HYCONSOL
Hybrid Gas Turbine Power Plants for Controllable Solar Energy

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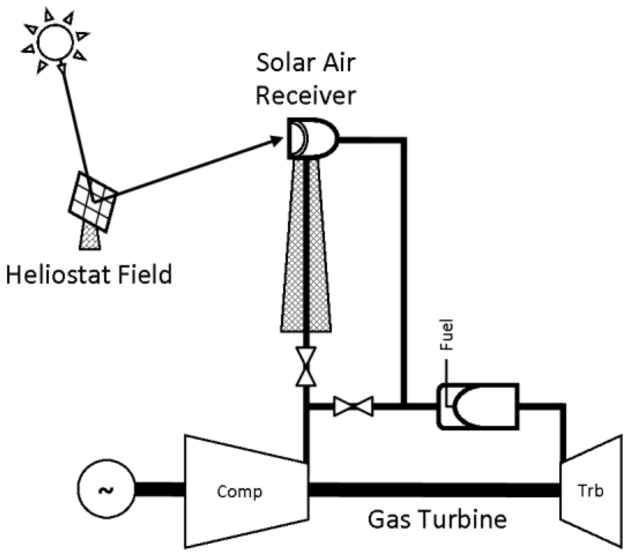
Introduction

Amongst the wide range of alternatives available for the sustainable generation of electrical energy, concentrated solar power (CSP) emerges as one of the most promising options. Through the use of thermal energy storage and/or hybridisation CSP can generate dispatchable power and is thus ideally suited to forming the cornerstone of a future energy grid based on renewable energy sources. Capable of being deployed in utility-size multi-megawatt plants, CSP benefits from economy of scale effects and, especially when installed in high-insolation areas, generate electricity at economically competitive rates.

The use of gas turbines in solar thermal power plants (STPPs) would offer a number of advantages over conventional steam-cycle systems, chief among them a reduction in water consumption, reduction in start-up and load ramping times and increased flexibility through hybridisation. The supply of solar energy to a gas turbine offers high solar-electricity conversion efficiencies (especially combined-cycle configurations) and consequently high potential for electricity cost reductions, as higher efficiencies reduce the size of the costly solar collector field and increase the effectiveness of solar electricity generation.

The hybrid solar gas turbine

The basic concept of a hybrid solar gas-turbine (HSGT) is shown in to the right. Solar heat is introduced at high temperatures into the gas-turbine unit, replacing fuel consumption. The main airflow leaving the compressor is re-routed and sent to a pressurized solar air receiver, where solar heat is added to the flow. As the solar heat is to be harnessed at high temperatures, heliostat field solar collectors are required. The pre-heated air produced by the solar receiver is then sent to the combustor where fuel (either conventional fossil-fuels or novel sustainable fuels) can be injected in order to reach the desired combustor outlet temperature. During solar operation, the higher temperature of the combustion inlet air results in reduced fuel consumption.



Project rationale

The concept at the core of this project is a high-temperature HSGT unit. High temperature refers to both the operating temperature of the receiver as well as the inlet temperature of the turbine. High temperatures are required in receiver in order to achieve high solar shares, whereas high turbine inlet temperatures are required to ensure high conversion efficiencies.

More precisely, the project will target a “core” system with a 1400°C turbine inlet temperature for the gas turbine, in order to allow integration with bottoming cycles where appropriate. As the solar share is dependent on the solar receiver temperature, the project will aim for a receiver temperature in the region of 950°C in order to increase the solar share. The focus of the project will be clearly placed on utility-scale, multi-megawatt, HSGT power plants.

High temperature thermal energy storage integration will also be studied, with direct contact solid media storage, (i.e. regenerative-type heat storage) considered a particularly promising technology option. This technology does not depend on expensive metallic components in the hot gas path and is thus well suited to cost effective operation at high temperatures.

Unlike previous projects, in which component development was prioritised, this will place the focus clearly on component integration and system control, with particular emphasis on receiver-combustion chamber integration. Furthermore, operation strategies and the adjoining emergency procedures will be elaborated and tested in order to allow safe, reliable and dispatchable operation of a hybrid gas turbine in a solar power plant.
The project will also address the question of identifying the optimal design of hybrid power plants and their future market roles through the use of techno-economic and market analysis.

Proposed focus areas
In order to address these different issues, three key project focus areas have been identified:
Focus Area 1: Techno-Economic Performance and Market Analysis
Work within this area will focus on analysing the cost and performance of hybrid solar gas turbine power plants, both from economic and environmental points of view. Techno-economic analysis will allow determination of power plant electricity production, investment and levelised costs, specific CO2 emissions as well as water consumption and other performance indicators.
Focus Area 2: Innovative Component Development, Integration and Demonstration
Work within this area will focus on the three critical technologies for high temperature hybrid solar gas-turbine units: pressurized solar air receivers, advanced combustion chambers and large-scale regenerative thermal energy storage. Innovative designs will be investigated and tested under relevant conditions for integration into a hybrid solar gas-turbine power plant. Input from the techno-economic analysis can be used to determine the optimal operating conditions.
Focus Area 3: System Integration, Simulation and Control
Work within this area will address the interfaces between the different components, along with integration issues resulting from joint operation of the receiver and combustion chamber. Novel control techniques will be elaborated to enable stable operation of the solar gas turbine under the influence of varying solar flux and with different fuel types (including sustainable biofuels).

Contact and express of interest
Please submit expressions of interest for participation in a first consortium-building meeting to:

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