NEWSLETTER

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What is the FLEX4H2 project?

The FLEX4H2 – Flexibility for Hydrogen – is an EU and Swiss funded project, that started in January 2023.

FLEX4H2's goal is to support European ambitious climate targets towards shifting away from the use of fossil fuels. It aims to develop a fuel-flexible combustion system and thus contribute to the EU's ambitious pathways towards decarbonisation of the electric power sector.

The project coordinator, Ansaldo Energia, on the main FLEX4H2 goals

Andrea Ciani, Ansaldo Energia

Vasileios Stefanis, Ansaldo Energia

The FLEX4H2 project fully supports the EU's ambitious climate decarbonisation targets. In this context, utilisation of hydrogen offers a unique opportunity to decarbonise the power generation sector reliably, independently from weather or seasonal conditions, contributing to the ongoing effort in the fight against climate change, enabling CO_2-free, dispatchable power generation. Consequently, the main FLEX4H2 goal is to design, develop and validate a safe, efficient, and highly fuel-flexible gas turbine combustion system capable of operating with any concentration of hydrogen blend up to 100% hydrogen.

Crucially, this objective will be pursued at the most challenging hydrogen combustion conditions, i.e., at H-Class operating temperatures and pressures, required for highest cycle efficiency, while still meeting emission targets without any use of diluents.

The project also aims at a demonstration of the system in a rig fully reproducing engine operating conditions (mass-flows, temperatures, pressures) thus achieving a technology readiness level (TRL) of 6, paving the path towards commercial deployment shortly after project completion. Likewise, the improved combustor design should be fully retrofittable to existing gas turbines, thereby providing significant opportunities for refurbishing existing assets.

(Excerpt from the June 2023 interview. Read the complete text here.)

A few words about financing institutions

FLEX4H2 is a project financed by two funding authorities: the Swiss Federal Department of Economic Affairs, Education and Research, and the Clean Hydrogen Partnership, which is a partnership between the European Commission, the fuel cell and hydrogen private industry represented by Hydrogen Europe and the research community represented by Hydrogen Europe Research.

This unique combination of project management framework, resources, scientific and commercial experience, makes projects like FLEX4H2 quite robust and focused on commercial implementation.

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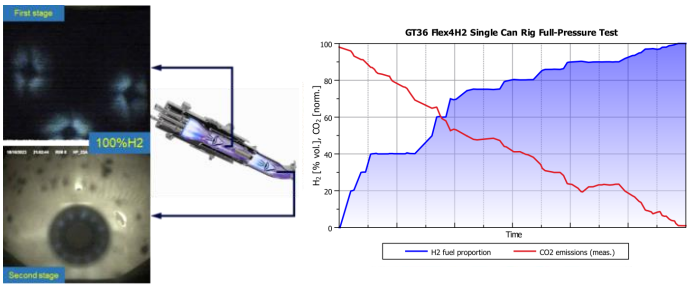
FLEX4H2 update

WP1 (Combustion system development and refinement) & WP4 (Testing and demonstration at TRL6): The design of the first generation of H_2-optimised prototypes has been completed successfully and full-scale prototypes have been manufactured and instrumented at outstanding pace thanks to additive manufacturing methods and techniques. Their performance was firstly assessed at atmospheric pressure conditions and based on the successful results, brought further to the high-pressure test cell, reproducing full engine operating conditions in the rig.

The testing activities were completed according to the project plan and all development targets of the first development loop were met. Further testing with H_2 up to 100% was also conducted.

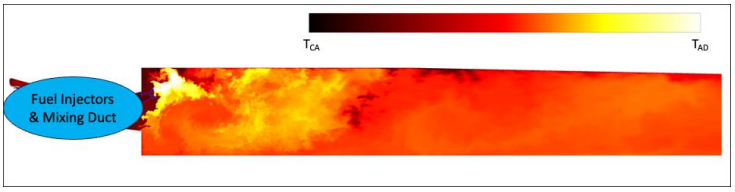
Reaching 100% H_2 operation was possible, low frequency pulsations were observed but could be maintained within allowable limits. Additionally, the NO_x emissions limits were also achieved, however at a reduced overall combustor exit temperature. This indicated the development area to be tackled within the upcoming development loops within FLEX4H2. The tests highlighted the combustor's ability to seamlessly switch between natural gas and hydrogen, demonstrating its remarkable fuel and operational flexibility.

