This doctoral thesis delves into the topic of electric vehicles (EVs) and lithium-ion batteries (LiBs) with the aim of making a contribution to developing efficient solutions for vehicle energy storage systems supervision, efficiency, and longevity from a Battery Management Systems (BMS) standpoint through Artificial Intelligence (AI) solutions. The current automotive sector is experiencing a growing demand for precise estimation and decision-making methodologies, and AI is looking to pave the way for future scenarios in the automotive industry. The research is motivated by the imperative for sustainable transportation solutions, addressing environmental concerns about the challenges and prospects of EVs, and emphasizing their pivotal role in reducing emissions and dependence on fossil fuels. This doctoral dissertation provides several contributions to fulfilling this research topic.

At the outset, a virtual simulation environment has been deployed to simulate the behavior of electric vehicles, with an initial focus on an electric two-wheeled performance evaluation with reference to experimental data. The overall model is obtained by coupling an electro-thermal battery model with a SoC estimator and a dynamic vehicle model, and it can calculate the instantaneous vehicle velocity knowing the battery current request. The model parameters were tuned with on-road experimental measurements. This simulation environment enables a comprehensive assessment of the overall vehicle efficiency, thereby aiding in the design and tuning of management strategies. Subsequently, a state-of-health (SoH) estimator is developed from the charging data of the battery, by using multiple bi-directional long-short-term-memory neural networks (Bi-LSTM), with a specific focus on a solution for computational time and memory occupancy reduction, so as to ensure a light embedding into the vehicle BMS. In further work, the concept of hybrid energy storage systems (HESS) in EVs has been explored in depth, finding in the use of supercapacitors a promising aid for the lithium-ion battery in achieving higher efficiency and battery longevity. Hence, a rule-based (RB) and a reinforcement learning (RL) agent have been compared for the on-board power-split strategy, in terms of vehicle autonomy increase and battery degradation reduction. Finally, an AI-based algorithm for internet communication latency canceling has been investigated in order to obtain a zero-latency connection between the EVs and a cloud BMS. The software principle of working consists of providing a forecast of the signal within few milliseconds so as to compensate for the further latency introduced by the communication loop. This solution could allow for the possibility of delivering some specific features to the cloud BMS that require real-time functioning.

In essence, this dissertation deals with innovative AI solutions to make a contribution to EVs efficiency, reliability, and lithium-ion battery management, and sustainability from the perspective of a cleaner and greener future in the automotive industry.