A diagram of a car

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**Publication title:**

A probabilistic approach for electric vehicle battery risk estimation based on a safe operating area

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**Links:** -

**Abstract:**

Safety concerns, particularly regarding Li-ion battery issues such as thermal runaway (TR), present significant challenges in developing safer electric vehicles (EVs). To address the complexities of predicting TR, this study introduces a probabilistic approach to assessing the risk of thermal and electrical abuse in EV batteries. Based on the concept of a safe operating area, a safety window probability (SWP) was introduced to quantify the likelihood of the battery operating outside safe temperature and voltage ranges. To achieve this, uncertainty quantification was applied to a mathematical model of an EV's battery thermal management system (BTMS), which includes powertrain, electrical, and thermal components. The model demonstrated close agreement with high-fidelity simulations for thermal and electrical performance. An autoregressive strategy and Latin hypercube sampling were then employed to transform the deterministic BTMS model into a stochastic model, enabling an uncertainty assessment of the battery performance variables. The output data generated by this stochastic model were used to estimate an empirical joint probability density function for temperature and voltage, which ultimately allowed the calculation of the SWP. Results revealed significant differences in cell temperature variance between passive and active cooling conditions, with passive cooling showing a widening variance over time, signaling potential thermal safety risks. This proposed approach offers valuable insights for enhancing BTMS efficiency, contributing to the overall improvement of EV safety.