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Modeling Battery Degradation for Electric Buses: Assessment of Lifespan Reduction from In-Depot Charging

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Abstract : A methodology to estimate the state-of-charge (SOC) of battery electric buses, including degradation effects, for a given driving cycle is presented to support long-term techno-economic analysis integrating electric buses and charging infrastructure. The degradation mechanisms, characterized by both capacity and power fade with time, have been modeled using an electrochemical model for Li-ion batteries. Iterative changes in the negative electrode film resistance and decrease in available lithium as a function of utilization is simulated for every cycle. The cycles are formulated to follow typical transit bus driving patterns. The power and capacity decay resulting from the degradation model are introduced as inputs to a longitudinal chassis dynamic analysis that calculates the power consumption of the bus for a given driving cycle to find the state-of-charge of the battery as a function of time. The method is applied to an in-depot charging scenario, for which the bus is charged exclusively at the depot, overnight and to its full capacity. This scenario is run both with and without including degradation effects over time to illustrate the significant impact of degradation mechanisms on bus performance when doing feasibility studies for a fleet of electric buses. The impact of battery degradation on battery lifetime is also assessed. The modeling tool can be further used to optimize component sizing and charging locations for electric bus deployment projects.

Keywords : battery electric bus, E-bus, in-depot charging, lithium-ion battery, battery degradation, capacity fade, power fade, electric vehicle, SEI, electrochemical models
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