ENERGETICS

MUR DM 117/Convergent Science - Flex-fuel IC engine modeling and optimization for carbon-free mobility

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] CONVERGENT SCIENCE GMBH [P.iva/CF:U65981645] Politecnico di TORINO [P.iva/CF:00518460019]
Supervisor	BARATTA MIRKO - mirko.baratta@polito.it
Contact	MISUL DANIELA ANNA - daniela.misul@polito.it BARATTA MIRKO - mirko.baratta@polito.it
Context of the research activity	The present project aims to provide mid- and long-term sustainable solutions to support hydrogen-based fuels as energy carriers for light mobility and long-haul transport. Objectives and added values from this research are summarized in what follows: 1. Quantification of ammonia and e-fuel combustion-related variables with respect to baseline NG or H2 fueling, under engine-relevant conditions. 2. Definition of guidelines for a factual carbon-free IC engine development. 3. Availability of fuel-flexible, reliable combustion models for the next-generation researchers. 4. Insight into the hydrogen/ammonia/e-fuel storage and distribution chain, as well as its impact on the fuel composition and properties. Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23001950004
	The continuously growing mobility demand and the raising concern about its environmental impact have thrust the industry to largely invest on R&D to define innovative solutions for internal combustion engines for automotive, marine, and off-roads applications. At the same time, as from the Next Generation EU, a relevant portion of the Italy budget has been devoted by the PNRR guidelines to the energy performance improvement and the promotion of joint research of academic institutions and industrial partner. This will have a beneficial impact on high-level education of professional figures to work in the energy and mobility field. The ambitious goals of the 'net-zero' scenario can only be targeted if a proper mix of fuels and technology ways will be pursued and developed. More specifically, net-zero CO2 emissions can either be achieved through the use of a bio-fuel or a carrier produced from renewable energy sources (such as, hydrogen and e-fuels). As a matter of fact, hydrogen is intrinsically a carbon-free energy

Objectives	carrier and has a good potential to be used in IC engines. Hydrogen-based fuels can also be a means to transport renewable energy from regions with abundant renewable resources to regions and cities with growing energy needs. In this perspective, fuel storage and safety can be a topic of concern, and ammonia and e-fuels represent sound alternatives to hydrogen, mainly due to the potential of being integrated completely or partly into the existing gaseous and liquid fuel infrastructure. The present project is carried out in cooperation with Convergent Science GmbH (Linz, Austria). Convergent Science is a leading CFD software development house, with a broad experience in research projects focused on energy conversion systems, in cooperation with both industrial and academic partners. The project aims to provide mid- and long-term sustainable solutions to support hydrogen-based fuels as energy carriers for light mobility and long-haul transport. With this aim, the following steps are defined: STEP 1 – Extensive literature review for the definition of the state-of-the-art on carbon-free IC engines, with specific reference to green hydrogen, ammonia, e-fuels solutions. STEP 2 – Preliminary modeling activity to quantify the ammonia/e-fuel combustion-related variables with respect to NG or H2 fueling, under engine-relevant conditions. STEP 3 – Definition of a target application and investigation on the suitable submodels concerning turbulence, combustion, pollutant formation, in order to put the basis for applied research beyond the state of the art and to promote the model flexibility with respect to the fuel composition. STEP 4 – Model validation with respect to a baseline engine configuration, to be defined. STEP 5 – Model application and definition of the guidelines for a factual carbon-free IC engine development. STEP 6 – Insight into the hydrogen/ammonia/e-fuel storage and distribution chain, as well as its impact on the fuel composition and properties. The expected added value from the project are as follows: - Availability of fuel-flexible, reliable combustion models for the next-generation combustion researchers; - Establishment of the guidelines for carbon-free IC engine development - Assessment on the potential of the main combustion concepts and engine chamber architectures, which are presented in the literature. - Extended know-how on the engine-relevant properties of ammonia, hydrogen and e-fuels.

Skills and competencies for the development of the activity	The candidate should have a solid background on thermos-fluid dynamics, energy balance of motor machines and reacting systems, as well as the attitude to a systematic and rigorous research activity. The specific background on turbulence and combustion modeling, as well as proven experience on 1D/3D CFD softwares, will be valued.