H_2-IGCC Project Update

First Reporting Period
November 2009 – October 2010

The overall objective of the H_2-IGCC project is to provide and demonstrate technical solutions which will allow the use of state-of-the-art highly efficient reliable gas turbines in the next generation of Integrated Gasification Combined Cycle (IGCC) plants. The goal is to enable combustion of undiluted hydrogen-rich syngas with low NO_X emissions and also allowing for high fuel flexibility. The challenge is to operate a stable and controllable gas turbine on hydrogen-rich syngas with emissions and processes similar to current state-of-the-art natural gas turbine engines.

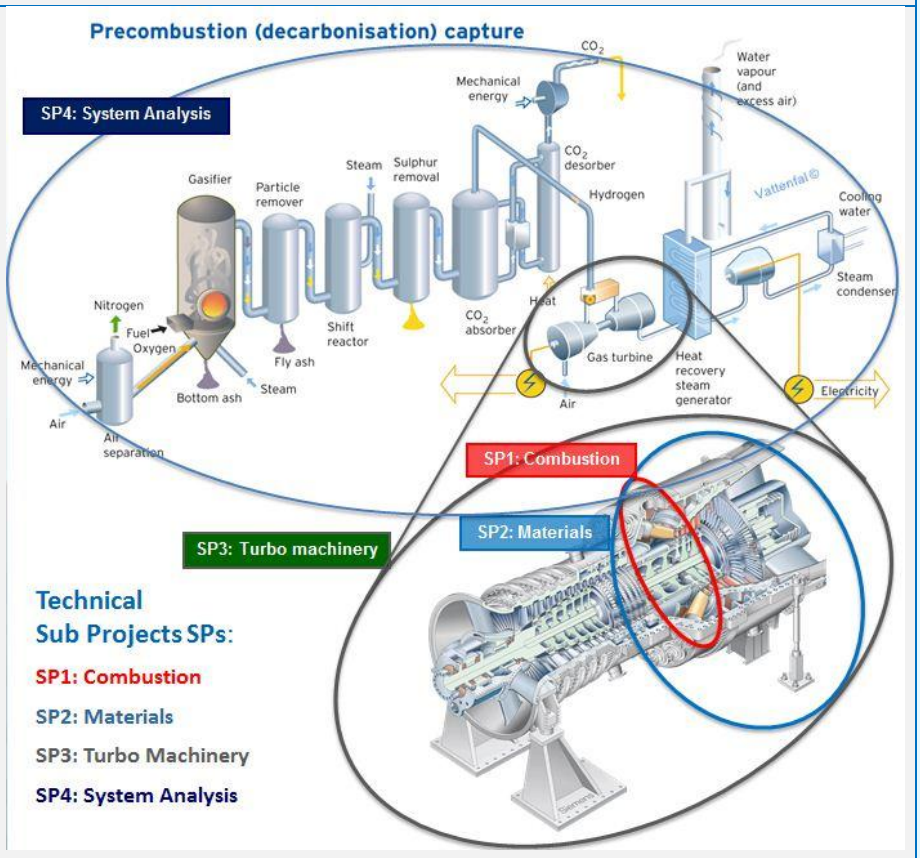
The H_2-IGCC project aims to tackle this challenge as well as fuel flexibility, by enabling the burning of back-up fuels, such as natural gas, without adversely affecting the reliability and availability. The project will be successful when it results in the identification and development of gas turbine technology able to operate on undiluted H_2-rich fuel gas (approx. 80 Vol. % of hydrogen) from a CO_2 capture process in an IGCC plant configuration which offers less than 5% efficiency penalty (compared to a non-CCS scheme).

Over the past decade, a number of initiatives on clean coal technology and IGCC have started around the world. Successful mitigation of climate change requires global efforts. Therefore, international knowledge sharing is essential to significantly reduce the time and the cost of bringing CCS to the market.

A successful outcome of this project will be an important step towards opening up the market for a commercial implementation of IGCC-CCS technology.