The flame images (shown in the figure) confirmed the readings from the instrumentation: with pure hydrogen the flame looked stable, without any signs of overheating. The first stage flame is barely visible, both because of the low light emissions of hydrogen as well as the operating conditions tuned to provide the sequential burner with the (target) low inlet temperature; the second stage flame is kept at its desired location.



WP2 (Numerical modelling): Advanced high-resolution numerical simulations performed by CERFACS and SINTEF, focusing on the CPSC first and second stage respectively, have already provided novel detailed insights into fuel-oxidizer mixing pattern and response of hydrogen-flames stabilization in the burners. Further numerical modelling work will assist the refinement of the combustion-system design by pre-assessing the response of the CPSC to design modifications that address the increased hydrogen fractions in the fuel. This research and development approach allows a cost-effective technology refinement of the H_2-optimised combustion system, relying to a lesser extent on expensive full-scale rig testing.

In parallel with the exploitation of their predictive capabilities, the numerical modelling tools used by CERFACS and SINTEF are also continuously assessed and validated against relevant experimental data. The latter consists of a combination of ongoing rig-testing experiments involving Ansaldo's CPSC first- and second stage burners and new experiments, performed at the Institute of Combustion Technology of DLR in Stuttgart, featuring optically accessible undiluted hydrogen flames stabilized at reheat conditions.



Instantaneous temperature field (2nd combustion stage – CPSC)

WP3 (Thermoacoustics): Ensuring stable operation across the full operational range of the gas turbine fuelled by hydrogen requires an in-depth thermoacoustic understanding. The first step for achieving this is setting up a surrogate model representing the thermoacoustics of the GT36. This entails the characterization of acoustic flame responses, which is commonly done for single stage systems. Due to the setup with two flames and the design of the test rig, a new dimension is to ensure that the behaviour of a single flame can be extracted from the measurement of the complete CPSC system and vice versa. This applies to both the modelled and the experimental behaviour. Hitherto, the invested effort in thermoacoustics has produced an algorithm capable of doing exactly that: it takes the model behaviour of the full CPSC system and deduces the model behaviour of the GT36's subsystem containing the first flame. But taking the algorithm from handling data of simplified models for which the algorithm excellently works to handling experimental data requires careful fine-tuning of various parameters that are determined from the experimental data, something that will be extended upon in FLEX4H2's next newsletter. Check out our LinkedIn post on thermoacoustics here!

WP5 (Communication, dissemination and exploitation): Our activities were concentrated around the project's visibility. To this end, communication materials (leaflet, poster, and roll-up) were created and already used at number of events. The communication channels (LinkedIn, X) have been setup at the beginning of the project and are regularly updated. The latest addition to the communication materials in the project video (available at our home page). The project has already been part of many events, see further down and/or at our website.

WP6 (Project Management): The project team behind FLEX4H2, under the leadership of Ansaldo Energia, has been thoroughly and successfully managing the project using the latest project management best practices as well as the key individual contributions from all the project partners.

We are happy to share that the project status is in line with the original FLEX4H2 project plan, the application of the resources received has been performed according to the financial objectives, and we have enhanced our reporting frequency to enhance visibility of any potential deviations and/or implement any required mitigation plans. The project is currently preparing for its first periodic reporting, after 18-months since project kick-off, in which the financial, administrative, and technical status of all FLEX4H2 contractual obligations will be officially reported.

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Interview with FLEX4H2 partners – Andrea Gruber (SINTEF) & Laurent Gicquel (CERFACS)

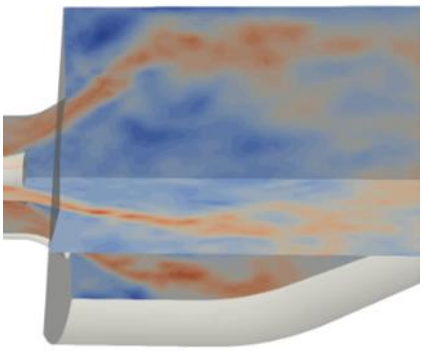
What was your company's motivation to join the project FLEX4H2 consortium?


