the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Recovery Act: Oxy-Fuel Turbo Machinery Development for Energy Intensive Industrial Applications—Clean Energy Systems

Background

Clean Energy Systems (CES), with support from Siemens Energy and Florida Turbine Technologies (FTT), has an ongoing U.S. Department of Energy (DOE) program to develop an oxy-fuel combustor for highly efficient near zero emission power plants. CES is expanding this development for an industrial-scale, oxy-fuel reheat combustor-equipped intermediate-pressure oxy-fuel turbine (IP-OFT) under the American Recovery and Reinvestment Act (ARRA). Through the design, analysis, and testing of a modified Siemens SGT-900 gas turbine, the team will demonstrate a simple-cycle oxy-fuel system. ARRA funding is accelerating advancement in OFT technology for commercial industrial oxy-fueled plants as an economical means to produce power with carbon capture and storage (CCS) technologies.

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

The core of CES's technology is a high-pressure oxy-combustor that produces a steam/CO_2 working fluid for expansion in a turbine. The oxy-combustor system is adapted from rocket engine technology and burns gaseous or liquid fuels with gaseous oxygen. Compatible fuels include syngas from coal, refinery residues, biomass gases, natural gas, landfill gas, glycerol solutions, and oil/water emulsions.

These fuels are combusted with oxygen in the presence of water used for controlling temperature, producing a high pressure working fluid comprised of steam and CO_2. This project focuses on the design, fabrication, and demonstration of an IP-OFT that incorporates an oxy-fuel reheat combustor, a second combustor and a variant of the main combustor that will reheat the exhaust from the high-pressure turbine to the higher temperatures desired for the intermediate-pressure turbine. CES will work with FTT to refine and finalize detailed design modifications to the Siemens SGT-900 gas turbine. CES will work with Siemens Energy to procure a used SGT-900 that will

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PARTNERS

Florida Turbine Technologies, Inc.
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PERFORMANCE PERIOD

Base

Start Date	End Date
10/01/2005	04/30/2011

ARRA

Start Date	End Date
10/01/2010	03/31/2013

COST

Total Project Value
$51,452,748

Base
DOE/Non-DOE Share
$4,707,837 / $2,150,647

ARRA Funded
Total ARRA Project Value
$44,594,264

DOE/Non-DOE Share
$30,000,000 / $14,594,264

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

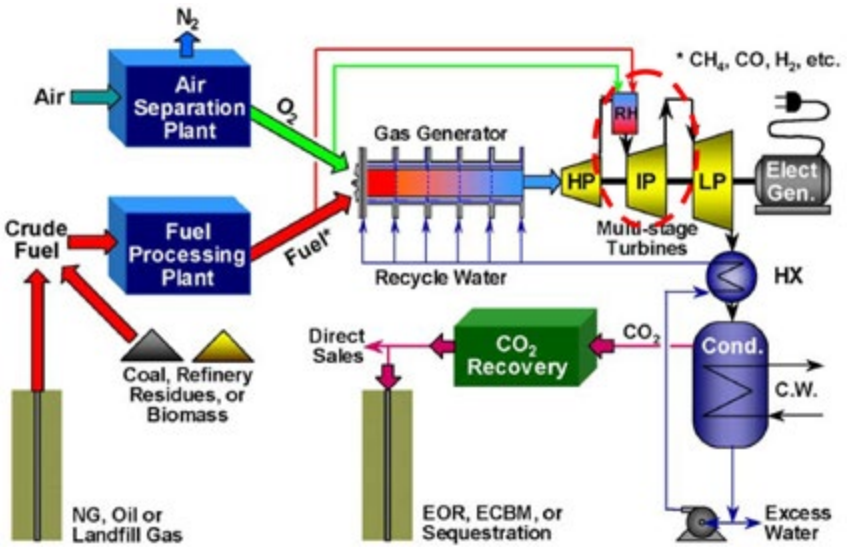
AWARD NUMBER

DE-FC26-05NT42645

be disassembled, inspected, refurbished, and modified according to the design definitions created by FTT. All necessary new components and packaging will be manufactured and installed on the IP-OFT by TurboCare with support from Siemens and FTT to take advantage of established knowledge and expertise. The final assembled unit will then be shipped to the CES test site for installation and demonstration. CES will work with experienced contractors to develop site layouts and balance-of-plant (BOP) equipment procurement plans.

Goals/Objectives

The ARRA objectives are to design, develop, and test a commercial-scale IP-OFT that can be deployed in industrial oxy-fuel plants with CCS greater than 99 percent of the produced CO_2 at competitive cycle efficiency and cost of electricity using diverse fuels.



Schematic of CES' Oxy-Fuel Power Cycle; Project Focus Circled in Red.

Accomplishments

- Completed cycle studies and analyses of 45 oxy-syngas combustor/turbine configurations, down-selecting to one near-term and one long-term baseline.
- Completed the detailed design of a 100-megawatt thermal (MWth) oxy-syngas combustor and its enclosure.
- Completed integrated testing of a 33-megawatt electric (MWe) OFT (modified J79 engine) and oxy-natural gas combustor.
- Designed, fabricated, and demonstrated a first-generation reheat combustor (capable of raising steam temperatures from approximately 600 °F to 2,000 °F), suitable for integration into an OFT-J79, in a dedicated test rig.
- Completed the detailed engineering design to convert an SGT-900 gas turbine into a 150-MWe OFT.
- Located, purchased, disassembled, and inspected a used SGT-900 B12 power plant.

- Refurbished, repaired, and replaced existing engine components to be reinstalled into a new OFT-900 engine. Major build activities included removal of the compressor blades and vanes, installation of a new thrust balance system and repair, rework and high-speed balance of the engine's rotor assembly. Manufactured new components required to convert an existing SGT-900 to an industrial-scale OFT. Assembled new OFT-900 engine and delivered to CES test facility.
- Completed the install, commissioning, and test of a commercial-scale OFT-900.
- Upgraded test facility to support commercial-scale OFT demonstration testing. Redesigned systems included natural gas and oxygen supply, electrical transformers and motor control centers, demineralized water makeup and supply and more.
- Designed, fabricated, and demonstrated a second-generation reheat combustor, suitable for integration into an OFT-900, in a dedicated test rig.
- CES experienced cost overruns in the SGT-900 overhaul and balance of plant failures at the Kimberlina test site, leaving insufficient resources to complete the full OFT test plan.

Benefits

A primary goal of DOE's Hydrogen Turbine Program for Oxy-Fuel Rankine Cycle Systems is to achieve highly efficient, near-zero-emission coal-based power systems. At the same time, DOE hopes to reduce capital costs in comparison to today's coal-burning plants. By leveraging the inherent high-temperature capabilities of gas turbines, this project will accelerate the design, development, and deployment of advanced oxy-fuel power systems. Studies show that the system-level performance is greatly enhanced by increasing inlet temperatures to the intermediate-pressure turbine.

Oxy-Fuel Combustor Assembly.

OFT-J79 and Electric Generator.

OFT-900 and Generator Installation at Kimberlina Test Facility.

Completion of OFT-900 Testing; February 2013.