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Research Paper

Smart green logistics solutions: the potential role of artificial intelligence in optimising the use of electric and gas-powered truck fleets

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Abstract: Artificial intelligence and digital technologies are reshaping sustainable freight transport. As road freight transport remains a major source of global carbon dioxide emissions, the transition to green logistics is essential. This paper examines how artificial intelligence and Internet of Things technologies can improve the operational efficiency of electric and gas-powered truck fleets through energy optimisation, emission reduction and data-driven decision support. The study applies an integrative qualitative multi-source research design combining a structured literature review, policy document analysis and documentary corporate case analysis. The analysis further examines how European Union policy initiatives, including the European Green Deal, the Fit for 55 package and the Sustainable and Smart Mobility Strategy, shape innovation in the logistics sector. The findings suggest that AI-supported logistics optimisation can improve fleet utilisation, reduce empty runs and support the operational integration of low-emission trucks. At the same time, organisational, technological and infrastructural barriers continue to constrain large-scale implementation. The study contributes an integrated analytical framework linking technological innovation, logistics operations and European transport policy within the concept of smart green logistics.

Keywords: Artificial intelligence, green logistics, digitalisation, sustainable transport, European Green Deal

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1. Introduction

Road freight transport plays a fundamental role in global and European supply chains, but it still remains one of the most carbon-intensive segments of the transport sector. Although heavy-duty vehicles represent a relatively small part of the total vehicle stock, their greenhouse gas emission contribution is significant. International energy and transport analyses regularly show that road freight transport is responsible for a large share of transport-related carbon dioxide emissions, which is why reducing carbon emissions in this area plays a key role in achieving international and European climate policy goals (International Energy Agency [IEA], 2017b; IEA, 2024). In response to these challenges, green logistics has become a key strategic concept aimed at reducing the environmental footprint of freight transport while maintaining economic efficiency and service reliability (Gillström et al., 2024). In line with this, the electrification of truck fleets and the introduction of alternative fuel vehicles – such as gas-powered trucks – are receiving increasing attention in political and corporate circles, while IEA projections underline the growing role of low-emission energy carriers in road transport decarbonisation (IEA, 2023).

Electric and alternative fuel trucks offer significant potential for reducing direct emissions, particularly in regional distribution, urban logistics and last-mile delivery (IEA, 2024). However, existing research highlights that vehicle technology alone is insufficient to achieve significant emission reductions. Operational constraints, like range limitations, charging and refuelling infrastructure availability, and total cost of ownership considerations, continue to hinder widespread adoption and limit performance (Stütz et al., 2022).

At the same time, the logistics sector is also undergoing rapid digital transformation. Artificial intelligence (AI), Internet of Things (IoT) technologies and advanced data analytics are increasingly playing a role in logistics planning processes, fleet management and decision-support systems (Chung, 2021; Tran-Dang et al., 2020; AlHousrya et al., 2025). AI-based applications enable dynamic and more efficient route planning, predictive maintenance, real-time transport monitoring and energy optimisation for logistics networks (Chung, 2021; Kaushik, 2025). Empirical studies show that such digital solutions can improve operational efficiency, reduce downtime and enhance asset utilisation in freight transport (Ferreira & Esperança, 2025). Despite these advances, their specific role in supporting the effective operation of low-emission fleets has received relatively limited academic attention. Most of the existing studies address green logistics and digitalisation as mainly separate research streams. On the one hand, the literature on sustainable freight transport usually focuses on the electrification of the fleets, alternative fuels and regulatory interventions (International Transport Forum [ITF], 2021), while on the other hand, research on AI in logistics primarily focuses on efficiency gains, cost reduction or service optimisation, but in most cases without adequately considering environmental outcomes or alternative fuel vehicle constraints (Suganya et al., 2025; Mecatti, 2025). As a result, the benefits of using AI-supported green logistics fleets remain an open area of research, particularly in the European Union, where significant commitments have been made to mitigate the effects of climate change.

This study aims to fill this research gap by examining the potential role of artificial intelligence in optimising the use of electric and gas-powered truck fleets within a smart green logistics framework. Based on a review of international and European literature, policy documents and documentary company sources, the study adopts an integrative qualitative multi-source research design to examine how AI-based logistics solutions may support energy efficiency and emission reduction in freight transport operations. In addition, the paper reviews how key European Union policy initiatives – including the European Green Deal, the "Fit for 55" package and the Sustainable and Smart Mobility Strategy – are shaping the direction of innovation in the logistics sector (European Commission, 2019, 2020, 2023). Although the literature on green logistics, fleet electrification and AI-enabled logistics has expanded in recent years, these streams still remain only partially connected. Recent review studies similarly indicate that research on green vehicle routing, fleet electrification and digital logistics remains fragmented, with limited attention to the combined role of AI-supported optimisation, low-emission vehicle constraints and policy-related implementation conditions (Alzate et al., 2024; Garside et al., 2024; Altaf et al., 2025).

Existing studies often analyse vehicle technologies, routing optimisation or digital tools separately, while fewer studies examine how AI can support the operational integration of electric and gas-powered truck fleets under real infrastructure and policy constraints. This gap is especially relevant in the European context, where decarbonisation ambitions and infrastructure readiness continue to evolve unevenly. Based on this, the central research question of this study is as follows: How can artificial intelligence-supported logistics optimisation improve the environmental and economic performance of electric and gas-powered truck fleets within a smart green logistics framework? To answer this question, the paper sets out three main objectives. First, to synthesise existing research on green logistics, artificial intelligence, and digitalisation. Second, to analyse corporate experiences with artificial intelligence-supported fleet planning and management. Finally, to assess the alignment between technological potential, operational practice and European policy frameworks.

2. Literature review

2.1 Green logistics and the decarbonisation of road freight

Green logistics has become an important concept in both academic research and political initiatives in response to the growing environmental impact of freight transport. The concept, which originally focused on improving the efficiency of logistics processes, has now become a comprehensive system that includes the environmental, economic, and organisational dimensions of sustainability. In the case of road freight transport, the main goal of green logistics is to reduce greenhouse gas emissions, energy consumption and local air pollutant emissions, while supporting the reliable and cost-effective operation of supply chains. In the literature, we often encounter the observation that road freight transport poses a challenge in the transition to sustainability. Heavy-duty vehicles represent a relatively small portion of the total vehicle stock, but they are still responsible for a significant part of transport-related carbon dioxide emissions and energy use (IEA, 2017b; IEA, 2024). This substantial contribution means that efficiency improvements alone will not be sufficient to meet established emissions reduction targets, but transformative changes in freight transport systems are needed.

