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A STUDY ON ALTERNATIVE FUELS IN FREIGHT COMMERCIAL VEHICLES

** Prof. Prajakta Bapat, **Tanishqa Sonawane, ***Iccha Gupta, ****Vikat Chogale, & *****Sharon Chathamvelli*

** Department of Business, Pillai College of Arts, Commerce & Science (Empowered Autonomous), New Panvel, Navi Mumbai*

Abstract:

This study explores the practicality and acceptance of alternative fuels in India's commercial vehicle industry, which is crucial for freight transport and economic development. Even with more stringent emission standards and increasing environmental worries, diesel remains the primary fuel in this sector because of its high energy content, dependability, and established refueling system. The research assesses the viability of alternative fuels like Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), battery electric vehicles (BEVs), and hydrogen, while also pinpointing the major factors and obstacles affecting their implementation in the logistics sector. Employing a descriptive research approach, primary data was gathered via a structured survey from 24 experienced professionals engaged in freight transport activities, including fleet managers and logistics executives. The results indicate that while knowledge of alternative fuels is widespread, actual implementation is still restricted due to substantial upfront expenses, insufficient charging and refueling facilities, and operational ambiguities. The study determines that a phased shift supported by a multi-fuel strategy, infrastructure expansion, and robust policy backing will be needed to foster sustainable and low-emission freight transport in India.

Keywords: *Alternative Fuels, Commercial Vehicles, Decarbonization, Diesel Dependency, Freight Transport, Logistics Industry, Sustainable Transportation.*

Introduction:

The commercial vehicle (CV) sector in India is essential to the country's freight transportation system. It plays a key role in economic growth, energy use, and environmental sustainability. Commercial vehicles include light delivery vans and heavy-duty long-haul trucks, mainly used for logistics and business activities. In India, these vehicles are classified into Light Commercial Vehicles (LCVs), Medium Commercial Vehicles (MCVs), and Heavy Commercial Vehicles (HCVs), based on their Gross Vehicle Weight (GVW) and operational use.

Road transport carries nearly 70% of India's freight, making commercial vehicles a crucial part of the logistics network. Although medium and heavy-duty trucks make up a small portion of the total vehicle population, they consume a significant amount of diesel and contribute greatly to air pollution and greenhouse gas emissions. Diesel remains the leading fuel in the commercial vehicle segment because of its high energy density, reliability, and the widespread availability of refueling options.

However, reliance on diesel raises concerns about increasing fuel imports, energy security, and environmental effects. Even with stricter emission rules like Bharat Stage VI, diesel-powered commercial vehicles continue to emit large amounts of carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter (PM) during normal operations. Therefore, cutting emissions in the freight transport sector is a top

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priority for both policymakers and industry players.

To tackle these challenges, India is looking at alternative fuel options for commercial vehicles, including Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), battery electric vehicles (BEVs), and hydrogen. CNG has gained popularity in urban LCVs and buses, while LNG is becoming a possible solution for long-haul heavy trucks. BEVs are also growing in urban logistics for short distances since they produce no tailpipe emissions. Despite these advancements, the use of alternative fuels is still limited due to high vehicle costs, lack of infrastructure, and technological uncertainties. In this context, the current study looks into the feasibility and acceptance of alternative fuels in India's commercial vehicle sector, focusing on the logistics industry and the factors that influence stakeholders' willingness to shift towards sustainable energy options.

Objectives:

1. To analyse fuel consumption trends in India's commercial vehicle sector and examine the continued dominance of diesel in freight transport.
2. To evaluate the potential of major alternative fuels such as CNG, LNG, electric vehicles, and hydrogen in the Indian commercial vehicle market.
3. To identify key drivers and barriers affecting the adoption of alternative fuels in logistics companies.
4. To examine the preparedness and readiness of logistics company management to adopt alternative fuel commercial vehicles.

Statement of the Problem :

India's commercial vehicle sector still relies heavily on diesel for freight transport, despite rising environmental concerns and the availability of cleaner alternatives such as CNG, LNG, electric, and hydrogen. However, adoption remains limited due to high initial costs, inadequate infrastructure, and operational uncertainties. Hence, it is important to assess the feasibility of these alternative fuels and identify the key factors influencing their adoption in the Indian logistics sector.

