Title
Benefits of Battery Electric Heavy-Duty Trucks Increase Rapidly over Time

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RESEARCH BRIEF

National Center for Sustainable Transportation

Benefits of Battery Electric Heavy-Duty Trucks Increase Rapidly over Time

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Research Question

In the United States, the transportation sector is the largest single source of greenhouse gas (GHG) and nitrogen oxide (NOx) emissions, and heavy-duty trucks contribute a disproportionately large share. Therefore, the trucking industry has been seeking ways to minimize emissions, such as adopting zero-emission vehicles and improving truck operating strategies to reduce truck miles. Battery-powered vehicles have different limitations than those with internal combustion engines. Our results show that, as the fleet adjusts, some of these limitations decrease over time, and that benefits rapidly increase.

In this study, researchers from the University of Southern California investigated the adoption of battery electric heavy-duty trucks (BEHDTs) in the short-haul freight movement sector and the drayage industry. Drayage is a short-haul pickup and delivery service for transporting freight among ports, warehouses, and other facilities. With drayage routing, vehicles have limited weight and volume capacities and often make many stops. Routing involves optimizing for multiple factors, like fuel, distance traveled, and timeliness.

Battery charging must be considered when routing BEHDTs. BEHDTs have a lower range per charge than diesel heavy-duty trucks (DHDTs) have per fill-up. Current technology allows for driving ranges between 60 and 100 miles between charging. The battery consumption rate for a BEHDT depends on the loading state of the truck because batteries drain faster when carrying fully loaded containers.

Most recent studies of BEHDTs have simple routing options and limited charging locations. For example, they require trips to start and end at the port with, at most, two stops outside the port and battery charging at the port, only.

Our work improves on existing mixed fleet drayage routing models by considering multiple charging locations and allowing more flexible routes for freight pickup and delivery. This can improve route efficiency for all trucks and reduce charging detours for BEHDTs. In this way, trucks are more efficiently scheduled, resulting in a smaller fleet size and fewer truck miles needed to meet daily demand satisfaction. Our routing schema also reduces GHG and NOx emissions.

As the world shifts to electric vehicle options wherever feasible, logistical support will need to shift as well. Our key findings and research implications are summarized below.

Key Findings

BEHDTs are preferable substitutions to DHDTs in terms of reducing GHG and NOx emissions. In 2022, up to 50.9% of CO2 emissions and 93.6% NOx emissions could have been prevented by employing BEHDTs. In 2025 and 2030, an additional 10% CO2 emissions can be reduced, and zero NOx can be achieved when only BEHDTs are used in drayage operations.

Additional truck miles caused by a shift to BEHDTs decrease over the years. As batteries improve, trucks will have a longer travel distance per charge and BEHDTs will require fewer detours for charging. This significantly reduces truck miles for daily drayage operations. In 2022, truck miles increased by 33% to reach the maximum BEHDT share in the fleet. In 2025 and 2030, the anticipated increase is only 8% and 3%, respectively.

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The fleet size required to reach maximum BEDHT share decreases sharply as battery technology improves because the length of trips between charging increases. To reach the maximum share of BEHDTs in the truck fleet while still meeting demand, the fleet size would need to increase by 47.2% in 2022, 3.4% in 2025, and 3.4% in 2030.

Research Implications

Using BEHDTs as substitutes for DHDTs in drayage operations can lead to significant reductions in GHG and NOx emissions. However, the adoption of BEHDTs will increase the size of the fleet. These conclusions suggest that, while the use of BEHDTs can lead to environmental benefits, it may come with logistical challenges. The simulation in the study assumed charging infrastructure outside the depot is sufficient to support BEHDT operations. Future research is needed to explore the most cost-effective allocation of infrastructures for freight movements with BEHDTs.

More Information

This research brief is drawn from "Routing of Battery Electric Heavy-Duty Trucks for Drayage Operations," a research report from the National Center for Sustainable Transportation, authored by Maged Dessouky and Siyuan Yao at the University of Southern California. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/routing-battery-electric-heavy-duty-trucks-drayage-operations.

For more information about the findings presented in this brief, please contact Maged Dessouky at maged@usc.edu and Siyuan Yao at siyuanya@usc.edu.

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