the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Recovery Act: Advanced Hydrogen Turbine Development—General Electric

Background

GE Power & Water, along with GE Global Research Center, has an ongoing U.S. Department of Energy (DOE) program to develop gas turbine technology for coal-based integrated gasification combined cycle (IGCC) power generation that will improve efficiency, reduce emissions, lower costs, and allow for carbon capture and storage (CCS). GE is broadening this development effort, along with expanding applicability to industrial applications such as refineries and steel mills under the American Recovery and Reinvestment Act (ARRA). ARRA funding will be utilized to facilitate a set of gas turbine technology advancements that will improve the efficiency, emissions, and cost performance of turbines with industrial CCS. ARRA industrial technology acceleration, application, and adaptation will also benefit the advanced hydrogen turbine development and existing machines in typical utility applications.

This project is managed by the DOE's National Energy Technology Laboratory (NETL). NETL is researching advanced turbine technology with the goal of producing reliable, affordable, and environmentally friendly electric power in response to the nation's increasing energy challenges. With the Hydrogen Turbine Program, NETL is leading the research, development, and demonstration of these technologies to achieve power production from high hydrogen content fuels derived from coal that is clean, efficient, and cost-effective, minimizes carbon dioxide (CO_2) emissions, and will help maintain the nation's leadership in the export of gas turbine equipment.

Project Description

Under the ARRA funded program, GE will develop advanced industrial-frame turbine technology for hydrogen fueled turbine machinery. These turbines can be utilized in conjunction with pre-combustion carbon capture systems to effectively reduce carbon emissions from a variety of industrial applications. This project includes the following work:

- Advanced Hydrogen Combustion System: The combustion work in the project will develop a new combustion system that will enable industrial gas turbine applications with CCS to reach higher efficiencies through higher firing temperatures with low NO_x. The developed combustion system will be validated in a gas turbine operating at full conditions. The validation step from testing a full-scale combustion can in the laboratory, to testing the multi-can configuration on the gas turbine, will enable accelerated transition of the technology to future gas turbine designs.

- Materials: The materials work will develop alloys that are specifically tailored to withstand elevated temperatures in the hot gas path in the high-moisture, and potentially highly corrosive environments of hydrogen-fueled industrial applications with CCS. This will enable industrial gas turbine applications with CCS to achieve improved efficiency through higher firing temperature while preserving traditional hot gas path component durability.

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PARTNERS

GE Global Research Center
GE Aviation (base only)

PERFORMANCE PERIOD

Base

Start Date	End Date
10/01/2005	06/30/2014

ARRA

Start Date	End Date
10/01/2010	06/30/2014

COST

Total Project Value
$134,309,886

Base
DOE/Non-DOE Share
$50,175,589 / $21,503,823

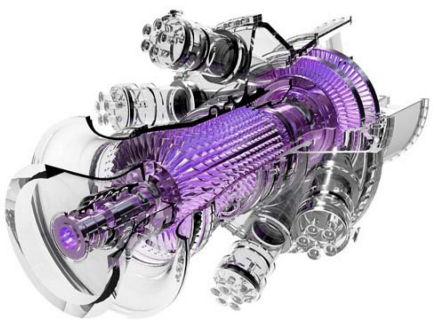
ARRA funded
Total ARRA Project Value
$62,630,474

DOE/Non-DOE Share
$31,315,237 / $31,315,237

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

AWARD NUMBER

NT42643



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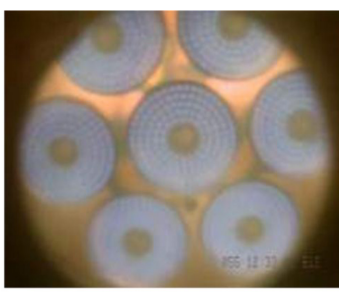
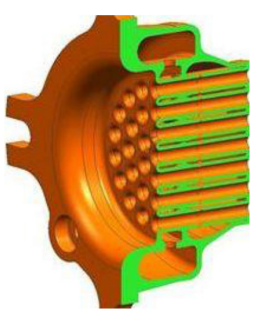


Fuel: 63/4/33 % H2/CH4/N2

Cooled CCD camera installed in stand (on transition piece) provides view of head end.



Cut away of small multi-tube mixer for rig testing for flash back on H_2-N_2 fuel.

- Sensors: The sensors work will focus on utilizing and integrating a variety of advanced sensor technologies into gas turbine control and operation. This will enable the gas turbine to be operated with real-time knowledge of actual parameters that are affecting component conditions and operation. Therefore, industrial gas turbine applications with CCS will be able to achieve improved efficiency and operability, and reduced emissions.
- Turbine Airfoil: The turbine airfoil work will develop technology that reduces required cooling flows to enable industrial gas turbine applications with CCS to achieve improved efficiency.

Goals/Objectives

The ARRA gas turbine effort will focus on developing and validating state-of-the-art component-level technologies for a gas turbine. The assessment of the impact to efficiency, CO_2 release, and emissions will utilize a baseline plant with CCS and a gas turbine that does not yet include the technologies to be developed as part of this project, and compare that to a similar plant with an advanced gas turbine. Validation that the program goals have been achieved will be accomplished through subscale and full-scale testing.

Accomplishments

- Continued development and optimization of pre-mixed combustion technology for hydrogen by utilizing extensive megawatt-scale, full head end testing on leading concepts from both the Base and ARRA portions of the program – achieved lowest (single digit) NO_x emissions to date and demonstrated fuel flexibility with durability at target 2012 cycle conditions.
- Downselected the best option for an element of the first stage architecture. Developed manufacturing feasibility and durability. Established heat transfer rig trial plans, identified key geometries, and began initial testing.
- Completed cooling effectiveness characterization for the next generation advanced cooling design concept.
- Completed testing of an optimal purge flow configuration.
- Improved and updated cycle models to determine the performance and output characteristics resulting from the technology advancements made under the program, including systems required for CCS.
- Downselected a new cost effective, mechanically and environmentally capable hot gas path alloy. Completed initial environmental testing and a first full-size component casting. Results show good castability and improvement over base-line material.
- Continued characterization of down-selected thermal barrier coating and bond coat.

Benefits

GE has extensive experience in supplying gas turbines for use in a broad range of applications, including the industrial space. Power generation systems based on advanced gas turbines offer efficient energy conversion solutions that meet the challenge of fuel diversity, while maintaining superior environmental performance. Gas turbine technology advances from the existing program are aimed at offsetting CCS penalties in terms of efficiency and cost while improving emissions performance in preparation for CCS in coal IGCC power generation. Similarly, this proposed program is focused on gas turbine technology advances that are aimed at offsetting CCS penalties, improving emissions and performance, and accelerating technology deploymentin preparation for CCS in industrial applications.