Numerous studies emphasise that without reducing freight transport emissions, broader decarbonisation strategies for transport are unlikely to succeed (ITF, 2021). Research on green logistics highlights the need for broader system analysis. Rather than focusing on individual technologies or efficiency measures, according to the literature, meaningful emission reductions can be achieved by coordinated changes across vehicle technology, logistics planning, infrastructure and regulatory frameworks (Gillström et al., 2024). Based on this, green logistics can be viewed as a socio-technical system in which technological innovation, organisational practices, and policy interventions interact with each other and thus shape environmental outcomes. According to the available literature, reducing harmful emissions from road freight transport can be achieved by taking the following three aspects into account: making vehicles more efficient, switching to low- or zero-emission vehicles, and optimising logistics networks.

Operational measures such as better route planning, load or shipment consolidation and the reduction of empty runs have been recognised as cost-effective options to lower the emissions for a long time. However, practical results show that these initiatives alone cannot offset growing transport demand, especially in areas where supply chain pressures have increased further in recent times (ITF, 2021). As a result, the introduction of alternative fuel vehicles has become an important aspect of green logistics strategies. Electric trucks and gas-powered vehicles are widely regarded as key technological options to reduce emissions from road freight transport, especially in urban, regional and last-mile applications (IEA, 2024). At the same time, the available literature warns that the performance of these vehicles depends heavily on the circumstances. Factors such as driving cycles and style, available infrastructure, fleet utilisation and total cost of ownership significantly influence their efficiency (Stütz et al., 2022).

The latest research shows that switching to alternative fuel vehicles does not necessarily guarantee sustainable results. We can see that the benefits of low- and zero-emission trucks can be significantly reduced by inadequate transition if logistics operations are poorly planned or if vehicle utilisation is low (Gillström et al., 2024). As a result, the view is gaining ground that green logistics requires not only cleaner vehicles, but also logistics systems capable of handling the more complex operations brought about by new technologies. With this in mind, digitalisation can increasingly become an important complement to green logistics, as IEA analysis suggests that digital technologies can contribute to energy demand reduction in road freight transport when combined with vehicle efficiency improvements, fuel switching and wider systemic measures (IEA, 2017a).

International policy and research reports highlight the benefits of data-driven logistics planning and digital decision-making tools for the environmental impact of freight transport, as they enable more efficient use of vehicles and available infrastructure (IEA, 2024; ITF, 2021). However, academic literature on green logistics has paid less attention to the role of advanced digital technologies, such as artificial intelligence, in reducing harmful emissions from road freight transport. Overall, the literature on green logistics provides a strong foundation for understanding decarbonisation goals in freight transport, but it remains more developed in relation to vehicle technologies and routing efficiency than in relation to the operational integration of low-emission fleets under real-world constraints. In particular, the literature still pays limited attention to how digital and AI-supported optimisation can improve the effective deployment of electric and gas-powered trucks in practice. This difference is particularly relevant for electric and gas-powered truck fleets, whose performance is closely linked to decisions related to freight planning, route planning, and energy management. These questions are discussed in the following subsection, which focuses on the electrification of logistics systems and the introduction of alternative fuel trucks.

2.2 Electrification of logistics systems: electric and gas-powered trucks

The electrification of logistics systems represents a central technological solution for green logistics strategies. As road freight transport accounts for a significant proportion of transport-related emissions, electric and alternative fuel trucks are increasingly being promoted as a key solution for reducing the carbon footprint of freight transport activities (IEA, 2024; ITF, 2021). In recent years, both battery electric trucks and gas-powered vehicles – primarily powered by compressed or liquefied natural gas – have become increasingly widespread as a result of political incentives and technological advances. Battery electric trucks are widely recognised for their potential to achieve zero emissions and significantly lower lifecycle greenhouse gas emissions, particularly when powered by low-carbon electricity (IEA, 2024; Mohammed & Villegas, 2023).

Empirical studies indicate that electric trucks are particularly well suited for urban logistics, regional distribution and last-mile delivery, where defined routes and lower daily distances reduce the range limitations (Stütz et al., 2022). On top of this, electrification can also deliver additional benefits such as reduced noise and improved local air quality. At the same time, the literature highlights that the use of electric trucks faces several challenges. High upfront purchase costs, limited vehicle type availability in some weight classes, and insufficient charging infrastructure hinder wider adoption of the technology (IEA, 2024). This transition is also increasingly visible in practice-oriented logistics analyses of electric fleet adoption (Firth, 2025). In addition, the operational features of electric trucks are significantly different from those of conventional diesel vehicles. Charging times, range limitations and available payload and driving habits introduce new factors of complexity into fleet planning and logistics optimisation (Gillström et al., 2024). Gas-powered trucks are often discussed as a complementary or transitional solution within the broader decarbonisation of freight transport. A clearer distinction between electric and gas-powered trucks is necessary due to their differing operational and environmental characteristics. Table 1 summarises the main operational and environmental differences between battery electric and gas-powered trucks in order to clarify the distinct planning implications of these technologies and is based upon the works of ITF (2021), IEA (2024), Gillström et al. (2024), and Castillo and Álvarez (2023).

Table 1. Operational and environmental comparison of battery electric and gas-powered trucks. Source: *authors' own.*

Dimension	Battery electric trucks	Gas-powered trucks
Tailpipe emissions	Zero tailpipe emissions	Lower than diesel, but not zero
Lifecycle performance	Strongly dependent on electricity mix	Strongly dependent on fuel origin and lifecycle emissions
Range	More limited	Typically longer
Charging / refuelling	Longer charging time	Faster refuelling
Infrastructure dependence	Charging infrastructure is critical	Compressed natural gas / liquefied natural gas infrastructure is critical
Typical suitability	Urban, regional and last-mile routes	Transitional and longer-distance applications
Long-term policy fit	Better aligned with zero-emission pathways	More contested as a transition technology

Battery electric trucks offer higher energy efficiency and zero tailpipe emissions, but their deployment is constrained by charging infrastructure, range limitations, and longer refuelling times. In contrast, gas-powered trucks, including liquefied natural gas (LNG) and compressed natural gas (CNG) vehicles, provide longer range and faster refuelling, supported by more established infrastructure in certain regions. However, their environmental performance remains dependent on fuel origin and lifecycle emissions. These differences highlight the importance of technology choice when evaluating the impact of AI-supported logistics optimisation. Vehicles powered by natural gas – particularly liquefied natural gas – can offer reductions in carbon dioxide emissions and significant improvements in local air pollutants compared to the conventional diesel trucks, depending on engine technology.

