Goods Distribution with Electric Vehicles: Integrating Battery Behaviour into Routing

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Abstract

We introduce a new electric vehicle routing problem in which a fleet of battery electric vehicles (BEVs) must deliver goods to a set of customers over the course of a week. Freight BEVs are typically charged at a central depot and rarely use public charging stations during delivery routes. Thus, the charging schedule of the vehicles at the depot over the planning horizon must be determined such as to allow them to complete their routes, and charging can be done during the working day or at night. There are different types of charging stations at the depot, and a limited amount of stations for each of these types. The battery is modeled as an equivalent electrical circuit in order to avoid overcharging degradation. As a result, charging functions are not linear throughout the charging process. Time dependant grid capacity constraints and charging costs are considered, and an energy consumption model based on vehicle mass, speed, and road grade is used. The objective is to minimize the sum of all energy and routing costs over the planning horizon. The problem is solved with an Adaptive Large Neighborhood Search (ALNS) algorithm. The charging schedule in the final solution is updated in order to reduce battery degradation resulting from storing batteries at a high state of charge. The schedule should therefore be updated such as to charge the vehicles as closely as possible to their departure time without increasing total costs.

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