# HYCOFLEX

## HYDROGEN FOR COGENERATION IN FLEXIBLE OPERATION

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| **Project ID** | 101138002 |
| **PRR 2025** | Pillar 4 - $H_2$ End Uses - Stationary Applications |
| **Call Topic** | HORIZON-JTI-CLEANH$_2$-2023-04-03 |
| **Project Total Costs** | 7 073 275.00 |
| **Clean $H_2$ JU Max. Contribution** | 4 442 550.75 |
| **Project Period** | 01-02-2024 - 31-10-2026 |
| **Coordinator Beneficiary** | SIEMENS ENERGY GLOBAL GMBH and CO. KG, DE |
| **Beneficiaries** | SMURFIT KAPPA PAPER SERVICES BV, ARTTIC INNOVATION GMBH, SIEMENS ENERGY SAS, ENGIE ENERGIE SERVICES, SMURFIT WESTROCK PAPER SERVICES B.V., CENTRAX LIMITED, SIEMENS ENERGY INDUSTRIAL TURBOMACHINERY LIMITED, EQUINOR ENERGY AS, BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE, ETHNICON METSOVION POLYTECHNION, DEUTSCHES ZENTRUM FUR LUFT - UND RAUMFAHRT EV |

### PROJECT AND GENERAL OBJECTIVES

HyCoFlex is developing a retrofittable decarbonisation solution package for combined heat and power plants by enabling gas turbines to operate on up to 100% hydrogen. This cutting-edge technology will be seamlessly integrated into an industrial cogeneration system at the Saillat-sur-Vienne site in France, where it will be demonstrated and validated.

Expanding on the achievements of the HYFLEXPOWER project, HyCoFlex will further enhance an industrial scale power-to-hydrogen-to-power facility, refining its infrastructure to improve efficiency and adaptability. HyCoFlex will:

- Develop operational strategies and flexible protocols tailored to the dynamic requirements of industrial cogeneration plants.
- Play a key role in accelerating the transition towards a low-carbon industrial and energy landscape by establishing viable pathways for scaling and replicating this solution.

### NON-QUANTITATIVE OBJECTIVES

Enhancing advance plant concept for hydrogen cogeneration operation:

- HyCoFlex will upgrade of the power-to-$H_2$-to-power cogeneration plant developed for the HYFLEXPOWER initiative at Saillat-sur-Vienne, enabling its gas turbine to operate up to 100% hydrogen. The upgrades will focus on improving safety and plant integration, and enhancing monitoring accuracy through advanced fuel composition and exhaust analysis systems. Additional modifications will facilitate precise fuel blending via new gas lines and updated control systems.

Development and validation of $H_2$ gas turbine combustion technology:

- HyCoFlex will design, develop, and validate a highly fuel-flexible Dry-Low Emissions (DLE) combustion system capable of operating with hydrogen concentrations ranging from 0% to 100%. This includes:
  - An optimisation of the Siemens Energy's existing hydrogen DLE technology through advanced design techniques, analytical research, and validation in relevant environments and gas turbine operating conditions.
  - An enhanced burner with improved safety, operational flexibility, and emissions compliance in line with the Clean Hydrogen Strategic Research and Innovation Agenda (SRIA).
  - High-pressure rig tests followed by engine testing to validate optimal performance at the full-scale industrial plant.

Demonstration of enhanced operational flexibility in the cogeneration plant:

- Development of a demonstration gas turbine with a combustion system designed for 100% hydrogen operation.
- Two demonstration campaigns at the industrial cogeneration plant in Saillat-sur-Vienne to test the turbine's performance across various loads and fuel mixtures. These tests will validate the advanced plant with the $H_2$ gas turbine, confirming its efficiency with hydrogen concentrations up to 100% and showcasing the plant's enhanced operational flexibility for future hydrogen applications.

Pathways to decarbonised power generation using gas turbines:

- Development of a flexible dynamic simulation and optimisation tool to analyse the operational performance of the Saillat-sur-Vienne cogeneration unit under transient conditions. This tool will also be applied to upscaled cogeneration units to evaluate the scalability and replicability of hydrogen-based retrofitting solutions.
- Assessment of circularity and sustainability aspects, focusing on efficiency improvements, economic viability, and environmental impact.
- Simulation of real-world operations through digital twins.
- Identification of optimal sites across Europe for implementing HyCoFlex's decarbonisation solutions through an information mapping tool.



