



# PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 40th cycle

**THEMATIC Research Field: UNDERSTANDING OF LITHIUM-ION BATTERY DEGRADATION FOR DEVELOPMENT OF AGING-AWARE POST-USE STRATEGIES**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1500.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>Lithium-ion battery (LiB) demand is heavily increasing, pushed by both the paradigm-shift of the transportation sector towards electrification and, secondarily, to stationary energy storage and powering portable electronics. As a consequence, spent (automotive) batteries, commonly retaining a considerable residual value exploitable in less-demanding applications or by recycling components and materials, are expected in next years to sky-rocket in returning volumes from the market. Heavy improvements in the sustainability of post-use management of the technology are desperately required. Nowadays, post-use management of LiB is dominated by non-conservative materials recycling or direct disposal, regardless of the specific battery history and conditions. Despite the full commercial development of the technology, research efforts are still needed to consolidate the understanding of LIB aging which is results from the complex superimposition of several electrochemical and transport fading mechanisms. Despite its complexity, it is typically investigated on single cells, focusing on single fading mechanisms and in conditions quite distant from the highly dynamical real-world operation. Also, due to uneven operating conditions as well as complex internal geometry together with non-ideal manufacturing effects, degradation within single cells is known to grow with a non-negligible heterogeneous</p>



	<p>variability. A reliable methodology, coupling specific experimental tests with dedicated physical models, is required to be developed and then applied on the understanding of real-world degradation. Hence, the effect of aging on post-use strategies (such as battery recycling or reutilization in a second-life perspective) could be understood and discretized. An aging-aware post-use strategy can be then developed, which should base the identification of the most proper post-use strategy on the maximization of the projected recoverable quality from each spent battery, based the estimation on the expected dominating aging mechanisms and the involved cell components. The work will involve MRT fuel cell &amp; battery LAB <a href="https://www.mrtfuelcell.polimi.it/">https://www.mrtfuelcell.polimi.it/</a></p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>The project will include:</p> <ol style="list-style-type: none"> <li>1) development of a comprehensive investigation methodology for lithium-ion battery at cell and sub-cell level, including: <ul style="list-style-type: none"> <li>•electrochemical characterization of both single cells and materials harvested from such cells, to characterize the performance through the quantification of key physical parameters and distinguishing the contribution of specific operating mechanisms and different cell components;</li> <li>•ex-situ morpho-chemical characterization of materials;</li> <li>•physical-model simulation of cell operation, including specific key operating mechanisms and their limitations;</li> </ul> </li> <li>2) harvesting (from field operation, in cooperation with suitable partners) and/or creation (by means of specific laboratory aging tests) of a significative population of single cells samples, comprising batteries in miscellaneous aging states, ranging from pristine to end-of-life;</li> <li>3) application of the investigation methodology to the samples population, specifically focusing on: <ul style="list-style-type: none"> <li>•relating operating conditions with the development actual aging mechanisms and their heterogeneity;</li> <li>•relating the actual aging mechanisms and their heterogeneity with localised degradation of cell components and properties of constituting materials;</li> </ul> </li> <li>4) manufacture (in cooperation with suitable partners) and</li> </ol>



	<p>characterize both performance and stability of recycled cells employing recovered components/and or materials from aged cells, to validate actual recyclability of materials depending on state of health of original cells;</p> <p>5) development and application of innovative strategies for an augmented-monitoring of recycled cells, by means of thermal and electrochemical internal sensors, to improve both safety and durability.</p>
<b>Educational objectives</b>	<p>The student will 1) deepen his/her theoretical knowledge in thermodynamics, transport phenomena and electrochemistry; 2) develop advanced expertise regarding electrochemical measurement techniques, together with physical-based modelling; 3) grow technical skills on cells manufacturing and testing; 4) coordinate graduating students theses.</p>
<b>Job opportunities</b>	<p>The acquired experience enables covering senior R&amp;D positions within industry, research centres or academia operating in the field of electrochemical energy technologies, with a specific focus on battery-based application including automotive and stationary storage.</p>
<b>Composition of the research group</b>	<p>1 Full Professors 2 Associated Professors 1 Assistant Professors 7 PhD Students</p>
<b>Name of the research directors</b>	<p>Claudio Rabissi</p>

<b>Contacts</b>	
<p>claudio.rabissi@polimi.it +390223993897 www.mrtfuelcell.polimi.it</p>	

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

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	750.0 €
<b>By number of months</b>	6



**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**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.

**Computer availability:** individual use.

**Desk availability:** individual use.

**Awards:** Awards will be recognized to the PhD candidate up to € 2000 (gross amount) per year, in case of exceptional achievements in the research project, subject to the evaluation of the research director.