POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 38th cycle

**Research Area n. 3 - Engineering Design and Manufacturing for the Industry of the Future**

**PNRR_352 Research Field: REPURPOSING STRATEGIES OF AUTOMOTIVE LI-ION BATTERIES FOR SECOND-LIFE BATTERY PRODUCTS**

| Monthly net income of PhDscholarship (max 36 months) |
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| **€ 1400.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | Free2Move eSolutions, a joint venture between the Stellantis group and NHOA (formerly Engie EPS), is co-funding a scholarship on the subject of second-life batteries to boost its grounding in this market and to develop long-term scientific-academic cooperations. The automotive sector is undergoing a critical transformation from internal combustion engines to fully electrified propulsion systems. The key enabling technology behind this shift is represented by Li-ion batteries, whose price has come down significantly over the last two decades. The rapid uptake of electric vehicles (EV) by motorists worldwide is however poised to leave a substantial amount of stranded assets in the form of spent batteries at the end of their vehicular life. Collecting and recycling these batteries represents both a cost and a logistical liability for car manufacturers and EV owners. For this reason, several companies are looking into ways to reuse and repurpose said batteries into less demanding energy storage devices as Second-Life Batteries (SLB). The main uncertainties linked to battery repurposing revolve around their state of health (SOH) and the remaining useful life (RUL) left inside the device, and how that metric impacts the decisional tree that can lead to either refurbishing, repurposing, or recycling. OEMs like Stellantis equip PHEVs and BEVs in their portfolio with as many as 10 |

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| | differing battery packs, with cells coming from competing manufacturers and consisting of different cell size, cell chemistry, module arrangement, and thermal behaviour. This extreme heterogeneity begs the need for a differentiated approach based on all these differences to develop a unifying algorithm to make informed decisions on the optimal strategy worth pursuing in each scenario. The aim of this project is to investigate SOH estimation methods applicable to commercial automotive battery packs, combining state-of-the art battery testing instruments as well as experimental techniques and machine learning algorithms. The outcome of this study will then be applied to develop a Decision Support System that takes into account battery degradation, remaining useful life, cell-to-cell heterogeneity, battery pack configuration, ease of disassembly, and other relevant parameters, to configure second-life modules and packs, thus guiding stakeholders identifying the best possible path to pursue in real-life commercial scenarios. The algorithm may be ultimately deployed in Free2Move eSolutions' existing battery sorting pipeline to be verified in a real-life scenario and to improve the company's industrial processes. |
| **Methods and techniques that will be developed and used to carry out the research** | The project will be articulated into the following phases:<br>1.Survey of existing and future automotive battery pack architectures, including their assembly and disassembly methodologies;<br>2.Market analysis of Second-Life Battery products as well as the battery recycling sector;<br>3.Study of SOH and RUL estimation strategies in the context of automotive battery packs;<br>4. Commercial battery data acquisition and processing;<br>5.Experimental comparison of SOH and RUL appraisal strategies;<br>6. Definition of a battery classification algorithm based on residual commercial value and other useful metrics;<br>7.Deployment of the decision support algorithm and validation in an industrial setting;<br>The project will make use of a combination of computational and experimental techniques to accomplish |

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| | its goal. These include and are not limited to:<br>• Battery simulation and modelling (Python, Matlab)<br>• Battery cycling<br>• Battery testing<br>• Battery disassembly and reverse-engineering<br><br>Free2Move eSolutions and its parent company NHOA will grant the PhD student access to their state-of-the art facilities to make use of dedicated testing instruments as well as testing pipelines. The project will make use of a combination of computational and experimental techniques to accomplish its goal. These include and are not limited to:<br>• Battery simulation and modelling (Python, Matlab)<br>• Battery cycling<br>• Battery testing<br>• Battery disassembly and reverse-engineering<br><br>Free2Move eSolutions and its parent company NHOA will grant the PhD student access to their state-of-the art facilities to make use of dedicated testing instruments as well as testing pipelines. |
| **Educational objectives** | The goal of this work is to leverage the academic excellence of Politecnico di Milano to craft an industrial decisional tree that can better inform stakeholders and decision makers in the e-mobility space on the opportunities and faux pas in battery reuse, repurpose, and recycling. |
| **Job opportunities** | The EU's Fit for 55 package and the ambitions of the Chinese government over the nascent e-mobility market make this PhD project an excellent entry point into a career that can be devoted to environmental sustainability and cutting-edge R&D in the automotive sector. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared to Master of Science holders in the same field. |
| **Composition of the research group** | 0 Full Professors<br>1 Associated Professors |

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| | 5 Assistant Professors<br>7 PhD Students |
| **Name of the research directors** | Prof. Marcello Colledani |

| **Contacts** |
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| *Telephone*: 02.2399.8530 *Email:* marcello.colledani@polimi.it<br><br>Web-pages of the research group: https://www.mecc.polimi.it/ricerca/personale-docente/personale-docente/prof-marcello-colledani/<br><br>phd-dmec@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** | |
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| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents (more than 80Km out of Milano)** | -- |

| **Scholarship Increase for a period abroad** | |
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| **Amount monthly** | 700.0 € |
| **By number of months** | 6 |

| **National Operational Program for Research and Innovation** | |
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| **Company where the candidate will attend the stage (name and brief description)** | eSolutions Free2Move S.p.A. |
| **By number of months at the company** | 6 |
| **Institution or company where the candidate will spend the period abroad (name and brief description)** | to be defined |
| **By number of months abroad** | 6 |

| **Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information** |
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| Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707, 13.<br><br>Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. |