From an operational perspective, gas-powered trucks typically provide longer driving ranges – close to the capacity of conventional vehicles – and faster refuelling compared to battery electric vehicles, making them more suitable for long-distance deliveries. The sustainable operation of gas-powered trucks remains a subject of debate. While some studies recognise their role as an interim or bridge technology between diesel and battery electric vehicles, others highlight that continued use of fossil-based natural gas further delays the transition to zero-emission solutions (ITF, 2021). Accordingly, gas-powered trucks are mainly seen as a transitional step rather than a long-term solution for decarbonising freight transport. Overall, this comparison highlights that the operational suitability and sustainability performance of electric and gas-powered trucks strongly depend on logistics conditions, infrastructure availability, and system-level optimisation.

Recent fleet transition studies underline that technology choice cannot be reduced to a simple electric-versus-conventional comparison, because relative performance depends on route structure, infrastructure access, total cost of ownership and the broader energy pathway

(Castillo & Álvarez, 2023; Jafari et al., 2025). For example, comparative fleet analyses show that battery electric vehicles can offer substantial emission and cost advantages in some operational scenarios, while the competitiveness of natural gas and other transitional technologies remains highly context dependent (Castillo & Álvarez, 2023; Jafari et al., 2025). In the case of electric and gas-powered truck technologies, the evidence suggests that their environmental and economic performance depends to a large extent on their operating conditions. Truck utilisation, route creation, load factors and infrastructure access are all significantly influencing the total cost of ownership and emission reduction potential (Stütz et al., 2022).

Several studies show that inadequate planning can significantly reduce the efficiency of alternative fuel vehicles, while well-designed logistics processes can improve cost efficiency and environmental performance (Gillström et al., 2024). This leads to the conclusion that electric propulsion should not be treated merely as a technological replacement, but as part of a wider transformation of logistics systems. Advanced design and management capabilities are important for the use of electric and gas-powered trucks. Recent research and policy analyses increasingly highlight the need for digital tools and data-driven decision-support systems to manage the complexity of alternative fuel truck fleets (IEA, 2024; ITF, 2021). Nevertheless, studies examining the potential of digital technologies – particularly artificial intelligence – for the effective integration of electric and gas-powered trucks, remain limited. While electrification studies often highlight the importance of planning and optimisation, they usually do not analyse how AI-driven solutions can support energy management, routing efficiency and fleet utilisation in operational usage. This highlights the importance of examining the role of AI and digitalisation in logistics.

2.3 Artificial intelligence and digitalisation in logistics

Digitalisation has become an important element in the transformation of logistics systems, driven by increasing complexity, growing sustainability demands, and the use of large amounts of real-time data (Kache & Seuring, 2017; Sun et al., 2022). Within this wider digital transformation, artificial intelligence (AI) and Internet of Things (IoT) technologies play a major role in supporting advanced decision-making in freight transport and logistics operations (Chung, 2021). These technologies support the collection, processing, and analysis of operational data, enabling logistics systems to respond more effectively to changing conditions.

AI solutions can cover a wide range of operational and strategic needs. AI applications in logistics are not uniform and can be categorised into several distinct functional areas. These include route optimisation, demand forecasting, predictive maintenance, fleet allocation, and energy or charging optimisation. This functional distinction is particularly important in the context of low-emission freight transport, because each application area addresses a different operational constraint. Route optimisation can reduce empty runs and unnecessary mileage, demand forecasting can improve fleet sizing and load planning, charging and refuelling planning can support the operational feasibility of low-range vehicles, predictive maintenance can reduce downtime in high-investment fleets, and energy management can improve the efficiency of electric vehicle operations (Ferreira & Esperança, 2025; Altaf et al., 2025; Mohsen & Mohsen, 2025). These systems are commonly used for dynamic route planning, load optimisation and real-time traffic management at an operational level, by continuously analysing data received from vehicle telematics, traffic sensors and external information sources to reduce travel times, energy consumption and empty runs (Kaushik, 2025; Mo et al., 2023; Hejazi & Soliman, 2025).

AI supports demand forecasting, fleet sizing, and network design, helping logistics providers align capacity with variable demand at a strategic level. Another important area of AI application in logistics is fleet management and maintenance. Predictive maintenance systems use AI algorithms to analyse data from IoT supported sensors embedded in vehicles, which allows early detection of component degradation and potential failures. This facilitates a shift from reactive to predictive maintenance strategies, so logistics operators can reduce unplanned downtime, improve vehicle availability and extend truck lifetimes. Since the purchase cost of new electric and alternative fuel trucks is significantly higher, their reliability and utilisation are key considerations for operators.

In terms of sustainability, AI and digital technologies are usually connected to efficiency improvements, and not to direct emission reductions. However, recent research indicates that efficiency improvements can generate significant environmental benefits in freight transport systems (Ferreira & Esperança, 2025). Recent review and case-based studies further suggest that the combination of electric vehicles and AI-supported optimisation may improve eco-efficiency not only through route optimisation but also through fleet coordination, charging-related planning and energy management in urban logistics systems (Altaf et al., 2025; Ferreira & Esperança, 2025).

Digital optimisation can reduce fuel and energy consumption. In this way, AI-supported logistics systems contribute to emission reduction indirectly, alongside improved operational performance. Despite these advantages, the integration of AI into logistics systems also has challenges. Data quality, differences between the operations of systems and standardisation remain critical constraints, especially where logistics markets are fragmented with diverse vehicle fleets and information systems (Chung, 2021).

The introduction of AI-based solutions by companies requires special organisational capabilities that go beyond technical expertise. The lack of these skills and resistance to organisational change can hinder effective implementation (Suganya et al., 2025). While AI systems are primarily designed to optimise performance indicators – such as costs or delivery times – environmental considerations are not always included among optimisation goals.

Without targeted consideration of sustainability indicators, digital optimisation can result in efficiency gains that do not take long-term decarbonisation goals into account. This highlights the need for AI models that simultaneously account for economic and environmental performance as well. In recent years, policy discussions and research have highlighted the important role of digitalisation to support the transition of sustainable transport. International institutions and European policy frameworks have found that digital tools support low-emission transport by improving system efficiency (IEA, 2024; ITF, 2021). Overall, the literature on AI and digitalisation shows significant potential for improving logistics performance, but research gaps remain on the interaction between digital optimisation and the introduction of alternative fuel vehicles. These results suggest that AI should not be viewed as a standalone technological solution, but rather as an important component of a broader smart green logistics system. This functional categorisation supports a more structured interpretation of AI applications in logistics and strengthens the analytical linkage between digital technologies and sustainability outcomes.

