

Beyond Fuel Switches: Re-Engineering Last-Mile Logistics for Low-Carbon Performance

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Abstract

Last-mile logistics is the final step of the logistics chain and is an important factor in customer satisfaction. However, it is also one of the biggest sources of carbon emissions in the logistics chain. Many companies have tried to switch from conventional fuel vehicles to electric vehicles to mitigate carbon emissions. While electric vehicles can mitigate carbon emissions from fuel, they cannot address all environmental issues associated with last-mile logistics. Problems such as inefficient routes, unsuccessful deliveries, traffic congestion, and low usage of vehicles are still sources of unnecessary carbon emissions.

This research paper explores the reasons why fuel switching is not enough to achieve low-carbon last-mile logistics. The paper relies on secondary data from other research papers and reports. A qualitative analysis is performed to explore the biggest problems and research gaps in the current state of the art.

The results indicate that carbon emissions are affected not only by the type of fuel used in vehicles but also by the design of the delivery system and customer behaviour. The paper concludes that system-level transformation, such as route optimisation, delivery consolidation, and different delivery points, is required for sustainable last-mile logistics.

Keywords: Last-mile logistics, carbon emissions, electric vehicles, delivery optimization, sustainability.

I. INTRODUCTION

Logistics is an integral part of business operations in the modern world. Last-mile logistics is one of the most crucial phases of logistics, which involves the final delivery of products from the distribution centres to the customers. The rise of e-commerce has increased the need for fast and convenient delivery services. This has made last-mile logistics more complex and costly.

Last-mile logistics faces various challenges, such as high transportation costs, traffic congestion, and environmental pollution. Various companies have introduced electric vehicles to overcome carbon emissions. Electric vehicles help in reducing fuel consumption and air pollution.

But even after the introduction of electric vehicles, emissions are still high. This is because the issue is not just related to fuel consumption but also to the design of the delivery system. For instance, delivery vehicles are often driven half-empty, and failed delivery attempts require additional trips.

Thus, there is a need to study last-mile logistics from a system perspective, rather than just concentrating on electric vehicles. This research paper will investigate how redesigning the delivery system can help in improving the environment.

Problem Statement

Many logistics companies feel that using electric vehicles instead of fuel vehicles is sufficient to reduce carbon emissions. But this is not a complete solution to the problem.

Even after using electric vehicles, last-mile logistics still cause high carbon emissions due to inefficient delivery systems.

The primary problems are:

- Multiple delivery attempts in the same region
- Delivery vehicles operating with low capacity
- Failed delivery attempts requiring second attempts
- Traffic congestion increases travel time
- Poor route planning

These factors cause increased fuel or energy consumption and, consequently, higher emissions.

Thus, there is a need to find a system-level solution to the problem, rather than just concentrating on fuel consumption.

Objectives of the Study

The objectives of this study are:

- To know why fuel switching is not sufficient to decrease carbon emissions.
- To analyse the existing literature on last-mile logistics in low-carbon transportation.
- To find the gaps in the existing literature.
- To suggest system re-engineering as a more effective alternative.

Significance of the Study

The significance of this study is:

- First, it will help the logistics industry understand why electric vehicles are not sufficient to reduce emissions.
- Second, it will emphasize the significance of delivery system design.
- Third, it will help in finding ways to increase delivery efficiency.
- Fourth, it will promote sustainable logistics practices.

This study will benefit:

- Logistics industry
- Researchers
- Students
- Policymakers

Research Methodology

Research Design

This study adopts a qualitative research methodology.

Data Source

The secondary data for this study is gathered from:

- Research articles
- Books
- Reports
- Web articles

Data Analysis

A qualitative data analysis technique was employed to:

- Find common issues
- Find patterns
- Find gaps in the literature

Ethical Considerations

This study adheres to all ethical standards of research.

- All sources are properly cited.
- No data is manipulated.
- No plagiarism is involved

Literature Review

There are several studies on last-mile logistics and carbon emissions.

McKinnon (2018) concluded that increasing delivery efficiency is a more effective method of lowering carbon emissions than fuel type alone. Route optimization and consolidation were also seen as key considerations.

Buldeo Rai et al. (2019) examined the impact of parcel lockers and pick-up points. The results indicated that alternative delivery points decrease failed deliveries and distance travelled.

Pourmohammadreza et al. (2025) conducted a literature review of several studies and concluded that current research on last-mile logistics is scattered. Most studies concentrate on individual solutions like electric vehicles or route optimization, but very few examine the overall delivery system.

These studies indicate that overall improvement is required.

Research Gap

Most studies concentrate on individual solutions such as:

- Electric vehicles
- Route optimization
- Delivery lockers

Very few studies examine the overall last-mile delivery system.

Key considerations such as:

- Customer behaviour
- Delivery patterns
- System integration

are frequently overlooked.

Analysis and Findings

Analysis of existing research reveals the following key findings.

Fuel Switching alone is not enough

Electric vehicles cut fuel emissions but do not remove operational inefficiencies.

Failed Deliveries Increase Emissions

Since customers are not present, delivery trucks have to return as well.

This leads to an increase in travel distance.

Poor Consolidation Increases Emissions

Since trucks carry fewer packages, energy consumption per package rises.

Customer Behaviour Matters

Customer behaviour, such as home delivery, increases emissions.

System Design is Important

Delivery system design impacts emissions.

Improved design leads to a decrease in travel distance.

Discussion

- The results indicate that a system-level approach is needed for low-carbon logistics.
- Rather than emphasizing electric vehicles alone, firms need to redesign delivery systems.

Key solutions include:

Route Optimization

Improved route planning leads to a decrease in travel distance.

Delivery Consolidation

Multiple deliveries in one go lead to fewer trips.

Alternative Delivery Locations

Parcel lockers reduce failed deliveries.

Smart Scheduling

Deliveries should be made when customers are available.

Customer Awareness

Customers should be encouraged to opt for environmentally friendly delivery options.

Case Insight

Companies like Amazon have made significant investments in electric vehicles.

However, challenges persist:

- Door-to-door delivery increases trips
- Failed deliveries occur
- Trucks are not fully loaded

This indicates that without system redesign, emission reduction is limited.

II. CONCLUSION

This research examines the role of fuel switching in reducing carbon emissions in last-mile logistics. The findings reveal that achieving low-carbon logistics cannot rely solely on the adoption of electric vehicles. Instead, carbon emissions are largely influenced by inefficient delivery system design. The study highlights that meaningful emission reduction requires structural improvements such as delivery network redesign, route optimization, shipment consolidation, and the use of alternative delivery points. Therefore, sustainability in last-mile logistics should be approached as a system design challenge rather than merely a fuel transition strategy.

III. REFERENCES

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