Pre-mixer Design for High Hydrogen Fuels
FACT SHEET

I. PROJECT DESCRIPTION

A. Objective:

This study will develop combustion technology that will enable fuel flexible gas turbines that are capable of operating on coal derived synthesis gas to achieve NOx emissions of 2 ppm or less at the exit of the gas turbine. Today, the combustion of Integrated Gasification Combined Cycle (IGCC) fuels use diffusion flame combustion with high diluents to manage NOx to the 15 ppm to 25 ppm level. This program, which will reduce NOx from combustion of high hydrogen IGCC fuels, is based on the Dry Low NOx (DLN) approach for the combustion of natural gas with DLN. The lean premixed technique will be adapted to the challenging and unique demands of high hydrogen fuels in an effort to achieve low NOx with elimination/ reduction of the diluents that are currently required for NOx abatement of IGCC fuels. This will be accomplished by the design of an IGCC premixed combustor nozzle that is revolutionary in both its ability to accommodate a wide range of fuel compositions and at the same time deliver dramatically reduced emissions with minimum diluent injection.

B. Background/Relevancy:

Background:

Emissions regulations for power plants have gradually become more stringent over the past few decades. This has driven interest towards gasification and gas turbines due to the potential for lower emissions and higher efficiency. Coal combustion in gas turbines is achieved by gasifying coal resulting in a mix of hydrogen, CO, nitrogen and other minor constituents. Depending on the gasification process, the relative proportion of hydrogen and CO can vary. Gas turbines utilizing these fuels are referred to as IGCC (Integrated Gasification Combined Cycle) machines.

IGCC fuels are currently burned in diffusion mode in gas turbine combustors. With diffusion combustion and diluent injection, current NOx guarantees for gas turbines utilizing IGCC fuels are still only as low as 25 ppm, with a few select offerings at 9 ppm. Reducing NOx by an order of magnitude requires a change in combustor design philosophy. In the past, natural gas combustion was first carried out in diffusion mode before premixed combustors were developed. This resulted in NOx guarantees dropping from about 25 ppm to 9 ppm. A similar evolution is needed for IGCC fuels to reduce NOx from 25 ppm towards the challenging DOE Turbine Program goal of 2 ppm.

Relevancy:

Achieving the goal of this program will constitute a significant engineering breakthrough and will set the stage for overall process improvements, broader application of gas turbines, and improve the economics of pre-combustion carbon capture concepts. IGCC combustion has been confined to diffusion combustors primarily because of the risks involved in premixing hydrogen. Using only diffusion mode combustion, the only strategy that can be successfully used for NOx control to levels below 25 ppm remains diluent injection, which has limits both from a materials and chemical kinetics viewpoint.

Currently, most of the advances that are being made in gas turbine design are focused on premixed combustion. The achievement of a IGCC premixer design for hydrogen based fuels will enable the use of alternative premixed combustion approaches such as Late Lean Injection or Catalytic combustion for IGCC applications. Designing a premixer for IGCC fuels will advance the gas turbine combustion of pure hydrogen in premixed mode, and be a significant first step in overcoming the obstacles of operating with hydrogen as a fuel without compromising on efficiency or capital cost.

The significant benefit to the US public will be the development of environmentally friendly power plants and broader use of our abundant coal resource, both from the point of view of decreased source emissions and, potentially, fuel efficiency. The increased fuel efficiency can be translated to lower CO_2 emissions, which is a greenhouse gas. Further, increased availability will translate to lower costs of electricity to the US public.

C. Period of Performance:
The scheduled project period is January 01, 2004 to June 30, 2005.

D. Project Summary:
This 18-month project will translate DLN technology to the unique properties of high hydrogen IGCC fuels, and yield an analytical design in preparation for future testing and validation phase. Data from GEPS DLN combustion experience will be used to tailor computational design tools and criteria to create a framework for predicting nozzle operability (e.g., flame stabilization, emissions, resistance to flashback/auto-ignition). This framework will be used to establish, rank, and evaluate potential solutions to the operability challenges of IGCC combustion. The leading contenders will be studied and developed with the most promising concepts evaluated via of computational fluid dynamics (CFD) modeling and GEPS combustion design tools and practices. Finally, this project will scope the necessary steps required to carry the design through mechanical/durability review, testing and, validation, on towards full demonstration of this revolutionary technology.

This project will be carried out in three linked tasks.

1. Develop conceptual designs of premixer and downselect the promising options.
2. Carry out CFD on chosen options (1 or 2) to evaluate operability risks.
3. Optimize design and reevaluate operability risks.

II. PROJECT PARTICIPANTS

A.	Prime Participant:	General Electric Company, General Electric Power Systems
B.	Sub-Award Participants:	None

III. PROJECT COSTS

A.	DOE Costs:	\$310,618 (60%)
B.	Prime Contractor Cost Sharing:	\$207,079 (40%)
C.	Total:	\$517,697 (100%)

IV. MAJOR ACCOMPLISHMENTS SINCE BEGINNING OF THE PROJECT

Dates: Accomplishment:

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V. MAJOR ACTIVITIES PLANNED DURING NEXT 6 MONTHS

Planned Activity:

- Program KickOff meeting (30 days of Award)
- Hazardous Substance Plan (30 days of Award)
- Monthly Highlight Status Reports (Monthly)
- Quarterly Milestone Status Report (Quarterly)
- Technical Progress Report (Semi-annual)
- Program Fact Sheet (Semi-annual)
- Financial Status Report (Quarterly)
- Federal Cash Transaction Report (Quarterly)

VI. ISSUES

No issues have been identified.

VII. ATTACHMENTS

A. Schematic: None

B. Project Schedule