2.4 Smart green logistics as an integrative concept

The previous sections have highlighted three key parts of literature that are relevant to the sustainability transition of road freight transport: green logistics and freight decarbonisation, the electrification of logistics systems through electric and gas-powered trucks, and the growing role of artificial intelligence and digitalisation in logistics operations. Although each stream of research provides important insights, the latest research increasingly suggests that treating them separately makes it difficult to understand how sustainable freight transport systems can be effectively implemented in practice.

The concept of smart green logistics emerged as an integrated system that specifically combines environmental goals with advanced digital intelligence. Within this framework, sustainability-oriented logistics solutions are supported by data-driven technologies that provide more adaptive, efficient and flexible freight transport systems (Chung, 2021). Instead of focusing only on cleaner vehicles or isolated efficiency improvements, smart green logistics takes a holistic view of freight transport, where digital tools support environmentally friendly performance. Recently, artificial intelligence has been viewed as an operational support tool rather than an independent solution.

AI-based efficiency improvements are particularly important for electric and alternative fuel truck fleets, as energy management, access to the necessary infrastructure, and vehicle utilisation can pose operational constraints. Studies on the electrification of freight transport highlight that the environmental and economic performance of low-emission trucks depends heavily on route planning, operation, charging or refuelling options, and fleet distribution strategies (Stütz et al., 2022). Smart green logistics concepts increasingly emphasise that these challenges can be addressed more effectively with the help of AI-driven planning and decision support systems. By integrating real-time operational data, predictive analytics, and optimisation tools, AI-based logistics systems can dynamically adapt to routes, improve vehicle utilisation, and align delivery tasks with available infrastructure (IEA, 2024; Ivanov et al., 2019). In this approach, digital intelligence helps make environmentally friendly vehicle technologies more efficient, enabling electric and gas-powered trucks to achieve higher utilisation rates and more cost-effective operation than when using traditional design tools.

The literature emphasises that the transition to smart green logistics processes is not a uniform process. Several comments highlight the importance of organisational capabilities, data availability, data quality, and institutional frameworks to adopt and effectively use digital sustainability solutions (Suganya et al., 2025). Inadequately interconnected data analysis systems and limited interoperability between logistics tools can limit the effectiveness of AI-supported green logistics systems, particularly in areas characterised by multiple different actors.

From a political perspective, smart green logistics is closely linked to the latest European goals, which emphasise the combined importance of digitalisation and decarbonisation. European Union initiatives – for example the European Green Deal and the Sustainable and Smart Mobility Strategy – highlight that digital technologies are very important for the widespread adoption of efficient low-emission transport systems (European Commission, 2019; European Commission, 2020). Although political initiatives increasingly support this integrated concept, empirical research about the operational implementation of these solutions is still limited. This difference may be even more striking in the case of heavy-duty trucks, where electric and gas-powered trucks are gradually becoming more widespread in fleets but still face operational challenges.

Available research confirms the potential role of digital tools but does not examine in depth how AI-based optimisation supports improved environmental and economic outcomes in everyday use. As a result, the relationship between vehicle technology, digital intelligence, and policy frameworks remains an under-researched area. Against this background, this study examines how artificial intelligence can support the efficient introduction of electric and gas-powered truck fleets using a smart green logistics approach.

Drawing on the reviewed literature, available corporate documents, and policy analyses, the study attempts to show how AI-driven logistics optimisation can help achieve significant decarbonisation goals. Recent systematic and review studies also highlight the increasing importance of optimisation models, fleet electrification, and digital technologies in green logistics research (Asghari & Mirzapour Al-E-Hashem, 2021; Alzate et al., 2024; Garside et al., 2024). Furthermore, emerging literature emphasises the role of Industry 4.0 technologies and artificial intelligence in logistics decision-making, while identifying gaps in the integration of sustainability outcomes (Çimen et al., 2024; Dong et al., 2021). Despite growing academic attention to green vehicle routing, sustainable freight operations and digital logistics, the existing literature still shows a fragmentation problem (Jahagirdar et al., 2025; Alzate et al., 2024; Garside et al., 2024). Routing and optimisation studies often focus on objective functions and algorithms, electrification studies often focus on vehicle technologies and infrastructure, while AI-related logistics studies frequently prioritise efficiency and automation without analysing low-emission fleet constraints in depth. This indicates a need for a more integrative perspective that connects technological, operational and policy dimensions within a common smart green logistics framework (Alzate et al., 2024; Garside et al., 2024; Altaf et al., 2025).

Overall, three main findings can be highlighted from the literature review. The first is that research on green logistic solutions emphasises that decarbonising road freight transport requires not only the use of cleaner and more advanced vehicle technologies, but also the optimisation of operational processes and system-level coordination (McKinnon, 2018; ITF, 2021). The second finding is that studies on electric propulsion show that the efficiency of electric and alternative fuel vehicles heavily depends on transport route planning, adequate utilisation, and available recharging and refuelling infrastructure (Stütz et al., 2022; IEA, 2024). The third finding is that studies on artificial intelligence in logistics have primarily focused on efficiency and cost effectiveness, while the environmental impact and operational characteristics of alternative fuel vehicle fleets have received less attention to date (Chung, 2021; Ferreira & Esperança, 2025). These findings highlight the need to combine AI-supported optimisation with the operation of low-emission vehicle fleets. Despite growing academic interest in green logistics, fleet electrification, and AI-enabled logistics optimisation, the literature still lacks sufficiently integrated analyses that connect these three dimensions within a common operational and policy-relevant analytical framework. This study addresses that gap by examining how AI-supported logistics applications may improve the environmental and economic performance of electric and gas-powered truck fleets in relation to both corporate practice and the evolving European policy context.

3. Methodology

3.1 Research design

This present study adopts an integrative qualitative multi-source research design combining a structured review of academic literature, policy document analysis and documentary corporate case analysis. The design is appropriate for an emerging field in which relevant evidence exists across multiple source types, whereas directly comparable primary operational datasets remain limited. The study is conceptually grounded in the intersection of digital transformation and sustainable logistics frameworks, integrating insights from green logistics literature and technology adoption perspectives. The integration of artificial intelligence with green logistics solutions, especially in relation to electric and gas-powered truck fleets, represents such an evolving field. The aim of the research is to synthesise the available knowledge and examine how technological, organisational, and policy-related factors influence the wider adoption of smart green logistics solutions (Gillström et al., 2024).

