Politecnico di Torino

ENERGETICS

DENERG - Eco-design toolchain for next generation electric vehicles and power electronic solutions for tomorrow's mobility

Funded By	Dipartimento DENERG

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Contact	

Context of the research activity	The automotive industry is moving from 400 V to post-800 V EV systems to enable faster charging and lower thermal stress. This shift requires advanced power electronics, integrated e-axle solutions, and high-power charging for next-generation batteries. The research focuses on developing automotive-specific life-cycle assessment methods to evaluate environmental trade-offs of post-800 V powertrains and to support eco-design and circular strategies, addressing current gaps in environmental impact studies of power electronics.

	The research aims to implement a comprehensive life-cycle-based environmental and economic sustainability assessment to demonstrate the full potential of post-800 V electric powertrain technologies. By performing life-cycle sustainability assessments in the early stages of product development, the project will steer design decisions toward advanced eco-design strategies ([1]), supporting environmentally and economically sound innovation in next-generation electric vehicles. The sustainability assessment will pursue three main objectives: (i) Environmental impact evaluation of the integrated systems and components—including the triple-use inverter, electric motor, transmission, DC/DC converters, and battery pack. Particular attention will be given to the use of critical raw materials such as Dysprosium and Terbium in NdFeB permanent magnets, and precious metals contained in printed circuit boards ([2]). The recyclability rate of innovative components will also be quantified. Within a digital-twin-based virtual development framework, this analysis will contribute to the definition of eco-design strategies accounting for both environmental and economic benefits. (ii) Comparative environmental performance of innovative post-800 V powertrains against current state-of-the-art architectures. This comparison will quantify potential reductions in environmental impact resulting from lower ohmic losses and cooling demands, while also evaluating trade-offs associated with the new system requirements and material use. (iii) Life-cycle cost (LCC) assessment of the powertrain systems, expressed in €/kW, to complement environmental results with economic insights.

Objectives	To achieve these objectives, the research will apply best practices in terms of life cycle assessment (LCA) and life cycle costing (LCC). While a framework for LCA application to automotive sector is under development ([3]), this is not the case for LCC ([4]). This research will also contribute to bridging this methodological gap. Since LCA is comprehensive in scope, it is reasonable to include the economic impact in a life cycle perspective, even though the ISO standards are limited to the “environmental aspects and impacts of a product system” The same assumptions made for the LCA will be used for the LCC, to ensure harmonization. To integrate LCC, cost flows will be added to the LCA model. Finally, since the LCA methodology is made for serially produced items and steady-state situations, the research must consider that the innovative components and systems will be delivered in the form of prototypes. Primary data will be available thanks to the involvement of the supervisor and of his research team in a number of EU research project on these topics, like Gen1200 ([5]) and HiPower 5.0 ([6]). Any data gaps will be filled in with secondary data from existing databases (e.g., Ecoinvent, GaBi, EF3.0, GREET, BatPac, EverBatt) and literature [1],[4],[7]. The uncertainties behind the assumptions will be accounted for through scenario analysis. [1] Giolito et al, Evaluation of the Environmental Benefit of an Eco-design Strategy on the LCA of a PM Magnet Synchronous High-speed Electric Motor, Transp. Res. Proc., 2023 [2] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661 [3] https://lca4transport.eu [4] Di Vittorio et al, LCA and LCC of a Li-ion Battery Pack for Automotive Application, SAE Technical Paper, 2023 [5] https://gen1200.eu [6] https://cordis.europa.eu/project/id/101194250 [7] Accardo et al, LCA of Recycled (NdDy) FeB Permanent Magnets through Hydrogen Decrepitation, Energies, 2024

Skills and competencies for the development of the activity	Technical competences about: Powertrain operation and modeling, pollutant and GHG emissions from vehicles, legislative framework for road transport and energy sector. Good knowledge of programming and simulation tools (Matlab, Simulink) and commercial codes for LCA (such as SimaPro). Capability to work in a multidisciplinary research team Good knowledge of English