



PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 39th cycle

PNRR 118 PNRR Research Field: ASSESSMENT AND UNDERSTANDING OF LITHIUM-ION BATTERY DEGRADATION FOR AN IMPROVED SECOND-LIFE OF BATTERY MODULES

Monthly net income of PhDscholarship (max 36 months)

€ 1500.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

Lithium-ion battery (LiB) technology, already heavily contributing to both to stationary energy storage and to the paradigm-shift of the transportation sector towards electrification, still requires improvement in durability and sustainability. Spent automotive batteries, commonly featuring just 20% capacity fade, retain a considerable residual value, exploitable in less-demanding applications, and are expected to sky-rocket in returning volumes in next years. Nowadays, post-use management of LiB is dominated by recycling or direct disposal. Research efforts are still needed to consolidate understanding of LiB aging which, despite being the complex superimposition of several electrochemical and transport fading mechanisms, it is typically investigated on single cells, focusing on single fading mechanisms and in conditions quite distant from the highly dynamical real-world operation. A reliable methodology, coupling experimental and semi-empirical with physical models, is required to characterize real-world degradation and estimate residual lifetime. Exploitation of battery field-data, requested in the recently approved EU Battery Directive, and of systems typical granularity, with diagnostics to estimate state of health of modules together with its heterogeneity beneath constituting cells, would enable physically sound post-use strategies. The work will involve MRT fuel cell & battery LAB together with Circ-eV and Pro-e storage



	interdepartmental LABs: https://www.mrtfuelcell.polimi.it/
Methods and techniques that will be developed and used to carry out the research	The project will include: •electrochemical investigation of degradation mechanisms involved in the automotive LiB operation, analysing real-world aged batter modules (exploiting field-data with data-driven logics) and adopting accelerated stress tests and ex-situ validation; •development of innovative diagnostic protocols, combining experimental techniques such as electrochemical impedance spectroscopy (EIS) with physical model-based interpretation, both at module and constituting single-cells level, aiming to its industrial implementation; •identification of innovative strategies for an augmented-monitoring of second-life modules and cells, e.g. by means of thermal and electrochemical sensors; •development of a state-of-health-dependent second-life strategy identification, including hybrid configurations, and demonstration on remanufactured modules.
Educational objectives	The student will: •deepen his/her theoretical knowledge in thermodynamics, transport phenomena and electrochemistry; •develop advanced expertise regarding electrochemical measurement techniques, together with physical, data-driven and AI-based modelling; •grow technical skills on electrified automotive systems and battery modules. Coordination of graduating students theses is also expected.
Job opportunities	Placement in enterprises operating in advanced material, electrochemistry, automotive and energy sectors. The acquired experience permits to continue the research



	career in academia and in research centers.
Composition of the research group	1 Full Professors 2 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Prof. Claudio Rabissi

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

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
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
Increase in the scholarship for stays abroad: euro 750 per month, for up to 6 months. Educational activities: Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. This amount is equal to 10% of the annual gross amount, for 3 years. Teaching assistantship: Availability of funding in recognition of supporting teaching activities by the PhD student. 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. <i>Computer availability:</i> individual use. <i>Desk availability:</i> individual use.



Awards: Awards will be recognized to the PhD candidate up to Euro 1000 (gross amount) per year, in case of exceptional achievements in the research project, subject to the evaluation of the research director.