

## Scalable single-module battery for on-road heavy-duty electrified vehicles

**Host organization:** Laboratory of Electrical Engineering and Power Electronics (L2EP)

**Internship location(s):** L2EP, University of Lille, Villeneuve d'Ascq, France  
AND Ampère laboratory, Claude Bernard University Lyon 1, Villeurbanne, France

**Dates:** from March to August 2025 – 6 months

**Supervisors:** Dr. Ronan GERMAN – [ronan.german@univ-lille.fr](mailto:ronan.german@univ-lille.fr)  
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**Required profile:** 2<sup>nd</sup> year master's student (or equivalent) with a specialization in electrical engineering with knowledge in batteries 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<sub>2</sub>) emissions standards have been in place in the European Union (EU) for a decade, the CO<sub>2</sub> 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<sup>1</sup> 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-module battery according to the generic method of MARSHALL. The scaling laws will be developed for relevant properties, such as losses, as well as component parameters, such as thermal resistance. 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

<sup>1</sup> 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.



representation of a reference component, but complemented with two power 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

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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](http://www.emrwebsite.org)). A scientific platform of 150 m<sup>2</sup> 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 Ampère Laboratory (CNRS UMR 5005, <http://www.ampere-lab.fr>) has been working for 30 years in the field of energy storage systems: batteries, supercapacitors and capacitors. The main skills developed concern electrical, electrochemical, electro-thermal characterization and modelling, as well as sustainable development aspects, management optimization and eco-design. An experimental characterization and reliability platform is dedicated to energy storage systems comprising a plurality of characterization and aging benches.

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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