Andrea Gruber, SINTEF

Andrea: SINTEF Energy joined FLEX4H2 in alignment with its strategic objective to advance the sustainability of clean energy supply and accelerate the development of low-emissions technologies through its expertise and research-based knowledge. Hydrogen-fired gas turbines play a key role as an enabling technology. Since 2004, we have partnered with ALSTOM Power and later Ansaldo Energia to enhance hydrogen-firing capabilities for their most advanced sequential combustion systems in various EU funded projects (e.g., "ENCAP" FP6 and "DECARBit" FP7) and nationally funded projects (e.g., BIGH2 and NCCS). Our fundamental research on hydrogen premixed combustion under gas turbine operating conditions — namely, high reactant temperature and pressure — has consistently supported applied research findings. These studies have demonstrated that gas turbine combustion systems, based on longitudinal fuel staging, also known as "sequential" or "reheat" combustion, offer optimal load and fuel flexibility, particularly for clean and efficient hydrogen combustion. FLEX4H2 specifically targets the development and validation of hydrogen-firing capabilities in one of the most advanced longitudinally staged combustion systems: the Constant-Pressure Sequential Combustor (CPSC), currently applied in Ansaldo Energia's GT36 heavy-duty gas turbine.


Laurent Gicquel, CERFACS

Laurent: CERFACS' motivation in joining FLEX4H2 comes from the company's objective to help and actively contribute to the energy transition process, by supporting the development of very promising technologies and accelerating the industrial progress towards CO_2-free power generation. To do so, experts from CERFACS provide their knowledge in combustion modelling, leveraging this societal and industrial challenge, by use of advanced high-performance computers and simulations. In this project, CERFACS is exploiting its experience in addressing fundamental problems encountered in the design of combustion systems, proven successful for several gas turbine applications, including aircrafts propulsion, power generation and rocket engines.
Fundamental scientific contributions cover fields like thermoacoustic instabilities, turbulence sub-grid scale models, turbulent combustion closures, CERFACS' model being then found in many commercial softwares dedicated to such problems. Furthermore, it has tight links with industry and frequently contributes to EU-funded projects. Through FLEX4H2 and thanks to advanced flow and flame predictions with hydrogen as a new fuel, designs from Ansaldo Energia can be assessed beforehand and possibly optimized before demonstration and market introduction.



Instantaneous velocity field (1st combustion stage - MBFS)

View of the flow velocity field (red: high speed, blue: stagnant or no flow) in transverse plans and within the first combustion stage. Such fields and information are obtained by LES at a given instant in time, the simulation providing a fully spatial and temporal evolution of this activity in the burner.

Continue reading the interview

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The Consortium's in-person meetings

The **first General Assembly** (GA)/Kick-off meeting took place on 10 & 11 January 2023 in Baden (Switzerland) at our Coordinator's Ansaldo Energia. As a part of the meeting, a tour in the test power plant in Birr was organised.

The **second GA** took place in Brussels at our partner's ETN Global on 19 & 20 September 2023. As a part of this meeting, filming of the official project video took place.

FLEX4H2 on the stage

- ETN Global's AGM & Workshop (28-29 March 2023, London, UK) – project expo
- IGTC – International Gas Turbine Conference (10-11 October 2023, Brussels, BE) – project expo
- EU Hydrogen Research Days (15-16 November 2023, online) – presentation by the project coordinator
- GPPS Forum24 (17-18 January 2024, Zurich, CH) – FLEX4H2 addressed in our coordinator's keynote speech
- Italian Clean Hydrogen Partnership info day (8 February 2024, Rome, IT) – FLEX4H2 presented by the project coordinator
- KEY24 – The Energy Transition Expo (28 February - 1 March 2024, Rimini, IT) – our project was featured in the "Hydrogen Arena – Hydrogen Combustion and the Energy Transition" and presented by the project coordinator
- ETN Global's AGM & Workshop (19-20 March 2024, Leiden, NL) – project expo
- Our first scientific paper by SINTEF Energy Research and Ansaldo Energia "Numerical investigation of reheat hydrogen flames in the sequential-combustion stage of a heavy-duty gas turbine" was presented at the ASME Turbo Expo (24-28 June 2024, London, UK)

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Communication highlights

- The project website 🌎 is online and regularly updated: www.flex4h2.eu
- Our leaflet, poster, and roll-up are available online 🪧
- FLEX4H2 brand-new project video is on our YouTube channel 🎞️
- Follow us on LinkedIn and X channels

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