



PhD in INGEGNERIA ELETTRICA / ELECTRICAL ENGINEERING - 38th cycle

**PARTENARIATO PNRR Research Field: DESIGN OF MODEL-BASED AND DATA-DRIVEN
METHODS FOR STATE OF CHARGE (SOC) AND STATE OF HEALTH (SOH) ESTIMATION IN
BATTERY MANAGEMENT SYSTEMS (BMS) AND THEIR INTEGRATION IN SMART GRIDS
ENERGY MANAGEMENT SYSTEMS (EMS)**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

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**

CUP D43C22001410007

Decreto di concessione D.D. 1055 del 23/06/2022

D.D. 3277 del 30/12/2021 Avviso pubblico per la presentazione di Proposte di intervento per la creazione di 12 Ecosistemi dell'innovazione sul territorio nazionale da finanziare nell'ambito del Piano Nazionale di Ripresa e Resilienza, Missione 4 Componente 2 Investimento 1.5 - Creazione e rafforzamento di 'ecosistemi dell'innovazione', costruzione di 'leader territoriali di R&S' - finanziato dall'Unione europea - NextGenerationEU.

The green energy transition is one of the most relevant challenges that the society should face in the next years. The transition to a carbon-neutral society involves important technological challenges and implicates a clear change of paradigm in the power generation and management. Furthermore, the PNRR requirements for new installation of Renewable Energy Sources (RES) set an important increase the installed capacity of RES within the European Countries. In this context, the integration of storage systems in the grid is fundamental to decouple the production and the load profiles. Moreover, a growing number of electric vehicles will be connected to the electricity grid of the future, leading to a drastic increase in electrical load and grid congestion, especially in urban areas. In this context, stationary storages, as well as



	<p>areas. In this context, stationary storages, as well as Vehicle-to-Grid (V2G) technologies, will allow to mitigate the negative effects of the forementioned loads.</p> <p>The main purpose of this research is to design and to test an innovative Battery Management System (BMS) for Battery Energy Storage Systems (BESS) included into smart grids integrating many distributed renewable generators and smart charging points for electric vehicles. Innovative algorithms for the precise estimation of the State of Charge (SOC) and the State of Health (SOH) of the BESS will be formulated. Besides traditional model-based methodologies, data-driven approaches based on neural networks and artificial intelligence will be designed. Smart BESS management methods will also be designed to minimize the battery ageing and improve their service life. The designed solutions in terms of power converters, monitoring methodologies and control algorithms should be suitable to different battery technologies, also achieving high efficiency and allowing the scalability by means of modular solutions. The designed algorithms should also be organized in functional layers and implemented on edge computing devices characterized by a small computational power, such as microcontrollers or FPGA.</p> <p>This PhD position falls within the Spoke 3 (Deep Tech: Entrepreneurship & Technology Transfer) of the project MUSA (Multilayered Urban Sustainable Action), whose challenging goal is to address several key issues identified by the Lombardy Region S3 strategy 2021-2027. MUSA acts in synergy with PNRR M4C2.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>Methods and techniques of this research are based on Mathematics, Physics, fundamentals of Electrochemistry, Circuit Theory, Control Theory and Optimization Theory in a Multiphysics framework. Advanced Computational Intelligence methods, such as Machine Learning, Evolutionary Optimization, Deep Learning, and Fuzzy Logic, can be successfully implemented to achieve the desired goals. Modeling and simulation techniques based on mixed and hybrid approaches, reduced-order techniques, and model parameters extraction from measurements complete the analytical frameworks. The</p>



	models and algorithms will leverage on and, eventually, extend the existing body of knowledge on the prediction of batteries SOC and SOH. Numerical simulations and experimental activities on small scale prototypes will be used to carry out the research. The project is at the intersection of different fields of investigation: electrical engineering, energy engineering, and computer science.
Educational objectives	The main educational objective of this research project is to form a highly qualified engineer in a highly qualified and strong motivated research group, gaining experience, knowledge and skills in cutting-edge technologies of the renewable energy generation, energy conservation, and power electronics, developing and testing innovative hardware and tools for energy management systems with possible involvement in international and EU projects, as well as in the cooperation with leading industries and R&D institutions. The candidate will learn how to communicate the results of the Ph.D. research presenting results and analysis in a scientific and industrial context.
Job opportunities	This research activity will qualify the candidate for highly skilled professional career in innovative companies operating in the fields of renewable energy, energy conservation and environmental sustainability, as well as for the creation of new start-ups or spin-offs. This research activity will also qualify the candidate for future academic and research positions.
Composition of the research group	2 Full Professors 3 Associated Professors 3 Assistant Professors 6 PhD Students
Name of the research directors	Alberto Dolara

Contacts
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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)	--
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Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	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.

Accommodation in Politecnico's Residences (<http://www.residenze.polimi.it>) is available for PhD candidates; special rates will be applied to selected out-of-town candidates (detailed info in the call for application).

Research period abroad: Our candidates are strongly encouraged (6 months minimum is mandatory) to spend a research period abroad, joining high-level, research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months.