Master Thesis internship proposal
March – August 2025

Scalable single-stack fuel cell for on-road heavy-duty electrified vehicles

Host organization: FEMTO-ST (Franche-Comté Electronics Mechanics Thermal Science and Optics – Sciences and Technologies) institute

Internship location(s): FEMTO-ST, University of Technology of Belfort-Montbéliard, Belfort, France AND L2EP, University of Lille, Villeneuve d'Ascq, France

Dates: from March to August 2025 – 6 months

Supervisors: Dr. HdR Elodie PAHON – elodie.pahon@utbm.fr
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Required profile: 2nd year master's student (or equivalent) with a specialization in electrical engineering with knowledge in fuel cells and electrified vehicles. A command of the EMR graphical formalism would also be appreciated. English writing capacities.

Internship allowances: ≈ 670€/month

Funding: French National Research Agency (ANR)

Possibility for a PhD thesis afterwards: Yes

Context

Unlike for new on-road light-duty vehicles, for which mandatory carbon dioxide (CO_2) emissions standards have been in place in the European Union (EU) for a decade, the CO_2 emissions standards for new on-road Heavy-Duty Vehicles (HDV) were only adopted in 2019. This delay is particularly due to more stringent requirements, to substitute the diesel engine-based HDV, in terms of lifetime, driving range or refueling time. Today, a fast deployment of new types of on-road HDV to reduce the ecological footprint of transportation is then required. To tackle this, the EU aims to deploy zero-emission vehicles using battery or hydrogen fuel cell. In order to expect a rapid growth of these vehicles the trend is to develop scalable and modular platforms. Applied to the power supplies, the modular and scalable platforms result to use multi-module batteries and multi-stack fuel cells. For this purpose, MARSHALL (ModulAR and Scalable battery and fuel cell systems for on-road HeAvy-duty eLectrified vehicLes) is a new project, funded by the French National Research Agency (ANR), within the framework of the French national network MEGEVH[1] on the electrified vehicles, between three labs; Ampère, FEMTO-ST and L2EP; to develop a generic methodology for the design of multi-module batteries and multi-stack fuel cells applied to on-road HDV. The ambition of the project is to accelerate the system architecture design process of the battery and fuel cell systems by at least 20%, thereby reducing the time-to-market of battery and fuel cell HDV.

Objective of the master thesis

The master thesis aims to develop scalable single-stack fuel cell according to the generic method of MARSHALL. The scaling laws will be developed for relevant properties, such as losses, as well as component parameters, by taking into account different active surface areas. This will be done by using Energetic Macroscopic Representation (EMR) formalism to develop innovative scaling laws that allow to up- or down-size reference components, making it needless to redo time consuming design steps. The organization will consist of keeping the model and the representation of a reference component, but complemented with two power

[1] MEGEVH is a French research group to foster collaborations between academic and industrial partners, into a coordinated and coherent whole from different disciplines, on the modelling and power management of electrified vehicles.

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adaptation elements. The difficulty relies on the embedding of the scaling factors in power adaptation elements and scale only the input and output properties of the reference model. Several steps will be achieved to reach this objective.

Laboratory involved

The L2EP (Laboratory of Electrical Engineering and Power Electronics, ULR 2697, https://l2ep.univ-lille.fr) has about 100 researchers (including 36 Professors and 42 PhD students) in the field of innovative electrical systems. Its control team is internationally recognized for the energy management of various electrified vehicles. Since 1990, the control team of L2EP has developed various generic method, such as the EMR graphical formalism. EMR is nowadays internationally taught and annual EMR summer school is organized every year (www.emrwebsite.org). A scientific platform of 150 m² is dedicated to validate new electrified vehicle concepts, from subsystems to vehicles, for more efficient and less pollutant transportation systems. The platform is organized in five workspaces, including the electrical storage workspace.

The FEMTO-ST (Franche-Comté Electronics Mechanics Thermal Science and Optics – Sciences and Technologies) Institute (CNRS UMR 6174, https://www.femto-st.fr) is a joint research laboratory whose competences cover several fields of engineering sciences with 7 departments, including the Energy department. With 130 members, the Energy department is very involved in Hydrogen Energy to design, evaluate, develop and integrate systems based on the use of the hydrogen energy vector for stationary and on-board applications, while taking account human and social sciences. An existing platform of 600 m² is dedicated to hydrogen system test. That includes 8 test rooms fully secured for advanced hydrogen testing. Long duration tests could be performed on test benches for fuel cell stack tests, ranging from 500 W to 120 kW.

Both laboratories, and in particular the people involved in this project, have a proven expertise in the field which can be demonstrated by the publications directly related to the subject.

Bibliography related to the Master thesis

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