HYPOWERGT - DEMONSTRATING A HYDROGEN-POWERED GAS-TURBINE ENGINE FUELLED WITH UP TO 100% H2

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Motivation

Amidst the urgency of combating climate change, the reliance on fossil fuels for energy production poses a challenge. Traditional gas turbines, while efficient, are hindered by their inability to run on hydrogen without dilution, limiting the transition to cleaner fuels. This represents a technical hurdle when retrofitting existing turbines to accommodate hydrogen.

The HyPowerGT concept

In this context, the HyPowerGT project aims at moving technological frontiers to enable gas turbines to operate on hydrogen, guaranteeing low NO_x emission using neither catalysts, nor diluents or thermodynamic efficiency reduction. The core technology is a novel dry-low emission combustion technology (H_2 DLE) able of handling any blend of natural gas and hydrogen up to pure H_2. Besides ensuring low emissions, the H_2 DLE combustion technology offers fuel flexibility and response ability on a par with modern gas turbine engines fired with natural gas. The DLE H_2 combustion technology will be fully retrofittable to existing gas turbines, thereby providing opportunities for refurbishing existing assets in industry: in the power sector, including Combine Heat and Power, and in mechanical drives applications. The DLE H_2 technology adheres to the strictest specifications for fuel flexibility, NO_x emissions, ramp-up rate, and safety, stated in the EU Strategic Research and Innovation Agenda 2021-2027.

Main Project developments

DLE H_2 combustor technology: Since turbulent flame velocity is affected by the hydrogen content in the fuel, the DLE H_2 combustor provides an enhanced gas injection and premixing technology, able to operate with pure hydrogen while guaranteeing a margin against flame flashback condition and ensuring the most efficient premixing with oxidants to maintain low NO_x emissions. The desired fuel flexibility to burn any blend of natural gas and hydrogen requires the combustor to be able to handle different flame stabilization conditions at all the engine loads, and the ability to control the possible sources of flame instability while limiting pressure oscillations within the acceptable durability limits. The relevant design enhancements of the gas injectors need to be demonstrated at full pressure and temperature conditions: the capabilities of the DLE H_2 system will be verified at TRL 6 by testing in an instrumented annular combustor rig, operated at engine representative conditions of pressure and temperature.

Figure 1: Left: NovaLT™16 100% H_2 ready gas turbine, installed on the Baker Hughes test bench at Florence site (IT). Image courtesy of Baker Hughes. NovaLT™ is a trademark of Baker Hughes and its affiliates. All right reserved.

Safety handling: The HyPowerGT project will address several safety aspects related to burning any blends of natural gas and hydrogen. These aspects will be analysed starting from the risk assessment performed on the DLE H_2 gas turbine, supported by detailed numerical simulations of different scenarios involving the presence of hydrogen-air mixtures within the flow path of a fueled gas turbine during off-design transients. An assessment for retrofitting the DLE H_2 gas turbines and a complementary risk analysis related to HSE (health, safety, and environment assessment will be performed. A safety management plan will be ultimately developed, with the aim of that enabling operation of retrofitted GTs with up to 100% H_2 and certifying the NovaLT™16 DLE H_2. To complete the design verification at TRL 7, the DLE H_2 combustor will be introduced in the instrumented prototype engine and tested at all the mission conditions, operating up to rated power (16.9 Mwe)

Retrofitting and techno-economic roadmap: Considering the future expected European hydrogen demand and the relevant infrastructure plans (e.g. European Hydrogen backbone Initiative), the potential market size of the DLE H_2 technology at different time horizons (e.g. in 2030 and 2050 will be evaluated within the HyPowerGT project. Techno-economic analyses will be conducted considering midstream hydrogen turbo-compressor stations, industrial cogeneration stations and energy systems solutions. Building on the results of these case studies, an exploitation roadmap will be proposed, considering both the R&D required to meet the expectations in the potential market segments, and regulatory framework gaps analysis that could support the deployment of the DLE H_2 technology as a pillar for accelerating the decarbonization of the European industrial and energy sectors.

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