Literature Review:

Deeptam Trivedi, Sujeet Kesharvani, Raj Suman, Gaurav Dwivedi, and Olusegun David Samuel (2025)

This study looks at various alternative fuel options for Indian commercial trucks. The goal is to reduce reliance on fossil fuels and lessen the environmental impact of freight transportation. The research evaluates multiple fuels, including compressed natural gas (CNG), liquefied natural gas (LNG), battery electric vehicles (BEVs), hydrogen fuel cells, and biofuels. It analyzes their technological maturity, infrastructure needs, operational feasibility, and environmental benefits. The study shows that diesel-powered heavy-duty trucks are the main contributors to greenhouse gas emissions in the freight sector due to their high fuel use and extensive operation in long-haul logistics. The authors find that CNG and LNG can reduce emissions in the near term due to their lower carbon intensity and existing natural gas infrastructure. Battery electric vehicles are suitable for urban and short-haul freight operations because of their high energy efficiency and zero tailpipe emissions. Hydrogen fuel cell technology has long-term potential for deep decarbonization of heavy-duty transport. The research concludes that no single fuel can completely replace diesel in all freight segments, so India needs to adopt a multi-fuel transition strategy. This strategy should be supported by technological innovation, infrastructure development, and favorable policy frameworks.

Sharif Qamar, Piyush Saxena, Arun Kumar, and Arun Babu (2026) The study looks at the growth of freight transportation and the environmental challenges in India. It shows that freight demand is expected to rise sharply from 2,682 billion tonne-kilometres in 2019 to about 7,260 billion tonne-kilometres by 2030. Road transport will continue to lead in freight movement.

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The authors discuss how this rapid growth in road freight will raise fuel use and greenhouse gas emissions unless cleaner technologies are used. The study reviews policy frameworks, emission tracking methods, and strategies for reducing freight emissions. It stresses the need for organized clean freight programs, better emissions monitoring systems, and stronger collaboration between government agencies and logistics companies. The research concludes that combining policy support, technological improvements, and industry involvement is crucial for shifting the Indian freight sector toward more sustainable and low-emission transport systems.

Pradeep Vishnuram, S. Alagarsamy, M. Bajaj, M. Alqahtani, and M. Khalid (2025) This study provides a review of emerging alternative fuels for transportation, including electric vehicles, hydrogen fuel technologies, methanol-based fuels, and biofuels. The research evaluates these fuels based on their environmental impact, lifecycle emissions, energy efficiency, economic viability, and infrastructure readiness. The study finds that electric vehicles can significantly reduce greenhouse gas emissions and operating costs when powered by renewable energy. However, the wide deployment of electric commercial vehicles is limited due to high battery costs, range restrictions, and inadequate charging infrastructure. Hydrogen fuel cell technology is seen as a promising long-term solution for heavy-duty vehicles because it offers high energy density and quick refueling. Nonetheless, hydrogen production, storage, and distribution infrastructure are still underdeveloped in many areas. Biofuels and methanol-based fuels are considered transitional options that can cut emissions while using existing internal combustion engine technology. However, their scalability depends on the availability of sustainable feedstock and efficient production methods. The study concludes that a diverse multi-fuel strategy is necessary for achieving long-term sustainability in commercial transport, especially in developing economies like India, where freight demand is growing rapidly.

Sharma, R., Kulkarni, A., Iyer, S., and Bansal, T. (2025) This research evaluates various low-carbon transition pathways for India's road transport sector, focusing on freight and commercial vehicle operations. The study investigates the roles of electrification, alternative fuels, and financial policy measures in cutting greenhouse gas emissions from transportation. The authors analyze policy tools such as carbon pricing, vehicle electrification incentives, fuel efficiency regulations, and investment in alternative fuel infrastructure. The study identifies major barriers that slow the transition to cleaner commercial transportation, including high upfront vehicle costs, lack of sufficient charging and refueling infrastructure, technological uncertainty, and limited financial incentives for fleet operators. Additionally, logistics companies often operate with thin profit margins, making them reluctant to adopt costly alternative technologies without clear economic benefits. The authors conclude that effective policy intervention, financial incentives, and infrastructure development are crucial for encouraging the adoption of low-carbon technologies in India's commercial vehicle sector.

