

# Optimization of a truck-autonomous unmanned vehicle distribution network with mobile charging and PV-storage integration

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## ABSTRACT

This study investigates the collaborative optimization of routing and charging in a distribution network comprising electric trucks (ETs) and autonomous unmanned vehicles (AUVs), supported by mobile photovoltaic (PV) storage charging. A comprehensive optimization model is developed to minimize the total daily operating cost of the logistics enterprise, encompassing vehicle acquisition, staffing, energy consumption, charging, and penalties. The model simultaneously determines coordinated ET-AUV delivery routes, mobile charging schedules, and parking node locations. The PV-storage system is incorporated as a green power-supply constraint, directly influencing charging costs. To address the model's complexity, an enhanced hybrid frog-leaping algorithm is proposed. This algorithm incorporates an initial solution construction method to improve population quality, an advanced local deep search to increase search efficiency, and diversity control strategies with clone selection programs to maintain population diversity. The effectiveness of the developed algorithm is validated through multiple case studies with varying customer sizes. Computational experiments on instances with up to 60 customers indicate that, compared with the ET-only mode, the proposed ET-AUV collaborative mode reduces total daily operating costs by 18.61 %, decreases staffing costs by 62.5 %, and lowers penalty costs by 23.21 %, thereby enhancing customer satisfaction and operational resilience. Sensitivity analysis shows that system efficiency depends on several operational parameters. Increases in ET payload and range are the main drivers of cost reduction. Additionally, the average speeds of both vehicle types have a critical U-shaped effect on total costs.

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