently targeted for incorporation into ATS demonstrations is supported under this activity.

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

Program Goal

Emphasis in the ATS Program is given to reducing 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 HOMEPAGES:

http://www.fetc.doe.gov
http://www.ornl.doe.gov
http://www.oit.doe.gov
http://www.fe.doe.gov/coal_power/ats_sum.html

Program Status

Industrial System Development

Allison Engine Company is pursuing an approach based upon their extensive aircraft gas turbine experience. Increased efficiency for their simple cycle engine is achieved by raising the turbine inlet temperature (2400°F and pressure ratio 30:1). Allison's approach is to develop a "core" ATS engine that will serve multiple applications (5 to 15 MW), with overall cycle efficiency of nearly 41 percent. The Allison ATS development team has made significant progress towards the design of their advanced simple cycle engine. Their ATS will be marketed commercially as the Allison 701-K.

Solar Turbines is pursuing an alternate approach which utilizes a recuperated cycle. The Solar concept takes advantage of their proprietary primary surface recuperator, with an effectiveness exceeding 90 percent and with demonstrated long-term performance and reliability. Solar's cycle provides (43 percent) efficiency at a more modest turbine inlet temperature (2200°F) and pressure ratio (9:1). Under the Ceramic Stationary Gas Turbine Program Solar Turbines is testing a Centaur 50S Engine that incorporates monolithic ceramic first-stage blades and a ceramic composite combustion liner. Solar Turbines has announced their ATS, the Mercury 50. The Mercury 50 is a single-shaft recuperated 5-MW turbine system for power generation applications.

Utility System Development

Utility-scale ATS developers, General Electric Company (GE) and Westinghouse Electric 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 superior environmental emissions. Closed-loop steam cooling utilizes the superior heat transfer characteristics of steam, as compared to air, and also enables better integration between the gas turbine and steam turbine cycles. Technology readiness and validation testing has 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.

GE's ATS, the Steam and Gas Turbine 107H, is a 400-MW combined-cycle system, with an overall efficiency in excess of 60 percent LHV. The high system efficiency is achieved by increasing turbine inlet temperature to 2,600°F and 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 23:1 pressure ratio.

Similarly, Westinghouse is developing a combined-cycle ATS system capable of producing 420 MW, with an overall system efficiency in excess of 60 percent LHV. The Westinghouse 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 Westinghouse to achieve its ATS target.

Technology Base Development

The Advanced Gas Turbine Systems Research (AGSTR) program is a collaborative university-industry R&D consortium that is managed by the South Carolina Energy R&D Center. AGSTR is a nationwide consortium dedicated to advancing land-based gas turbine systems for improving future power generation capability. It 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, 90 performing member universities and 5 cost-sharing U.S. gas turbine corporations make up the consortium. Forty-one research projects are underway at member universities in the areas of materials, combustion, heat transfer, and aerodynamics. Nine workshops have been organized and hosted by the consortium, and 37 university student interns have been positioned 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 to develop airfoil manufacturing technologies and thermal barrier coatings (TBC's). Under this effort the single crystal casting production capability has been demonstrated with reduced sulfur levels and no grain defects. Thermal barrier coatings are being developed with enhanced oxidation resistance, improved environmental performance, and a longer life.

The Federal Energy Technology Center (FETC) combustion group supports the AGSTR Consortium and provides technical evaluation of novel concepts generated both by small businesses and from internal sources. The problem of combustion oscillations has emerged as a critical problem for all ATS engine developers. FETC 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 FETC combustion group.