The documentary analysis applied in this study follows the qualitative document analysis approach widely used in social science research. According to Bowen (2009), document analysis is a systematic procedure for reviewing and evaluating documents in order to identify patterns, themes and relevant analytical categories. This approach is particularly suitable for emerging research fields where empirical datasets are limited but extensive policy and corporate documentation is available. In the context of this research, documentary analysis enables the structured examination of policy documents, academic literature and corporate reports related to the integration of artificial intelligence and sustainable logistics systems.

The research covers three complementary areas. First, a review of international and European academic literature on green logistics, electrification of freight transport and AI-enabled logistics solutions. Second, a review of European Union policy frameworks relevant to freight transport decarbonisation and digitalisation. Finally, document-based corporate case studies illustrating the use of AI-supported logistics solutions in real-world logistics operations. This approach helps to connect theoretical insights with operational practice and policy objectives. The final selection includes a diverse set of studies, consisting of review articles, model-based optimisation research, and empirical case studies. A large proportion of the literature focuses on routing optimisation and operations research models, particularly within the context of green vehicle routing problems, mixed fleet optimisation, and emission reduction strategies. In addition, several studies examine the integration of artificial intelligence and digital technologies into logistics processes, including route optimisation, demand forecasting, and fleet management applications. At the same time, a smaller subset of studies explicitly addresses the combined interaction of artificial intelligence and alternative fuel vehicle fleets in operational logistics contexts, highlighting a gap in the literature. This pattern indicates a research gap in the integrated analysis of artificial intelligence and alternative fuel logistics systems, particularly in real-world operational contexts.

Document analysis in this study also follows the principles of qualitative content analysis, which allows researchers to systematically interpret textual materials through coding and thematic categorisation (Mayring, 2014). The analysed articles were further categorised based on their primary research focus, including routing optimisation, fleet electrification, digitalisation and artificial intelligence, and sustainability performance. In the context of this research, documents were reviewed and interpreted according to predefined analytical categories related to operational optimisation, environmental performance and organisational capabilities. This structured analytical procedure improves the transparency and reliability of the research process when analysing secondary data sources.

3.2 Data sources and selection criteria

The study relies solely on secondary data from publicly available and verifiable sources. The literature search was structured around four main conceptual blocks reflecting the key dimensions of the research topic: green logistics, artificial intelligence and digitalisation, alternative fuel vehicle technologies, and logistics optimisation. The keyword groups used for each conceptual dimension are summarised in Table 2.

Table 2. Conceptual dimension for Scopus search keywords. Source: *authors' own.*

Concept	Keywords
Green logistics	"green logistics", "sustainable logistics"
AI / Digitalisation	"artificial intelligence", "AI", "digitalisation"
Fleet technologies	"electric trucks", "alternative fuel vehicles", "fleet electrification"
Logistics operations	"logistics optimisation", "route optimisation", "fleet management"

Based on these conceptual dimensions, a structured and systematic search query was developed to ensure comprehensive coverage of the research topic. The academic literature review was conducted using the Scopus database, focusing on peer-reviewed articles and review papers published between 2017 and 2025 in the subject areas of Business, Engineering, and Environmental Science. The academic literature search used the following search string and query: ("green logistics" OR "sustainable logistics") AND ("artificial intelligence" OR "AI" OR "digitalisation") AND ("electric trucks" OR "alternative fuel vehicles" OR "fleet electrification") AND ("logistics optimisation" OR "route optimisation" OR "fleet management").

To improve methodological transparency and reproducibility, the search and screening process was documented using a PRISMA-style logic. The search was limited to publications indexed in Scopus between 2017 and 2025, restricted to the document types "Article" and "Review", and to the subject areas "Business", "Engineering", and "Environmental Science". The filtered search produced 23 records in total. After title and abstract screening, 6 records were excluded. The remaining 17 records were assessed in full text and retained for the qualitative synthesis. The main reasons for exclusion were lack of direct relevance to freight logistics operations, a primary focus on technical vehicle subsystems rather than logistics systems, or optimisation contexts outside the interaction between artificial intelligence, green logistics, and alternative fuel freight transport. A PRISMA-style summary of the literature search and screening process is presented in Table 3, indicating the number of articles found at each stage.

Table 3. PRISMA-style summary of the literature search and screening process. Source: *authors' own.*

Stage	Description	n
Identification	Records identified through the filtered Scopus search	23
Screening	Records excluded after title and abstract screening	6
Eligibility	Full-text records assessed for eligibility	17
Eligibility	Full-text records excluded	0
Included	Studies included in the qualitative synthesis	17

Three main categories of data are used. The three source categories serve different analytical purposes. Academic literature is used to establish the conceptual and analytical framework of the study. Policy documents are used to contextualise regulatory priorities, infrastructure-related constraints and European decarbonisation goals. Corporate and industry documents are used as documentary evidence to illustrate operational applications, reported benefits and the practical limitations of AI-supported logistics solutions. Corporate and industry sources are used exclusively for the empirical illustration of AI-supported logistics practices and reported operational outcomes; they are not used to substantiate the core theoretical arguments or literature-based analytical claims of the study. This explicit separation of source types is important because the study does not assign the same evidentiary status to peer-reviewed literature, policy documents, and company-reported materials; instead, each source category is used for a distinct analytical purpose within the overall research design.

Academic literature was selected from peer-reviewed journals and academic publishers focusing on green logistics, sustainable transport, and digitalisation in logistics systems. Priority was given to recent publications in order to reflect current technological and policy developments. Documents and reports from the International Energy Agency, the International Transport Forum, the European Commission, and the European Environment Agency were also analysed. These documents provide important insights into the recent emission trends, regulatory targets, and strategic priorities for the topic (IEA, 2017a, 2017b; IEA, 2024; ITF, 2021; European Commission, 2019, 2020). Corporate reports, industry publications and independent research documents describing AI-supported logistics solutions were also examined. These include publicly available company reports, industry documents, and independent research findings involving logistics companies and technology developers. Cases were selected based on the following criteria: relevance in freight transport and heavy-duty logistics fleets; and reported use of AI-based or advanced digital tools in their logistics processes.

