

# ENERGETICS

## AMMIN/FEV ITALIA - Innovative fuels for low-/zero-carbon large scale usage of ICEs

|                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Funded By</b>                        | FEV ITALIA SRL [P.iva/CF:09005180014]<br>Politecnico di TORINO [P.iva/CF:00518460019]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Supervisor</b>                       | PIANO ANDREA - andrea.piano@polito.it                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Contact</b>                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Context of the research activity</b> | <p>In the context of global efforts to decarbonize transport and power-generation sectors, internal combustion engines (ICEs) are expected to remain relevant in applications where high energy density, fast refuelling, long operating range and compatibility with existing assets are critical. According to current long-term scenarios, liquid and gaseous fuels are still likely to provide a significant share of transport energy in 2050; therefore, the transition towards low- and zero-carbon fuels must also address the large installed base of ICE-based systems and the related infrastructure.</p> <p>Innovative fuels such as advanced biofuels, e-fuels, methanol-to-gasoline (MtG), hydrogen and ammonia can enable substantial reductions in life-cycle greenhouse-gas emissions. However, their practical use in large-scale ICE applications is not straightforward. Drop-in fuels are closest to deployment because they minimize changes to engines, fuel systems and logistics, while non-drop-in fuels may offer higher decarbonization potential but require more significant redesign of the combustion system, aftertreatment, storage and safety concepts.</p> <p>The key scientific and technological gaps concern the understanding and prediction of fuel-specific combustion behaviour under engine-relevant conditions: ignition delay, flame propagation, mixture formation, abnormal combustion, efficiency limits and pollutant formation mechanisms such as NO<sub>x</sub>, soot, unburned hydrocarbons and fuel slip. These gaps are particularly critical when fuel properties differ strongly from conventional hydrocarbons and when multi-fuel or fuel-flexible operation is targeted.</p> <p>Focused research is therefore needed to develop validated experimental and numerical methodologies able to translate fuel properties into robust engine-design guidelines, supporting the large-scale adoption of low-/zero-carbon fuels while minimizing the impact on existing ICE architectures and industrial development processes.</p> |
|                                         | <p>The primary goal of this PhD research is to develop, validate and apply methodologies for the numerical and experimental investigation of combustion processes of innovative low-/zero-carbon fuels in internal combustion engines, with the final aim of supporting efficient, low-emission and scalable engine concepts.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## Objectives

FEV Group is carrying out extensive research activities on innovative fuels for ICEs through both virtual analysis and experimental testing. The proposed PhD will be integrated into this industrial research ecosystem and will strengthen the connection between Politecnico di Torino, FEV Italia, the wider FEV Group and international academic partners, with particular reference to RWTH Aachen University, enabling a structured exchange of data, models, know-how and validation results.

Specific objectives include:

- Characterization of combustion-relevant properties and mechanisms of selected innovative fuels, such as MtG/e-fuels, advanced biofuels, hydrogen and ammonia, under engine-relevant pressure, temperature and mixture conditions.
- Selection, reduction and validation of fuel-specific chemical-kinetic mechanisms suitable for 0D/1D and 3D-CFD combustion simulations.
- Development and validation of predictive numerical models for mixture formation, ignition, flame propagation, heat release and emissions formation, using experimental data from engine test benches or dedicated combustion facilities.
- Assessment of fuel-engine interactions, including injection strategy, ignition system requirements, combustion stability, abnormal combustion and aftertreatment-related constraints.
- Definition of fuel-flexible and fuel-specific combustion strategies able to maximize efficiency and minimize pollutant emissions while reducing the need for major modifications to existing engine platforms.

The element beyond the current state of the art is the integration of fuel chemistry, high-fidelity CFD, experimental validation and industrial engine-design requirements into a coherent methodology that can support technology-neutral decisions for the deployment of low-/zero-carbon fuels in ICEs.

## Skills and competencies for the development of the activity

The PhD candidate will work in a multidisciplinary environment combining engine thermodynamics, combustion science, numerical simulation and experimental data analysis. The activity will require close interaction with academic researchers and industrial engineers, with the objective of translating fundamental combustion knowledge into engineering methodologies for engine development.

The candidate will contribute to:

- Understanding the combustion characteristics of innovative fuels under engine-relevant operating conditions.
- Developing and validating 0D/1D and 3D-CFD combustion models, including chemical-kinetic and turbulent-combustion sub-models.
- Planning, interpreting and exploiting experimental campaigns on engine test benches or dedicated combustion facilities.
- Investigating fuel-engine interactions, including injection, ignition, flame propagation, combustion stability and emissions formation.
- Supporting the development of multi-fuel and fuel-flexible combustion strategies for efficient and low-emission ICE operation.

Required skills:

- Solid background in internal combustion engines, thermodynamics and fluid dynamics.
- Knowledge of numerical simulation tools for engine applications, preferably including 1D and/or 3D-CFD codes such as GT-SUITE, CONVERGE CFD or equivalent tools.
- Programming and data-analysis skills, with ability to process experimental and numerical results critically.
- Good written and oral communication skills in English.

Preferred qualifications:

- Knowledge of innovative low-/zero-carbon fuels and their impact on combustion and emissions.
- Experience with combustion modelling, chemical kinetics, engine testing or laboratory experiments.
- Understanding of pollutant-formation mechanisms, including NO<sub>x</sub>, soot, unburned hydrocarbons and fuel slip.

Soft skills:

- Strong analytical and problem-solving attitude.
- Ability to work independently and in interdisciplinary, international teams.
- Curiosity, innovation-driven mindset and willingness to interact with industrial partners.