ACHIEVE

ADVANCING THE COMBUSTION OF HYDROGEN-AMMONIA BLENDS FOR IMPROVED EMISSIONS AND STABILITY

ACHIEVE

Project ID	101137955
PRR 2025	Pillar 4 - H_2 End Uses - Stationary Applications
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-04-02
Project Total Costs	2 994 200.00
Clean H_2 JU Max. Contribution	2 994 200.00
Project Period	01-01-2024 - 30-06-2027
Coordinator Beneficiary	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA, IT
Beneficiaries	STATE ENTERPRISE ZORYA MASHPROEKT GAS TURBINE RESEARCH AND PRODUCTION COMPLEX, PHOENIX BIOPOWER SWITZERLAND GMBH, PHOENIX BIOPOWER AB, CENTRALESUPELEC, KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, ZABALA INNOVATION CONSULTING SA, UNIVERSITA DEGLI STUDI DI FIRENZE, TECHNISCHE UNIVERSITEIT DELFT, TECHNISCHE UNIVERSITAT BERLIN, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS

https://achieve-project.eu/

PROJECT AND GENERAL OBJECTIVES

ACHIEVE (Advancing the Combustion of Hydrogen-AmmonIa blEnds for improVed Emissions and stability) aims to accelerate the transition of the gas turbine power generation industry from carbon-based natural gas combustion to carbon-free fuel blends. ACHIEVE seeks to achieve zero-carbon emissions, ultra-low NO_x emissions, and stable gas turbine operation by focusing on hydrogen (H_2) and ammonia (NH_3) mixtures. The project follows a three-pronged approach:

- Experimental campaigns to investigate combustion stability, emissions, and performance under increasingly realistic conditions.
- Numerical modeling to address challenges such as chemical kinetics, flame dynamics, and combustion instabilities.
- Engagement with industry stakeholders, including OEMs and end users, to facilitate technology adoption.

ACHIEVE aims to advance the technology readiness level (TRL) to 4, demonstrating its feasibility in a controlled environment and laying the groundwork for future industrial implementation.

NON-QUANTITATIVE OBJECTIVES

- Develop a deeper fundamental understanding of hydrogen-ammonia combustion processes.
- Investigate the stability, emissions, and operational feasibility of unconventional hydrogen-based fuel blends to overcome key scientific and technological barriers that currently limit widespread adoption.
- Focus on efficient burning while minimising harmful emissions and preventing flame instability, flashback, and thermoacoustic oscillations.
- Create advanced numerical modeling techniques that enhance the predictive capabilities of combustion simulations, contributing to more accurate and reliable gas turbine designs.
- Foster strong collaboration between academia, industry, and policymakers, ensuring that the project's findings are aligned with real-world energy demands and regulatory requirements and to support a smooth transition toward sustainable energy solutions, ultimately contributing to global decarbonisation efforts.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

ACHIEVE has made significant progress in the following:

- Understanding and implementation of hydrogen-ammonia combustion for gas turbines meeting key deliverables and milestones, including the completion of preliminary experimental and numerical studies aimed at improving combustion stability, reducing NO_x emissions, and optimising fuel blends for practical applications.
- Testing to assess the feasibility of hydrogen-based fuels under varying operating conditions, providing valuable insights into their behavior and potential integration into energy systems.
- Computational modeling efforts focusing on refining predictive tools for flame dynamics, emissions, and thermoacoustic stability, enhancing the accuracy of combustion simulations.
- Dissemination activities, with multiple publications and presentations showcasing results in scientific and industrial forums.

FUTURE STEPS AND PLANS

- Conduct more extensive experimental campaigns at progressively higher pressures and power levels to simulate real-world gas turbine conditions more accurately to refine the understanding of static and dynamic combustion stability, emissions control, and operational efficiency, ensuring that the proposed fuel blends meet industrial standards.
- Enhance combustion models by integrating improved chemical kinetics, turbulence-chemistry interactions, and predictive tools for NO_x emissions and thermoacoustic instabilities, contributing to more reliable and optimised simulations.
- Prioritise knowledge dissemination through scientific publications, conference presentations, and stakeholder engagement activities to maximise impact.

Clean Hydrogen Partnership
Co-funded by the European Union

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	H_2 range in gas turbine fuel	% mass	100% in conventional swirl-stabilised and novel burners	
	H_2 range in gas turbine fuel	% vol.	Up to 20% NH_3 (TUB burner)	
	H_2 range in gas turbine fuel	% vol.	Validation of models to within 5% accuracy	
	NO_x emissions	-	65% reduction NO_x in premixed, 80% in non-premixed operation (jet in hot coflow)	
	NO_x emissions	NO_x ppmv@15%O_2/dry	Validation of models to within 10% accuracy	
	NO_x emissions	NO_x mg/MJ fuel	NO_x < 25ppm with 100% H_2 (TUB burner)	
	NO_x emissions	NO_x mg/MJ fuel	NO_x < 100ppm with up to 20%NH_3 (TUB burner)	
	Ability to handle H_2 content fluctuations	% mass/min	Stable combustion with 100% H_2 (TUB burner)	
	Ability to handle H_2 content fluctuations	% vol./min	Stable combustion of H_2 blends with 20%NH_3 (TUB burner)	
	Ability to handle H_2 content fluctuations	% vol./min	Low combustion instabilities (lower than 0.15 % of the operating) for 100% H_2	
	Ability to handle H_2 content fluctuations	% vol./min	+/- 30 (TUB burner)	
	Ability to handle H_2 content fluctuations	% vol./min	Low combustion instabilities (lower than 0.15 % of the operating) for 100% H_2	
	Ability to handle H_2 content fluctuations	% vol./min	Stable operation with H_2 fluctuations +/- 30%vol./min (TUB burner), no instabilities p_RMS/p_op < 0.15%, no flashback, no lean blowout - Real-time monitoring system to achieve stable operation	
	Validated Computational Singular Perturbation (CSP) skeletal, and virtual-chemistry reduced mechanisms for a use case	-	28% thermal cracking of NH_3 yielding 32.8% H_2 / 10.9% N_2 / 56.3% NH_3 by volume	
	Events presenting the project per year and links with other EU projects	Number	3	
	Peer-reviewed papers published	Number	12	