Because public company documentation differs in scope, disclosure detail and publication year, the analysed company materials are interpreted as documentary comparative evidence rather than directly equivalent performance datasets. This distinction is important for framing the empirical section as a structured comparative illustration of operational practices, reported benefits and evidence limitations rather than as a benchmark comparison of firm performance. The screening process was conducted in two stages. First, titles and abstracts were reviewed to exclude records that were not directly relevant to freight logistics operations, sustainability outcomes, or digital technologies in logistics. This stage resulted in the exclusion of 6 records from the 23 initially identified Scopus results. Second, the remaining 17 records were assessed in full text to confirm their relevance to the interaction between artificial intelligence, green logistics, and alternative fuel freight transport. The final screening log retained all 17 full-text records for the qualitative analysis. Excluded studies typically focused on technical vehicle subsystems, broad optimisation contexts outside freight logistics, or topics that did not address the intersection of AI, sustainability, and low-emission fleet operations. The screened literature was then linked to the study's analytical logic through thematic categorisation. More specifically, the selected sources were reviewed in relation to three analytical dimensions: operational optimisation mechanisms, environmental and energy performance implications, and organisational and technological capabilities. This step helped ensure that the literature selection was not only topically relevant but also aligned with the analytical structure used in the subsequent interpretation of policy and corporate evidence.

3.3 Analytical approach

Based on the principles of qualitative document analysis, the study applies a structured three-step analytical procedure. First, relevant documents were collected and screened according to predefined inclusion criteria related to green logistics, artificial intelligence and freight transport decarbonisation. Second, the selected documents were systematically coded using thematic categories derived from the literature. These categories include operational optimisation mechanisms, environmental performance implications and organisational capabilities. Third, the coded material was analysed in order to identify recurring patterns and relationships between artificial intelligence applications and the operational challenges of low-emission freight transport systems.

The same analytical dimensions were then applied consistently across academic literature, policy documents and corporate materials in order to identify convergences, tensions and recurring operational patterns across source types. This cross-source interpretation helped connect conceptual insights, regulatory context and documentary corporate evidence within a single analytical framework. This analytical approach follows established qualitative research practices in document analysis and content analysis (Bowen, 2009; Mayring, 2014) and improves the transparency and replicability of the research process when analysing secondary sources.

The analysis was based on three dimensions: operational optimisation mechanisms (transport route planning, fleet utilisation, energy management); environmental and energy performance implications (potential emission reduction, energy efficiency); and organisational and technological capabilities (availability of data, digital infrastructure, organisational readiness). The analysed literature, policy documents and corporate materials were interpreted based on these dimensions in order to identify recurring patterns and operational challenges.

The processing of available data began with a detailed analysis of information from various data sources. When reviewing academic and regulatory documents, we focused on concepts such as emission reduction processes, the difficulties of operating trucks running on alternative fuels, and digital optimisation strategies. Special attention was paid to determining how AI and digital tools relate to the achievement of sustainability goals in order to support logistics processes. While analysing the corporate case studies, great attention was paid to the types of AI-supported solutions used, the logistical challenges, and the operational and sustainability results achieved. Rather than comparing company results, the analysis aims to present typical use cases and processes where artificial intelligence can influence fleet utilisation, energy-efficient operation, and operational efficiency. The findings from the literature and corporate case studies were then interpreted in light of European regulatory initiatives, revealing the extent to which current technological solutions meet regulatory objectives. This type of study can help identify the current limitations, shortcomings, and difficulties of smart green logistics solutions that may hinder their widespread adoption. The main limitations of the study are acknowledged in the Conclusions section in order to distinguish the methodological design from the interpretive constraints of the analysis. Based on this analytical procedure, the following section presents the findings derived from the documentary comparative analysis of AI-supported logistics practices. The findings focus on how artificial intelligence contributes to route optimisation, fleet utilisation, predictive maintenance and the operational integration of electric and alternative fuel truck fleets, while also highlighting the limitations of the available corporate evidence.

4. Findings

In order to illustrate the operational role of artificial intelligence in smart green logistics, the selected corporate cases are analysed as documentary comparative evidence using a structured analytical framework based on key dimensions identified in the literature, including AI application type, logistics challenges, operational outcomes, environmental implications, economic effects and evidence limitations. The selected cases are Amazon, DHL and UPS (United Parcel Service) represent companies that have publicly documented the use of AI-supported logistics optimisation systems in their operations. The analysed materials are drawn from publicly available corporate sustainability reports, innovation reports and independent industry publications. Because these documents differ in source type, reporting detail, publication year, and analytical scope, the cases are not treated as directly equivalent or year-on-year comparable performance datasets. Instead, they are interpreted as documentary comparative evidence illustrating recurring AI-supported logistics application areas, reported operational and environmental benefits, and key limitations of the available evidence. The cases were selected because they demonstrate three AI application areas in logistics operations: route optimisation, fleet electrification planning and predictive maintenance.

The key characteristics of the selected corporate cases are summarised in Table 4, based on data from Amazon (2024, 2025), DHL (2024), UPS (2018) and Ascend Analytics (2025). The comparison is therefore analytical rather than benchmark-oriented, and the cases should be interpreted as illustrative examples of reported AI-supported logistics practices under different organisational and reporting conditions. To enhance analytical transparency and structured comparison, the cases are analysed using a common framework based on key analytical dimensions identified in the literature. Given the heterogeneity of the source materials, this framework is intended to support analytical comparison rather than direct performance benchmarking across firms.

Table 4. Comparative analysis of AI-supported logistics cases. Source: *authors' own.*

Company	AI application type	Logistics problem addressed	Operational impact	Environmental impact	Economic benefit	Relevance for low-emission integration
Amazon	Route optimisation and EV integration	Complex routing and EV constraints	Improved routing efficiency and fleet utilisation	Reduced distance and energy use	Operational cost savings	EV allocation under constraints
DHL	AI-supported analytics and forecasting	Demand variability and network inefficiencies	Improved planning accuracy and coordination	Reduced empty runs and energy use	Resource optimisation	Network-level efficiency gains
UPS	Route optimisation (ORION system)	Inefficient routing and high mileage	Optimised delivery routes and reduced mileage	Lower fuel consumption	Significant cost savings	Mileage and fuel reduction

The comparison highlights that AI applications primarily contribute to operational efficiency through optimisation and predictive capabilities, while environmental benefits appear to arise indirectly from reduced fuel consumption, improved resource allocation, and minimisation of empty runs. At the same time, the analysis reveals that available evidence is largely based on company-reported data, which limits comparability and highlights the need for more standardised evaluation approaches. In addition, because the selected company documents originate from different reporting years and publication formats, the table should be interpreted as a comparative analytical aid rather than as a harmonised year-specific dataset.

The table also illustrates that artificial intelligence is applied in logistics operations through different processes, including route optimisation, network planning and predictive maintenance systems. It also highlights that the reported environmental and economic benefits are closely linked to operational improvements, while comparability remains constrained by differences in reporting quality and performance metrics. In addition, the table explicitly shows that economic benefits such as cost savings and efficiency gains are closely linked to operational improvements. At the same time, the comparison reveals important limitations, including data availability constraints, model uncertainty, and the lack of standardised performance metrics across companies. Although the specific technological solutions vary between the companies, all cases demonstrate how AI-supported decision-making can contribute to both operational efficiency and environmental performance in freight transport systems.