Singh V., Agarwal, A., Shukla, P., and Mishra, D. (2022/2023) This study explores several decarbonization strategies for India's road transportation sector. It analyzes the potential of alternative fuels such as biofuels, compressed natural gas (CNG), electricity, and hydrogen. The research evaluates these fuels based on environmental performance, technological readiness, infrastructure availability, and economic feasibility. The study shows that CNG has seen significant use in urban transport systems due to its lower emissions compared to diesel and gasoline. Electric vehicles are recognized as highly energy-efficient options with strong long-term

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potential, especially for urban logistics and short-distance freight transport. Hydrogen fuel technologies are also discussed as emerging solutions for heavy-duty and long-distance transportation due to their high energy density. However, the study highlights challenges such as infrastructure development, high capital costs, and the need for supportive policy frameworks. The research concludes that successfully decarbonizing India's transport sector will require coordinated efforts among government agencies, vehicle manufacturers, fuel suppliers, and logistics operators to create a comprehensive ecosystem for alternative fuels.

Research Methodology:

1. This study uses a descriptive research approach to explore the practicality and implementation of alternative fuels in commercial vehicles in the Indian logistics industry. The research aims to understand industry views, adoption trends, and operational issues associated with alternative fuel technologies.
2. The study relies mainly on primary data gathered via a structured questionnaire from professionals in freight transport operations. A total of 24 usable responses were collected and used for analysis.
3. The research employs purposive (non-probability) sampling, where respondents were chosen based on their professional background and participation in logistics and transportation activities. The respondents include Directors, CEOs, Operations Heads, Fleet Managers, and Senior Supply Chain Executives who are directly engaged in operational and fleet-related decision-making.
4. The questionnaire covered questions about awareness of alternative fuels, current adoption rates, infrastructure availability, cost factors, regulatory impacts, and future adoption plans, which aided in assessing the readiness of logistics companies to shift to alternative fuel commercial vehicles.
5. A few secondary sources, such as research papers, industry articles, and reports, were consulted to develop a basic understanding of alternative fuels and trends in the commercial vehicle sector. However, the study's primary analysis is based on the primary survey responses obtained from industry professionals.

Descriptive Analysis:

1. **Respondent Profile :** The responses came from transport companies, logistics service providers, and fleet operators involved in freight transport. A significant portion of those responding manage fleets of medium and heavy commercial vehicles. This shows that the responses are from stakeholders directly involved in decisions about operations and fuel.
2. **Awareness and Current Adoption :** The analysis indicates that those responding are highly aware of alternative fuels like CNG, electric vehicles (EVs), LNG, and hydrogen. However, the actual use of these fuels is still limited. Most organizations said they are not currently using alternative fuel vehicles, and the fleet conversion levels among those who have adopted them are fairly small. This suggests that adoption is still in its early stages.
3. **Preferred and Future Alternative Fuels :** Of the available options, CNG is now seen as the most practical because of its existing infrastructure and operational practicality. However, electric vehicles are widely seen as having the greatest future potential for sustainable freight transport. LNG and hydrogen are recognized as possible alternatives but are still being considered.
4. **Infrastructure Availability :** Infrastructure availability is seen as limited. Many respondents pointed out that charging and refueling stations are not sufficiently developed or evenly spread along freight routes. This infrastructure gap is a major

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obstacle to large-scale adoption.

5. **Financial Feasibility :** Financial feasibility was a major concern among those responding. The high initial cost of alternative fuel vehicles makes adoption difficult, especially in the cost-conscious logistics industry. While the long-term benefits of lower operating costs are recognized, uncertainty about return on investment discourages quick adoption.
6. **Risk Perception and Organizational Readiness :** Most respondents see the adoption of alternative fuels as involving moderate risk. Concerns mainly have to do with vehicle reliability, maintenance support, and the long-term viability of the technology. As a result, many organizations show partial readiness and prefer a gradual transition instead of immediate large-scale adoption.
7. **Adoption Across Vehicle Categories :** Adoption is more apparent in Light Commercial Vehicles (LCVs), especially for short-haul and urban tasks. In contrast, adoption in Medium Commercial Vehicles (MCVs) and Heavy Commercial Vehicles (HCVs) is minimal. This is mainly due to factors related to operations like long-distance travel needs and infrastructure limits.