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## PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

Power-to-$H_2$-to-power advanced plant concept:

- Execution of preliminary studies, including process design analyses and updated safety reviews with risk assessments related to hydrogen combustion.
- Identification of key measurements, such as temperatures and emissions, and preparations for their implementation are ongoing.
- Execution of maintenance of existing installations, and preparation of necessary modifications to the mixing station, including the ordering of long lead items.

Combustion system:

- Identification of gaps in project key performance indicators based on insights through the HYFLEXPOWER demonstration engine test experience.
- Identification of operational improvements with hydrogen based on numerical simulations, manufacturing of new combustion system hardware, and high-pressure tests at the Siemens Energy combustion test facility Clean Energy Center (CEC).
- Manufacturing of combustion system components for validation in the gas turbine during the first demonstration campaign at the Saillat site, scheduled for 2025.

Demonstration and validation of the advanced plant concept:

- Utilisation of existing measurements from HYFLEXPOWER for preparation of a comprehensive data monitoring for the 2025 Test Campaign.
- Establishment of a detailed test schedule for the 2025 Test Campaign.
- Securing the test engine for the 2025 Test Campaign.
- Finalisation of the engine build specifications.
- Manufacturing and procurement of essential components, including burners, are ongoing.
- Performance of a works acceptance test of a test engine with a comparable $H_2$ combustor, using natural gas, to establish engine control parameters for transient operation, guiding the site testing strategy.

Dynamic simulations and upscaled scenarios:

- Establishment of the requirements and boundary conditions for the dynamic simulation framework of the power-to-$H_2$-to-power unit.
- Development of dynamic models to analyse the transient behaviour of the advanced plant.
- Performance of a multi-objective optimisation to minimise the Levelized Cost of Hydrogen and/or Hydrogen Carbon Intensity.
- Determination of the necessary capacity for the proton exchange membrane electrolyzer and hydrogen storage unit based on preliminary results for cost-optimal base load gas turbine operation at 50% $H_2$ by volume.

## FUTURE STEPS AND PLANS

The initial test campaign is set and will last approximately 12 weeks. During this period, the operational and flexible performance of the gas turbine will be validated, starting with natural gas and progressively increasing to 100% hydrogen. The campaign will also include initial tests with the heat recovery steam generator. Key focus areas will include:

- The stability of the fuel supply system at varying hydrogen concentrations.
- Identification of operational limits.
- Correlation of the rig to engine combustor performance (including emissions).
- Safety considerations related to flashback and flameout detection.

## PROJECT TARGETS

| Target source | Parameter | Unit | Target | Target achieved? |
|---|---|---|---|---|
| Project's own objectives | Advance the HYFLEXPOWER plant concept and infrastructure for 100% $H_2$ cogeneration operation. | % $H_2$ | up to 100 | |
| | Design, develop and validate a safe and efficient, low-emission $H_2$ GT combustion system. | - | HyCoFlex will validate the combustor design at relevant gas turbine pressures and temperatures in dedicated high-pressure rig test campaigns at TRL6 and then finally achieve TRL7 by the 2nd engine validation test. | |
| | Demonstrate and validate the retrofitted cogeneration advanced plant for operational flexibility at varying natural gas/hydrogen mixtures and loads while achieving state-of-the-art efficiency and low $NO_x$ emissions. | $NO_x$ emission in ppm @ 15% $O_2$; Ramp rate in load/min; $H_2$ content fluctuations % vol. / min; power reduction in %points, | $NO_x$ emission: <15 (0-30% $H_2$), <25 (30-100% $H_2$) ramp rate: >10, $H_2$ fluctuations ±30 % vol. / min power reduction 0.5-2 | |
| | Present pathways for decarbonised power generation from gas turbines through retrofits, upscaling and uptake while addressing circularity aspects. | - | Technoeconomic and Environmental Assessment. Digital twins simulating annual operation in transient conditions of up to three real large scale cogeneration units. Information Mapping Tool | |



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