4.1 AI-supported route optimisation and electric fleet deployment: the case of Amazon

One example of AI-supported logistics optimisation can be seen in Amazon's operations. The company has devoted considerable attention and investment to artificial intelligence-based logistics systems in order to improve route planning, delivery efficiency, and the integration of electric delivery vehicles into its logistics network (Amazon, 2024). AI-driven route optimisation systems analyse large volumes of operational data including delivery locations, traffic patterns, vehicle capacity and charging infrastructure availability. These systems dynamically adjust delivery routes and schedules, which allows logistics operators to reduce travel distances, minimise empty runs and also to improve vehicle utilisation. Amazon has also introduced a large fleet of electric delivery vehicles as part of its sustainability strategy (Amazon, 2025). According to available public company reports, the integration of digital route optimisation tools is essential for managing the operational constraints of electric vehicles, for example range limitations and charging requirements. AI-supported planning allows electric vehicles to be allocated to routes where their operational characteristics are most suitable. These initiatives improve both their environmental performance and delivery efficiency. This case primarily illustrates AI-supported route optimisation and EV allocation planning, showing how digital tools may improve the operational feasibility of electric vehicle deployment under range and charging constraints.

4.2 AI-supported logistics optimisation in large-scale logistics networks: the case of DHL

DHL is another example of the application of artificial intelligence in logistics operations as one of the largest global logistics providers. The company has increasingly integrated AI-supported analytics and digital optimisation tools into its logistics operations to improve fleet utilisation and reduce environmental impacts (Thompson, 2023). According to DHL's Logistics Trend Radar reports, artificial intelligence technologies are used to analyse operational data, forecast transport demand and optimise delivery networks (DHL, 2024). These systems process large volumes of logistics data including shipment flows, traffic conditions and vehicle performance indicators. AI-supported planning tools enable the company to improve route efficiency, reduce empty runs and better coordinate vehicle deployment across distribution networks. These digital optimisation tools are particularly important in the context of sustainability strategies, as they allow logistics providers to reduce fuel consumption and improve energy efficiency across large-scale logistics operations. DHL's documented experience suggests that AI-based logistics optimisation can contribute to both operational efficiency and indirect emission reduction in freight transport systems, especially when digital planning tools are integrated with broader sustainability strategies (Thompson, 2020). This case primarily illustrates AI-supported demand forecasting, planning analytics and network coordination, highlighting the indirect environmental benefits that may arise from reduced empty runs and improved fleet deployment.

4.3 AI-driven route optimisation and sustainability: the case of UPS

The next example of artificial intelligence-supported logistics optimisation is the ORION (On-Road Integrated Optimisation and Navigation) system used by UPS. The ORION system is an advanced AI-based route optimisation platform that analyses large volumes of operational data in order to determine the most efficient delivery routes for drivers (UPS, 2018). The system processes millions of possible route combinations by considering factors such as delivery locations, traffic patterns, vehicle capacity and operational constraints. According to UPS reports, ORION helps drivers follow optimised delivery routes that reduce unnecessary mileage and improve delivery efficiency. The introduction of the ORION system has significantly improved operational efficiency. UPS estimates that route optimisation supported by AI can reduce millions of kilometres travelled annually, leading to significant fuel savings and emission reductions. UPS invested approximately $250 million in the development of the ORION system, while the savings exceeded $320 million by 2015 and are projected to reach $400 million annually by 2025 (Ascend Analytics, 2025). The case of UPS demonstrates that AI-supported route optimisation can contribute not only to cost efficiency but also to environmental sustainability by reducing fuel consumption and improving vehicle utilisation across large logistics networks. This case primarily illustrates AI-supported route optimisation, demonstrating how operational efficiency gains can translate into lower mileage, reduced fuel use and indirect environmental benefits.

These examples illustrate how AI-based optimisation systems can transform logistics decision-making by integrating operational data, vehicle constraints and sustainability objectives into a single planning framework (Amazon, 2024, 2025; DHL, 2024; UPS, 2018; Ascend Analytics, 2025).

4.4 AI-driven fleet management and predictive maintenance

An important application area of artificial intelligence in logistics concerns fleet management and predictive maintenance. AI-based systems can be used in fleet management and maintenance operations. Large logistics operators and fleet management companies are increasingly relying on artificial intelligence-based systems to analyse telematics data from their vehicle fleets in order to support predictive maintenance and operational decision-making (Villano, 2025). These systems can provide real-time feedback and support more proactive maintenance planning. These systems track and analyse, for example, the engine performance and the wear of different components. In doing so, they can detect abnormalities and predict longer and more expensive maintenance needs, preventing breakdowns. Available industry practices show that AI-powered predictive maintenance can reduce unplanned downtime, improve vehicle availability, and extend asset lifespans (Villano, 2025). These advantages are important for alternative truck fleets, which usually have significantly higher investment costs and more complex maintenance requirements. Improving vehicle reliability can increase fleet utilisation and reduce the operational risks.

In addition, AI-based fleet analysis allows for comparison of vehicle performance across different routes and under different operating conditions. Driving habits can also be examined and analysed. These facilitate data-driven decision-making in relation to vehicle deployment, maintenance planning, and operational optimisation (Villano, 2025). Although publicly available sources rarely analyse performance metrics by technology, the use of AI-based systems shows that these systems can support more efficient and sustainable operation of mixed vehicle fleets.

4.5 Synthesis of corporate evidence

Overall, these corporate results show that AI-supported logistics solutions contribute to smart green logistics through a variety of mechanisms. AI-based route planning enables better coordination between transport demand, route characteristics, and the operational constraints of electric or alternative fuel trucks. Predictive maintenance or fleet analysis can improve vehicle utilisation and increase the economic viability of low-emission fleets. The results suggest that AI alone does not lead to increased sustainability, but it does support the use of environmentally friendly vehicle technologies. Without advanced planning and digital decision support, electric and alternative fuel trucks risk not being used efficiently. But if they are integrated into AI-based logistics systems, these vehicles can achieve greater emission reductions and better cost efficiency. The lack of publicly available company data limits the assessment of the full impact of AI-supported green logistics. The available results often depend on the type of use and are influenced by the operating conditions specific to the company. Additional company-reported sustainability examples from logistics and transport-related practice also indicate continuing experimentation with lower-emission fleet solutions and operational decarbonisation measures, although the reporting formats and performance indicators remain heterogeneous (Jöhren, 2024; Williment, 2025).

