

GTCO2

Technologies for Gas Turbine Power Generation with CO₂ Mitigation

Scope of project

The world primary energy demand is expected to double by 2050. It is assumed that this increased demand cannot be solely covered by renewable energy sources (such as hydro, wind, or solar), or by nuclear energy. Thus, an increased number of fossil-fuel-powered gas turbine systems for electricity generation will be implemented in the coming decades. The current project addresses specifically the challenge of developing a gas turbine with reduced CO₂ emission. Advanced technologies in various fields (fuel conversion, membrane systems, enhanced heat management) will impact future gas turbine concepts. Thermo-economic process modeling will be applied to select promising technology pathways toward a zero emissions, fossil-fuel powered gas turbine. The overall goal is a commercially viable process for mitigation of CO₂ at a cost of <20 €/ton CO₂ avoided. The modeling effort will establish quantitative targets for process components (e.g. sequential combustor, turbomachinery and membrane-based air separation).

Goals and activities

The first step towards realization of CO₂ removal will be based on the use of a gas turbine process with exhaust gas recirculation. Here, the main challenge is on achieving stable and complete combustion at the highest levels of exhaust gas recirculation, where the oxygen excess concentration is small (< 2 volume %). For this reason, the main technology development in this project will be focused on a) extension of fundamental knowledge on combustion systems with low oxygen excess and b) enhancing combustion stability through in situ production of hydrogen. Based on these fundamental results a sequential combustor will be designed together with the industrial partner.

Zero emissions gas turbine development pathways may be greatly influenced by advances in the area of ceramic membranes for air separation. For this reason, the performance of air separation membranes will be benchmarked at

process conditions relevant to specific proposed gas turbine processes. The results of the component tests will be integrated into the overall process model to allow refinement of the thermo-economic models and overall process parameters.

Expected results

Strategic pathways for development of a zero emissions gas turbine will be established through thermo-economic modeling. Fundamental combustion knowledge (oxidation and pollutant formation kinetics, flame speeds) will be extended towards systems with low oxygen excess. Catalytic partial oxidation reactors will be characterized regarding hydrogen production rates and selectivity. Sequential combustion designs will be proposed to allow stable operation at high levels of exhaust gas recirculation. High temperature ceramic air separation membranes will be benchmarked as regards permeation rates and high temperature robustness.

Main Investigator
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Project Partners
FHNW
PSI
EPFL
Empa