INFLUENCE OF HYDROGEN ADDITION TO METHANE UNDER MILD CONDITIONS

G.B. Ariemma*, G. Sorrentino*, P. Sabia*, M. de Joannon, R. Ragucci*
giovannibattista.ariemma@stems.cnr.it
*Institute of Sciences and Technologies for Sustainable Energy and Mobility (STEMS-CNR), Italy

Abstract
Environmental issues related to CO_2 emissions deriving from power and energy sectors are amongst the most relevant industrial challenges [1]. In particular, an effective approach to address the needed CO_2 emissions reduction is based on the gradual replacement of hydrocarbon-based fuels with hydrogen. However, many techno-economic barriers hinder a straightforward transition to a hydrogen economy [2]. The use of hydrocarbon/hydrogen blends has been proposed as intermediate and bridge solution, thus providing a transition strategy to a carbon-free energy system in the future. In addition, MILD combustion [3] was already proven as suitable and effective technology. However, the step toward the technological readiness of MILD based devices has not yet been completed. In this framework, the present study wants to shed light on the combustion features of methane/hydrogen blends and on the related pollutant emissions in a truly MILD burner. The influence of reactive mixture composition (ϕ) and the hydrogen content in the fuel mixture (%H_2 vol) was highlighted, focusing on oxidation process stability and NO_x emissions. Results confirm the wide fuel flexibility of the MILD combustion process, whose performance is totally released from the fuel mixtures combustion properties. Specifically, results testified the ability of efficiently convert CH_4/H_2 blends by substantially keeping unaffected operating temperatures and NO_x emissions to the levels typically detected for pure methane combustion. In this respect, kinetic analyses highlighted the main reaction involved in NO_x production/consumption for CH_4/H_2 blends and the key role of radical species deriving from both the fuels. In particular, the increased radical pool concentration deriving from the increasing %H_2, along with the resulting decreasing ones from CH_4, balance each other, thus not affecting the NO_x net production.

Acknowledgments
We acknowledge the partial financial support of the European Union NextGeneration EU in the framework of: PE00000021 - NEST - Network 4 Energy Sustainable Transition, Italian Ministry of University and Research Decree n.341 - March 15, 2022 - Spoke 3, CUP B53C22004060006; the National Sustainable Mobility Center - MOST, CN00000023, Italian Ministry of University and Research Decree n. 1033-17/06/2022 - Spoke 12, CUP B43C22000440001; EU initiatives under the National Recovery and Resilience Plan (NRRP-PNRR): "POR H2 AdP MMES/ENEA-CNR", Mission 2, Component 2, Investment 3.5 "Ricerca e sviluppo sull'idrogeno", CUP: B93C22000630006.

References
[1] IEA, Energy Technology Perspectives 2020. Rep., Int. Energy Agency Paris.
[2] Dincer, I. "Green methods for hydrogen production", *Int J Hydrogen Energy*, vol. 37, 1954–71 (2012)
[3] Sabia, P., Sorrentino, G., Ariemma, G.B., Manna, M.V., Ragucci, R., de Joannon, M., "MILD Combustion and Biofuels: A Minireview", *Energy and Fuels* 35:19901–19 (2021)