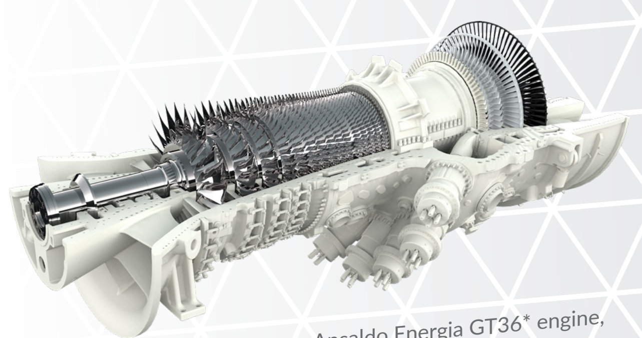
Main impacts

Advancing fundamental knowledge

InsigH$_2$t will provide detailed fundamental knowledge as well as improved predictive capabilities with regards to the physical processes responsible for static and dynamic flame stabilisation in modern gas turbine

Improving gas turbines technology

The advanced fundamental knowledge will actively drive the optimisation of combustor designs and operating strategies.



Ansaldo Energia GT36* engine, featuring sequential combustion technology*

Decarbonising electric power sector and industrial processes

InsigH$_2$t will present novel pathways towards enhanced design methodology for gas turbine combustion systems with the potential for replication and upscaling.

*GT36 is a registered trademark of Ansaldo Energia and its affiliates.

Consortium

NTNU, SINTEF, ETN Global, CERFACS, ansaldo energia, Università degli Studi Firenze, Baker Hughes, ARTTIC by PNO Group, RWTH Aachen University, Technische Universität Berlin, zhaw

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Associated parties	EUR 2 235 940.00
Duration	4 years (Jan 25 – Dec 28)
Project Coordinator	NTNU

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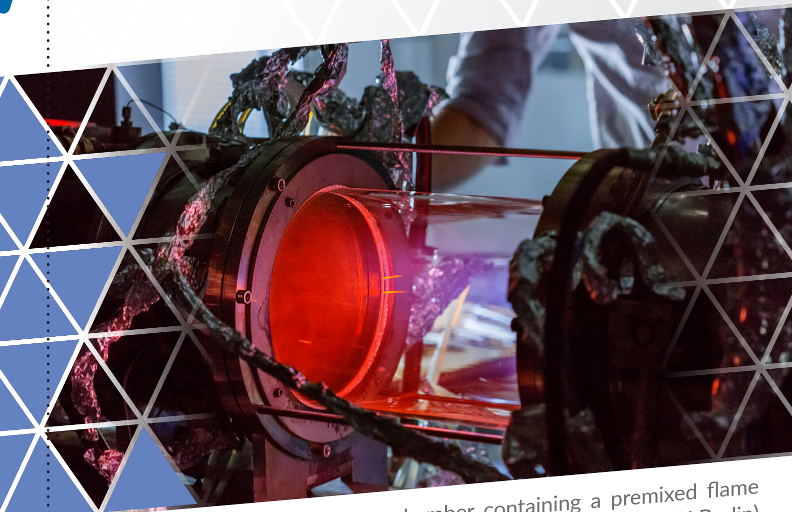
SCIENTIFIC INSIGHTS INTO H$_2$ COMBUSTION UNDER ELEVATED PRESSURE CONDITIONS – (INSIGH$_2$T)



A glass combustion chamber containing a premixed flame under atmospheric pressure (Copyright TU Berlin)

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Clean Hydrogen Partnership

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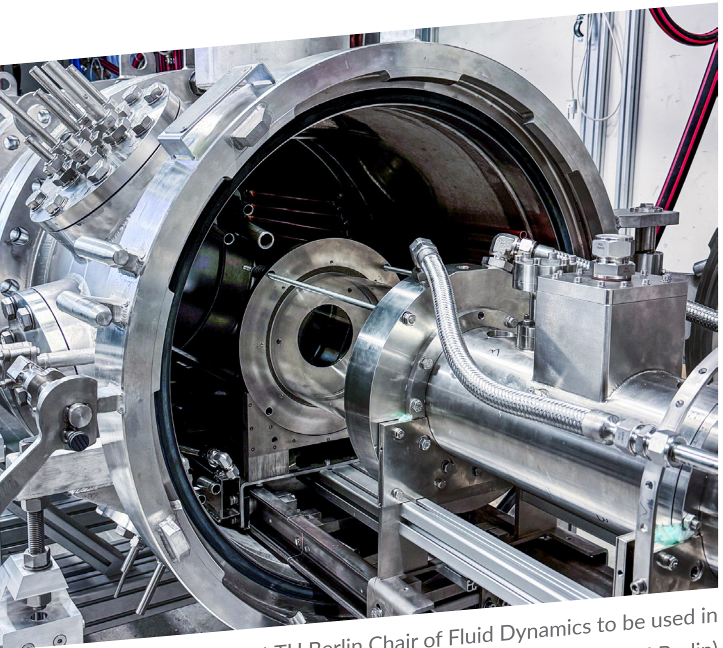
State Secretariat for Education, Research and Innovation SERI