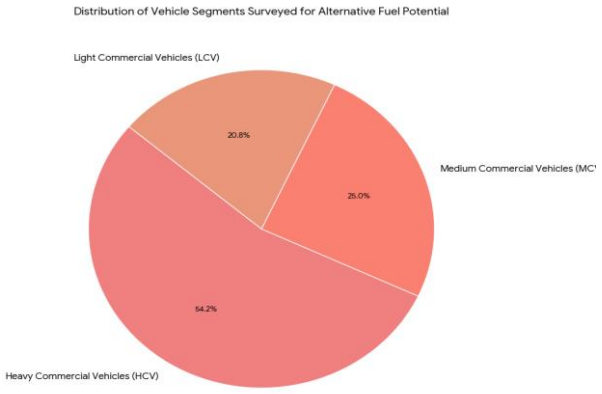

Fig 01. Composition of the Commercial Fleet Stakeholders evaluating Alternate Fuels

The above graph (Fig 01.) depicting vehicle types handled by those surveyed indicates that Heavy Commercial Vehicles (HCVs) make up most fleets at 54.2%, with Medium Commercial Vehicles (MCVs) next at 25.0% and Light Commercial Vehicles (LCVs) at 20.8%, according to the survey data from 24 responses. This distribution has significant consequences for using alternative fuels in freight transport. Given that HCVs are the primary fleet vehicles, switching to alternative fuels is made more difficult because heavy vehicles need greater energy capacity, longer driving distances, and more sophisticated refuelling facilities.

As shown in the prior analysis of the survey answers, adoption is presently more practical in LCVs, especially for shorter routes and travel between cities, where range and infrastructure issues are less important. Nevertheless, the prevalence of HCV fleets among those surveyed implies that widespread use of alternative fuels will mostly rely on technological progress and infrastructure improvements that can support heavy-duty freight vehicles.

8. **Barrier Analysis to Adoption of Alternative Fuel Vehicles :** The study explored the key operational, financial, and infrastructure-related limitations in the logistics sector to grasp the obstacles influencing the adoption of alternative fuel vehicles in the freight commercial vehicle sector. Given that freight transport depends on dependable operations, cost-effectiveness, and sufficient support infrastructure, these elements greatly impact choices about fuel transition. The results emphasize that logistics firms frequently assess alternative fuel implementation by considering long-term operational practicality and investment return.

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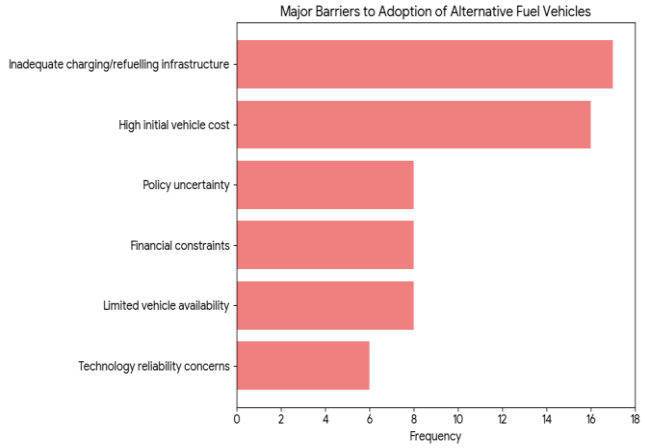

Fig 02. Barriers to Adoption of Alternate Fuels in CVs

The horizontal bar chart emphasizes the main obstacles noted by respondents that impede the acceptance of alternative fuel vehicles. Based on the survey information, insufficient charging or refueling infrastructure was the biggest obstacle with the greatest frequency, followed by high initial vehicle cost, demonstrating the financial impact of changing to alternative fuel technologies. Additional obstacles identified in the data include policy uncertainty, financial limitations, and limited vehicle availability, each getting a similar number of responses, pointing to systemic and regulatory issues impacting adoption decisions. Furthermore, technology reliability worries received relatively fewer responses, implying that while technological trust is growing, it is still a concern among some stakeholders.

