ACHIEVE

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

Project ID	101137955
PRR 2024	Pillar 4 – H_2 end uses: stationary application
Call topic	HORIZON-JTI-CLEANH2-2023-04-02: Research on fundamental combustion physics, flame velocity and structure, pathways of emissions formation for hydrogen and variable blends of hydrogen, including ammonia
Project total cost	EUR 2 994 200.00
Clean H_2 JU max. contribution	EUR 2 994 200.00
Project period	1..1.2024–30.6.2027
Coordinator	Sapienza Università di Roma, Italy
Beneficiaries	CentraleSupelec, Centre national de la recherche scientifique, King Abdullah University of Science and Technology, Phoenix Biopower AB, Phoenix Biopower Switzerland GmbH, State Enterprise Zorya Mashproekt Gas Turbine Research and Production Complex, Technische Universität Berlin, Technische Universiteit Delft, Università degli Studi di Firenze, Zabala Innovation Consulting SA

https://cordis.europa.eu/project/id/101137955

PROJECT AND GENERAL OBJECTIVES

The main objective of Achieve is to enable the reduction of pollutant gases (CO_2 and NOx) from current and future gas turbine installations by providing a broad knowledge base and set of validated (technology readiness level 4) solutions for the combustion of unconventional H_2 blends in gas turbines – that is, with combinations of H_2, NH_3, CH_4, N_2 and H_2O. Focused dissemination of and efforts to exploit results within the research and industry communities will allow those conducting the project to build on these results to (i) develop technology and solutions for current gas turbine engines equipped with conventional swirl-stabilised dry low emission combustion systems; and (ii) develop novel combustor systems for future gas turbines with significantly lower emissions and better operability than current engines over a wider range of unconventional H_2 blends.

H_2 is envisaged by many as the main substitute for natural gas in the short/medium term when produced from renewable or low-carbon energy sources, particularly when these are in excess. However, there are several challenges with the combustion of H_2, which include higher chances of static (flashback) and dynamic (thermoacoustic) instabilities, and the strong sensitivity of hydrogen flames to pressure. Critically, there are also significant challenges related to the storage and transport of hydrogen due to its high reactivity and low energy density, making widespread implementation economically and technically difficult.

NH_3 can act as a carbon-free carrier of hydrogen. NH_3 flame speeds are much lower than those of hydrogen, and the infrastructure and knowledge required to produce, transport and store large quantities of ammonia are already established, as NH_3 is used extensively in fertilisers. However, NH_3 has a low burning velocity, has a narrow flammability limit, can produce a very high level of NOx and can be toxic, limiting its use in practical combustion applications. Blends of ammonia and hydrogen have been studied as means to combine the benefits of both fuels while mitigating their limitations. These blends can be tailored to have more favourable combustion characteristics, for example flame speeds, flammability limits and NOx emissions, than pure NH_3, and better safety than pure H_2 flames.

One promising pathway is to utilise NH_3 for the transport and storage of renewable energy. Others are the (partial) local conversion of NH_3 into H_2, and the combustion of H_2/NH_3 mixtures for power generation.

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PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
SRIA (2021–2027)	Ability to handle H_2 content fluctuations	-	For stable operation with H_2 fluctuations, around 30 %vol./min (TUB burner)	
	NOx emissions	-	65 % reduction in NOx in premixed operations; 80 % in non-premixed operations (jet-in-hot-coflow burner)	
	Ability to handle H_2 content fluctuations	%vol./min	Stable combustion of H_2 blends with 20 % NH_3 (TUB burner)	
	Range of H_2 content in gas turbine fuel	%mass	100 in conventional swirl-stabilised and novel burners	
	Ability to handle H_2 content fluctuations	-	Low combustion instabilities (lower than 0.15 % of the operating) for 100 % H_2	
	NOx emissions	ppm	< 100 with up to 20 % NH_3 (TUB burner)	
	Events presenting the project per year and links with other EU projects	number	3	
	Range of H_2 content in gas turbine fuel	%vol.	Up to 20 % NH_3 (TUB burner)	
	Ability to handle H_2 content fluctuations	-	Stable operation with H_2 fluctuations around 30 %vol./min (TUB burner); no instabilities p_RMS/p_op < 0.15 %; no flashback; no lean blowout, with a real-time monitoring system to achieve stable operation	
	Peer-reviewed papers published	number	12	
	Range of H_2 content in gas turbine fuel	%vol.	Validation of models to within 5 % accuracy (KPI 2.1)	
	NOx emissions	ppmv at 15 % O_2 (dry)	Validation of models to within 10 % accuracy	
	Ability to handle H_2 content fluctuations	%mass/min	Stable combustion with 100 % H_2 (TUB burner)	
	Validated computational singular perturbation skeletal-mechanism- and virtual-chemistry-mechanism-derived mechanisms for a use case	-	28 % thermal cracking of NH_3 yielding 32.8 % H_2, 10.9 % N_2 and 56.3 % NH_3 by volume	
	NOx emissions	mg/MJ fuel	< 25 ppm with 100 % H_2 (TUB burner)	

Clean Hydrogen Partnership
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