Abstract

The global push towards cleaner energy is gaining momentum, driven by stricter climate policies, technological progress, and economic incentives to cut greenhouse gas emissions and achieve Net Zero Emission (NZE) targets. Among regions, the European Union stands out for its active promotion of the NZE agenda, spurred by environmental concerns and the aim to reduce reliance on fossil fuels from external sources. This transition calls for substantial shifts in both energy production and consumption, with renewable and clean energy sources taking the lead. Electric vehicles play a crucial role in emission reduction, experiencing a surge in global sales, particularly in China, the EU, and the US, despite facing infrastructure hurdles. In the realm of electric machines, there is a growing demand for higher torque and power density, particularly in traction applications. Developing cost-effective, lightweight, and compact designs necessitates a multi-physics approach. While various design methodologies exist, such as analytical models and Finite Element Analysis (FEA) combined with algorithmic optimization, they often entail high computational costs and offer limited insight to designers. One notable contribution addresses this challenge by proposing a hybrid approach, integrating FEA with equations to strike a balance between computational efficiency and design accuracy. This method, grounded in the design plane and considering magnetic, mechanical, and inverter specifications, offers promising results. Another proposed approach revolves around design via scaling laws. These laws enable the evaluation of new machines with varying dimensions and ratings with minimal computational burden. By refining these laws, especially for traction motors, and considering specific dimensional and power converter constraints, designers can achieve accurate and optimized solutions. Addressing structural and thermal aspects of scaled designs further enhances the reliability of the design process. The majority of findings from years of research have been experimentally validated, and all procedures are documented in the open-source software SyR-e, to which the author has contributed as one of the developers.