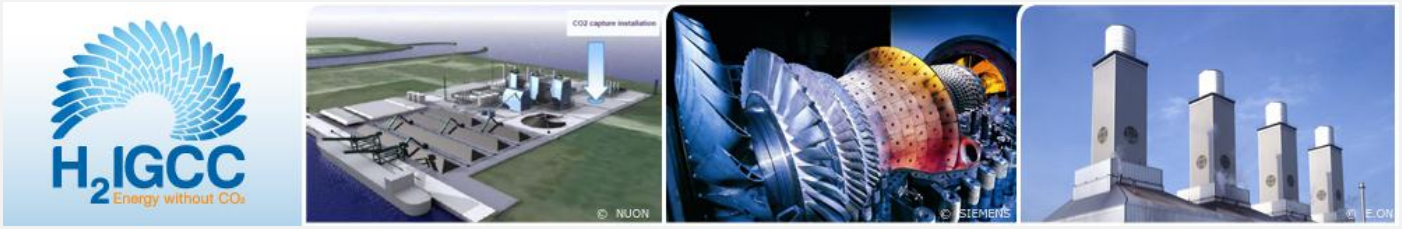
The H_2-IGCC project brings together 24 partners from industry and academia with the common goal to increase gas turbine efficiency and fuel flexibility without affecting the reliability and availability in a pre-combustion IGCC-CCS plant configuration.

The technical challenges addressed by the H_2-IGCC project are divided into 4 Subprojects (SP).



The H_2-IGCC project is in its first phase of research and development, and its second phase of proof of principle (lab-scale) has recently started.
In the first year the SPs aligned their research efforts and initiated the following activities:

- Design of a prototype scaled burner;
- Generating kinetic validation data;
- Manufacturing and coating the testing samples;
- Construction of generic geometries for a compressor, cooling system and turbine;
- Decision on plant specification and detailed thermodynamic performance analysis of the selected IGCC cycles.



Subproject Updates

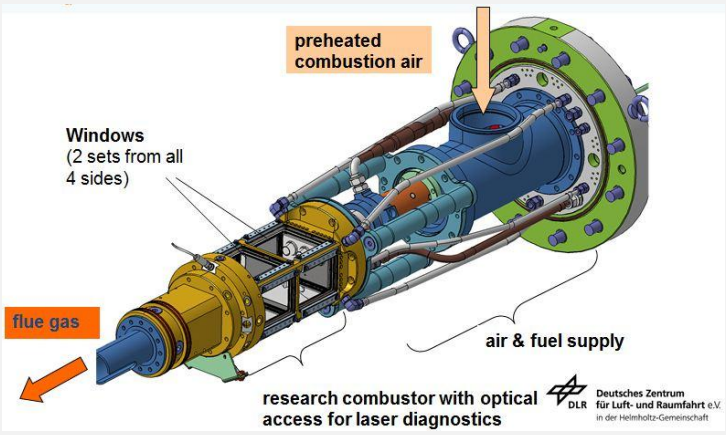
November 2009 – October 2010

SP1 – COMBUSTION

Subproject Objective: demonstrate the use of (undiluted) high hydrogen syngas in typical natural gas combustion systems with minimal modifications in order to conserve the ability to burn a variety of fuels; demonstrate the safe use of (undiluted) high hydrogen syngas in lean premixed combustion mode at competitive low emission levels.

First year results:

- ✓ Performed experimental studies to measure the ignition delay times that showed that the ignition delays of hydrogen decreases with increasing temperature and pressure (in the low temperature range).
- ✓ Designed a heat flux burner for elevated pressures to measure laminar flame speeds.
- ✓ Tested several kinetic mechanisms to investigate their applicability for NO_X prediction and hydrogen combustion.
- ✓ Defined experimental techniques to be used in the investigations of the lean premix combustor design for hydrogen-rich syngas.
- ✓ Initiated a series of full scale burner prototype CFD calculation and prepared preliminary designs for various syngas prototype burners for a 280 MW rated heavy duty industrial gas turbine.
- ✓ Initiated the preparations design and manufacturing of combustors) for testing innovative combustion techniques, for instance flameless oxidation and catalytically supported "wet" combustion.

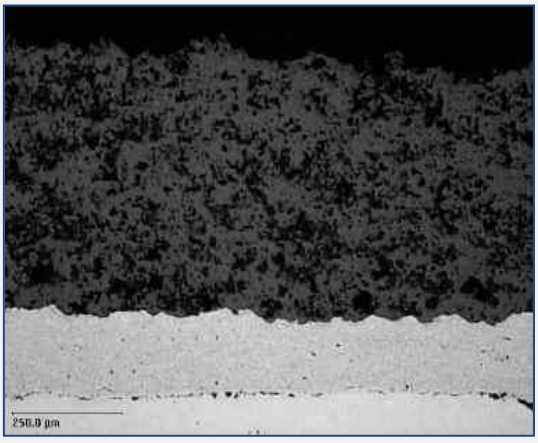


SP2 – MATERIALS

Subproject Objective: demonstrate cost-effective materials and coatings technologies to overcome the component life-limiting problems of overheating and of hot corrosion resulting from the higher temperatures and from residual contaminants in the syngas respectively; validate materials performance data, life prediction and monitoring methods applicable to the industrial implementation in advanced IGCC plants.

