ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

MUR DM 117/Comau - Innovative formation system for lithium-ion cells

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Context of the research activity	The process of cell formation (activation) is a very long process, requiring several days or even weeks and a large amount of energy. The PhD activities will focus on the development of an innovative system for charging the cells, able to reduce and optimize the conversion steps required by the process. This will allow to utilize in a more efficient way the energy needed for cell charge/discharge, halving the energy currently consumed and at the same time reducing the plant footprint. Progetto finanziato nell'ambito del PNRR - MUR DM 117/2023 - CUP E14D23002000004
	The realization of giga-factories aimed at the production of electrochemical storage systems such as lithium-ion batteries (LiBs) is one of the major objectives of the new European green energy transition. The demand of batteries has been exponentially increasing in the last years, mainly driven by the increased market for electrified mobility: such a request moved from about 2GWh in 2000 to 160 GWh in 2018 and is expected to reach nearly 1000 GWh by 2025 and exceed 2600 GWh by 2030. The production of LiBs is dominated by the Far-East, where the technology has been developed for more than 20 years. However, the necessity for Europe to reach climate neutrality by 2050 leads to a continuous increase in demand, so that several battery producers (both well-established Asiatic players and European newcomers) are installing new facilities in our continent. It is expected that by 2040 the European production will reach up to 1 TWh/year of battery systems. In this context, there is an urgent need of development and production of innovative equipment for cell manufacturing, able to fasten the processes and reduce the relative energy consumption. The cell manufacturing consists of three main steps: (i) electrode preparation, leading

Objectives	to the production of electrode coils, being active materials deposited on thin foils (few microns) of copper or aluminum current collectors; (ii) cell assembly, consisting in the mechanical assembly of the cells, starting from the electrode coils and other materials, to the final format; (iii) cell formation, where, through a series of electrical processes with moments of rest, the cell is activated before being ready for the end-user. Cell formation is a very long process, requiring several days or even weeks. During this process, the individual cells undergo a series of charge and discharge cycles, at different currents (from few Amps up to some hundreds of Amps) and in different temperature conditions (typically between 20 and 60°C). The electrochemical steps are alternated by moments of rest (aging), which can last from a few hours to some days each and that can be performed either at room temperature or at higher temperature (40-60°C). Considering that a plant of 1 GWh/year capacity produces several thousands of industrial format cells per day, it is understandable that the formation process consumes a large amount of energy, being also dramatically time and floor-consuming. It is therefore essential to develop innovative formation systems, able to use in a more efficient way the energy needed for the process and at the same time reducing the plant footprint. This is the objective of the present PhD project. The activities will focus on the development of proper power electronics and management systems able to optimize the conversion steps. The aim is to reduce the external energy consumption, recirculating within the process the energy coming from cell discharging and limiting as much as possible the energy losses. Currently the equipment is based on at least three different conversion steps (AD/DC - DC/DC - DC/DC), leading to a typical efficiency around 75%. A giga-factory has megawatts of installed power, thus the efficiency chain has a crucial role. The work could be enriched by the development of new thermal management systems, allowing to properly reuse the heat generated by power electronics and cell cycling to condition other portions of the plant, such as, for example, the high temperature aging warehouses. Indeed, also the HVAC system has a big impact in terms of energy consumption and space occupation in state-of-the-art formation plants. To reach those targets, the current power electronics, as well as the formation protocols and management systems, will have to be reconsidered and new configurations will have to be proposed. At the same time, the new solutions will need to be compliant with the logistics of the other portions of the plant, in order not to require big efforts for their implementation in the factory and thus make them easily acceptable by the cell manufacturers. The work will be performed in collaboration with the company Comau, which is developing and realizing both state-of-the-art and innovative formation systems and will support in the feasibility study and testing of the proposed solutions. Part of the activity will also be realized abroad, on the site of one of Comau's industrial partners active in cell manufacturing at multimegawatt scale, with the aim of carrying out further tests in relevant environments and comparing the innovative solutions with the current ones. The result of the research work will be the design of an innovative system providing competitive advantages to the cell manufacturing companies and moving a step forward towards climate neutrality.

Skills and competencies for the development of the activity	The ideal candidate should have a power electronic profile as well as an electric background with strong team working capabilities. The activities will require simulation capabilities skills at the instantaneous level well as at the development of the activity functional level. English is mandatory and laboratory experience is welcome.