In general, the data findings support the previous descriptive analysis that infrastructure shortcomings and high investment costs are the two main factors limiting large-scale acceptance of alternative fuel vehicles in the freight commercial vehicle sector.

Findings:

1. In India freight commercial vehicles continue to rely on diesel as their primary fuel source.
2. Logistics companies have yet to implement alternative fuel solutions despite growing knowledge about these options.
3. CNG and LNG demonstrate their capacity to function as cleaner diesel substitutes during the initial period of their existence.
4. Electric commercial vehicles function best in operations that require short-distance transportation and delivery within city areas.
5. The high initial expenses combined with insufficient refueling and charging stations create significant obstacles for people who want to use electric vehicles.
6. The transition to alternative fuels depends on three major factors which include economic viability, existing infrastructure and government backing of the transition process.

Conclusion:

Commercial Vehicles play a vital role in India's economic development, freight movement and energy consumption patterns. This research paper shows that Diesel continues to dominate Medium & Heavy Commercial Vehicles in India, mainly due to its very high Energy Density, Operational Reliability and the existing Refuelling Infrastructure. However, the reliance on diesel has very significant environmental consequences including Carbon Dioxide (CO2), Nitrogen Oxides (NOx) and Particulate Matter (PM) emissions; which is why Freight Transport is one of the most important areas for Decarbonisation.

The Research Paper indicates that there are Alternative Fuels available in the market today like Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Battery Electric Technology and Hydrogen etc. These alternative fuels have the potential to reduce Emissions,

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but the rate at which these alternative fuels are being adopted is quite low when compared to Vehicle Categories. For example, CNG has had a much better success rate in Light Commercial and Urban Segments while LNG is becoming a viable option for Long Haul Heavy Duty Transport. Battery Electric Vehicles have demonstrated the potential for Short Haul and Urban Logistics Operations while Hydrogen Technologies will represent a Long Term Decarbonisation Strategy for Heavy Freight Applications.

Although, there is increasing Government Support and Regulatory Measures in place such as BS-VI Norms and Fleet Modernisation Initiatives etc., there are still many Barriers to Large Scale Adoption of Alternative Fuels. The main barriers are High Upfront Capital Costs, Limited Refuelling and Charging Infrastructure, Technological Uncertainty and Operational Constraints etc. Further insights from Senior Management of Logistics Companies also indicate that Economic Feasibility, Availability of Infrastructure and Long-Term Return on Investment are all Key Determinants Influencing Fuel Transition Decisions in Logistics Companies.

Therefore, the transition towards Alternative Fuels in the Indian Commercial Vehicle Sector is happening Gradually rather than Disruptively. Therefore, it will be necessary to have a Multi-Fuel Strategy supported by Expansion of Infrastructure, Advancement of Technology and Consistency of Policy to achieve both Economic Growth and Environmental Sustainability. The Future Trajectory of Fuel Adoption in the Logistics Industry will ultimately depend on Coordinated Efforts from Governments, Manufacturers, Energy Providers and Fleet Operators to provide an Economically Viable and Operationally Feasible Pathway towards Cleaner Freight Transport.

Recommendations :

1. **Improve Alternative Fuel Infrastructure**
   The government and the private sector should increase the availability of CNG, LNG, and EV charging stations on key freight routes to help alternative fuel vehicles become more common.
2. **Provide Financial Incentives**
   To lower the high upfront costs of alternative fuel commercial vehicles, incentives like subsidies, tax breaks, and low-interest loans should be offered.
3. **Promote Electric Vehicles for Urban Freight**
   For last-mile and short-distance deliveries in cities, logistics firms should start using electric light commercial vehicles.
4. **Adopt a Multi-Fuel Strategy**
   To slowly move away from using only diesel, the industry should use a mix of fuels including CNG, LNG, electricity, and hydrogen.
5. **Strengthen Policy Support**
   To promote clean fuel technologies and encourage freight transport that is sustainable, government policies and rules should be consistent and supportive.

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