The findings presented in this section provide an empirical basis for a broader examination of AI-based green logistics. Based on these findings, the next section examines how AI-supported optimisation influences policy frameworks, operational constraints, and organisational capabilities. It also assesses the broader significance of smart green logistics for sustainable freight transport. While the selected corporate cases reflect internationally visible logistics applications, the European perspective of the study is addressed through the interpretation of these findings in relation to the European Green Deal, the Sustainable and Smart Mobility Strategy, the Fit for 55 package, and AFIR in the Discussion and Implications sections.

5. Discussion

The findings of this present study are consistent with previous research highlighting the role of digital technologies and artificial intelligence in improving the environmental performance of freight transport systems. For example, Helo and Hao (2021) emphasise that AI-supported logistics planning can significantly improve supply chain efficiency and reduce energy consumption in freight transport networks. Similarly, Chen et al. (2024) show that artificial intelligence-based logistics optimisation can reduce transport distances, improve fleet utilisation and contribute to lower energy consumption in logistics systems. The results of the present study support these conclusions by showing that AI-based logistics optimisation can enhance the operational integration of electric and alternative fuel truck fleets.

The aim of the study was to examine how artificial intelligence-supported logistics optimisation can improve the environmental and economic performance of electric and gas-powered truck fleets within a smart green logistics framework. The findings indicate that AI contributes mainly as an enabling technology: it improves route planning, demand forecasting, fleet utilisation, predictive maintenance and energy-related decision-making, but its environmental benefits remain indirect and depend on integration with low-emission vehicles, infrastructure and organisational capabilities.

These findings are consistent with previous studies highlighting that digital optimisation tools mainly improve operational efficiency in logistics systems. In addition, the environmental benefits are mostly indirect, through reduced fuel or energy consumption (Chung, 2021; Chen et al., 2024). The findings of this study are also broadly consistent with recent research examining the role of digital technologies in sustainable logistics systems. For example, McKinnon (2018) and ITF (2021) highlight that operational optimisation plays a crucial role in reducing freight transport emissions alongside technological innovation. Similarly, Chung (2021) emphasises that artificial intelligence can significantly improve logistics efficiency through dynamic route planning and data-driven decision-making. The corporate cases analysed in this study support these observations by illustrating how AI-supported logistics systems contribute to improved vehicle utilisation, reduced travel distances and more efficient fleet management. At the same time, the results also confirm the findings of Ferreira and Esperança (2025), who argue that the environmental benefits of digital logistics technologies are largely indirect and depend on their integration with broader sustainability strategies. These findings highlight the importance of integrating digital capabilities with the deployment of low-emission vehicle technologies in order to achieve the environmental objectives of sustainable freight transport.

From a European perspective, there is a significant gap between political ambitions and practical reality. The European Union's strategies clearly link decarbonisation with digitalisation, promoting an integrated vision of sustainable and smart mobility. The results of the study suggest that AI-based logistics solutions can play a decisive role in complying with increasingly stringent emission regulations. This is likely to be particularly important in contexts characterised by uneven infrastructure development and diverse logistics systems. An important implication of these findings is that the introduction of electric and gas-powered trucks cannot be fully effective without adequate investment in digital capabilities. Without AI-supported planning and fleet management, alternative fuel vehicles risk not reaching their full potential. This could be the case, for example, if they are used on unsuitable routes or operated inefficiently, thereby reducing their potential. In contrast, AI-supported logistics systems can increase the benefits of environmentally friendly vehicles by improving energy efficiency.

The study contributes to the literature by connecting three often fragmented research directions: sustainable freight decarbonisation, low-emission fleet transition and AI-enabled logistics optimisation. Rather than treating artificial intelligence as a standalone innovation, the analysis shows that its relevance lies in supporting the more effective operational integration of electric and gas-powered truck fleets under infrastructural, organisational and policy constraints. In this sense, the study extends existing green logistics frameworks by clarifying how digital capabilities can support system-level decarbonisation through operational coordination rather than through direct technological substitution alone. At the same time, the document-based methodology means that the findings remain interpretive rather than causal, and future studies should test these relationships using company-level operational data, interview-based primary research or additional comparative case studies.

6. Implications

The findings have practical implications for logistics managers, companies operating mixed fleets, policymakers and future research. For logistics managers, AI-supported optimisation should be used not only as a cost-efficiency tool, but also as a planning mechanism for improving the operational feasibility of low-emission fleets. Route optimisation, demand forecasting, predictive maintenance and vehicle allocation can help align electric and alternative fuel trucks with routes, infrastructure availability and operational constraints. For companies operating mixed fleets, the findings indicate that digital capabilities are a necessary complement to vehicle technology. The benefits of electric and gas-powered trucks depend strongly on utilisation, routing decisions, charging or refuelling possibilities and data availability. Therefore, investments in low-emission vehicles should be supported by investments in telematics, data integration, analytical capabilities and organisational readiness. For policymakers, the findings suggest that regulatory incentives and infrastructure development should be coordinated with digital logistics capabilities. AI-supported planning tools can help firms adapt to uneven infrastructure conditions and operational uncertainty, but their effectiveness depends on data availability, interoperability and supportive implementation frameworks. For researchers, the study highlights the need for more empirical evidence on the measurable effects of AI-supported optimisation in low-emission freight operations. Future studies should examine company-level operational data and comparative mixed-fleet settings to assess the contribution of AI to emissions reduction, cost efficiency and fleet utilisation.

7. Conclusions

This study examined how artificial intelligence-supported logistics optimisation can improve the environmental and economic performance of electric and gas-powered truck fleets within a smart green logistics framework. The findings show that AI does not function as a standalone sustainability solution, but as an enabling technology that can improve route planning, fleet utilisation, predictive maintenance, energy efficiency and the operational integration of low-emission vehicle technologies.

The study contributes to the literature by connecting three research streams that are often treated separately: green logistics and freight decarbonisation, low-emission fleet transition, and AI-enabled logistics optimisation. By integrating academic literature, policy documents and documentary corporate evidence, the study provides an analytical framework for understanding how digital optimisation can support smart green logistics under operational, organisational and infrastructural constraints.

The study is limited by its reliance on secondary sources and publicly available corporate materials. As a result, the study cannot independently verify company-reported performance claims or quantify the standalone effect of AI on emissions reduction or cost savings. Future research should therefore examine company-level operational datasets, interview-based evidence and comparative case studies to assess the measurable effects of AI-supported optimisation in low-emission freight operations.

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