First Year Results:

- ✓ Detailing of the three gas turbine component operating conditions in process.
- ✓ Gas turbine materials, both base alloys and coatings, have been identified, purchased and machined into samples, ready for the application of the state of the art coatings.
- ✓ Validated the coating application process by performing test on dummy test pieces using various sample geometries.
- ✓ Detailed planning of the non-destructive examination (NDE).
- ✓ Performed initial NDE trials on a combustor.



Subproject Updates

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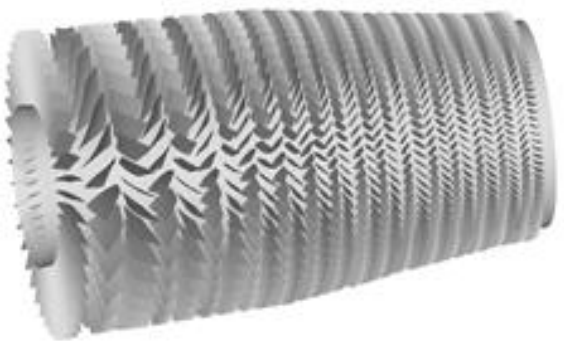
SP 3 – TURBOMACHINERY

Subproject Objective: deliver a compressor design with a stability margin enabling the switch between fuels without compromising its efficiency; deliver a turbine design and cooling system capable of coping with the resulting heat transfer environment dominated by water vapour; verify designs using large scale virtual testing environment to meet industrial standards.

First Year Results:

- ✓ Performed a literature survey to compose a list with gas turbines in the 250-300 MW class currently on the market, to serve as a basis to select a reference machine.
- ✓ Used a generic compressor model and engine as a reference for thermodynamic analysis.
- ✓ Designed the baseline geometry of the compressor.
- ✓ Completed the generic geometry for the turbine and the cooling passages of the turbines.

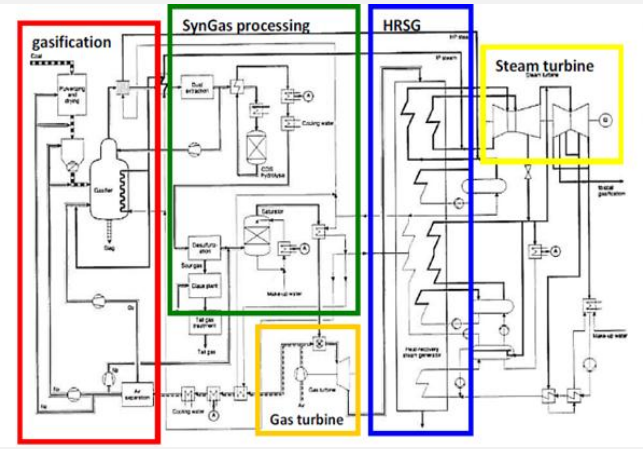


SP 4 – SYSTEM ANALYSIS

Subproject Objective: provide a detailed system solution/system analysis that generates realistic techno-economical results for future gas turbine based IGCC plants.

First Year Results:

- ✓ A literature survey was performed to collect both technical and performance data of existing IGCC plants. Also, an inventory of features of existing available machines and apparatuses suitable to be used in advanced ICGG plants was made.
- ✓ Defined a reference plant layout as well as relevant data for a plant simulation.
- ✓ Performed a survey of existing simulation component models available at partners' facilities.
- ✓ System modeling and subsystem integration work in progress through close collaboration between all SPs.
- ✓ On-going development of the Gas Turbine simulator: developed and tested the models for the gas turbine inlet section and compressor; other components are foreseen to be added.
- ✓ Preliminary plant specification for reference configuration was specified and fuel flexibility was clarified.



The H_2-IGCC project is financed under the European Union's 7th Framework Programme - FP7-ENERGY-2008-TREN-1ENERGY 6.1.4:
Advanced Gas Turbines for Solid Fuel Gasification Processes
Low Emission Gas Turbine Technology for Hydrogen-Rich Syngas

*Acronym: **H_2-IGCC***
*Collaborative Project: **FP7-239349***
Duration: 4 years (2009-2013)
Budget: 17.8 M Euro (11.3 M Euro EU funding)

Project website: www.h2-igcc.eu

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