InsigH$_2$t concept

Gas turbines have the potential to be fuel flexible and to generate large-scale, zero carbon power using hydrogen. However, hydrogen is extremely reactive, compared to conventional hydrocarbon fuels, and its reactivity is strongly dependent on pressure. It is hence critical to improve the simulation reliability for the hydrogen flames stabilisation and support technological development, whilst minimising the experimental costs.



Pressurised test rig at TU Berlin Chair of Fluid Dynamics to be used in InsigH$_2$t project (Copyright TU Berlin)

The aim of InsigH$_2$t is to acquire a fundamental scientific understanding of the effect of pressure on the turbulent burning rate, thermoacoustic response and pollutant formation mechanism of lean premixed hydrogen flames under gas turbine relevant operating conditions. This will be achieved through a set of systematic experiments and direct numerical simulations of canonical flame configurations over a wide range of elevated pressures. The experimental data will be utilised to produce scaling laws, develop new combustion models for numerical simulations and low order tools which will be applied to different industrial combustor designs.

Main project outcomes

Understanding pressure scaling on the turbulent burning rate and stability of premixed hydrogen flames

The first outcome will be achieved by experimentally measuring with advanced laser diagnostics the effect of pressure (1-10 bar) on the turbulent burning rate in canonical hydrogen-flames configurations. These simplified flames are opportunely selected to represent a range of more complex industrial applications. The experiments will be conducted in a newly established pressurised and staged combustion facility at Norges Teknisk Naturvitenskapelige Universitet (NTNU), and they will be complemented by direct numerical simulations (DNS) of the same canonical flames to provide access to details of the flame structure not directly measurable.

Understanding the effect of pressure on the thermoacoustic response of premixed hydrogen flames

The second outcome will be pursued by experimentally investigating the thermoacoustic response of the same canonical hydrogen-flames configurations over a range of pressures (1-10 bar) using a unique facility located at TU Berlin. Additionally, Large-Eddy Simulation (LES) of the forced target flames will be conducted to provide more detailed information on the flame response. Finally, physics-informed low-order models will be developed based on the experimental and numerical data to identify mitigation strategies.

Advanced design and validation of gas turbines combustors for clean and efficient 100% hydrogen operation

The fundamental knowledge gained from outcomes 1 and 2 will be transferred in the form of improved combustion models for numerical codes used by industry and applied to industrially relevant geometries and operating conditions (Technological Readiness Level 5, TRL 5). The industry partners will conduct tests, numerical simulations, and apply the new low-order tools to optimise flame stability and emissions assessing their predictive capabilities in the single-stage and sequential combustion systems.

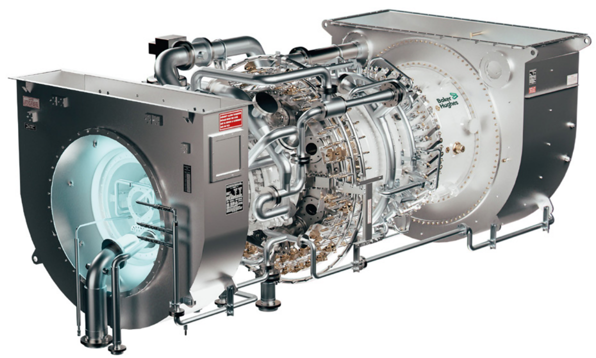
Innovation

Fostering sustainable innovation and improving EU competitiveness

InsigH$_2$t will serve as a catalyst for advancing the industry's innovation for integration of new knowledge.

Reduce dependency on fossil fuels

InsigH$_2$t will contribute to reduce dependency on fossil fuels, enhancing Europe's energy security and resilience.



Baker Hughes NovaLT™16 gas turbine, 100% H_2 ready.
Image courtesy of Baker Hughes. (*).

Providing opportunities to utilise existing infrastructure

InsigH$_2$t will deliver deep physical understanding and new models for stabilisation, flashback and blow-off for lean premixed H_2-air flames which can in principle be transferred for the optimisation of any industrial burner design. Ultimately, this can result in the retrofit of existing assets.

Transfer to the wider technical and scientific community

InsigH$_2$t will ensure that the fundamental understanding on combustion characteristics and stability limits of premixed hydrogen flames will be transferred.