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GREEN TRANSITION IN HANOI'S URBAN TRANSPORT

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ABSTRACT
This study analyzes the current state of Hanoi's urban transportation. Based on secondary data from sectoral reports and expert consultations, the findings reveal a profound imbalance between infrastructure development and the rapid escalation of private vehicle ownership. Beyond chronic traffic congestion, internal combustion engine (ICE) vehicles are a primary driver of greenhouse gas emissions, causing environmental degradation and compromising public health, which serves as a critical bottleneck for Vietnam's 'Net Zero' commitment. The research suggests that Vietnam must implement a dual-track transition strategy: prioritizing the decisive development of a multimodal public transport system (comprising Metro, Bus, and Bicycle) while simultaneously enacting specialized regulatory frameworks to facilitate a synchronized and sustainable electrification of private transportation.

Keywords:
Green Transition, Greenhouse Gas (GHG) Emissions, Net Zero, Transportations, Pollution.

INTRODUCTION

Environmental pollution, global warming, and climate change have become critical focal points, garnering significant attention not only within academic research but also in national governance and management. According to Alm and Kinney [1], transportation represents a primary source of urban air pollution, contributing substantially to the global burden of disease. The World Health Organization [2] emphasizes that road transport is a major emitter of particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), and ozone precursors, which are predominant factors in urban air degradation. Long-term exposure to traffic-related emissions increases the risk of cardiovascular and respiratory diseases, lung cancer, and adverse reproductive outcomes, such as preterm birth and intrauterine growth restriction. Furthermore, the Health Effects Institute [3] concludes that traffic-related air pollution significantly contributes to premature mortality, particularly in densely populated urban areas.

Extensive quantitative assessments have been conducted to determine the specific emission impacts of internal combustion engines (ICE). Notably, Grigoratos et al. [4] demonstrated that CO2 emissions from gasoline engines are approximately 25–30% higher than those of diesel engines over equivalent distances. Conversely, diesel vehicles exhibit real-world Nox emissions ranging from 0.4 to 0.9 g/km, exceeding laboratory limits (0.08 g/km) by a factor of 5 to 11. Furthermore, Saito et al. [5] observed that the CO2 reduction advantage of diesel over gasoline is significantly offset by the emission of Black Carbon—a primary driver of global warming. On a 20-year horizon, a single unit of Black Carbon from diesel exhaust possesses a heat absorption capacity 1,500 times greater than that of CO2, further complicating global climate mitigation efforts. Klimont et al. [6] emphasized that even with the installation of Diesel Particulate Filters (DPF), internal combustion engines still contribute up to 15% of total PM2.5 in major metropolitan areas, acting as condensation nuclei for chemical reactions that generate photochemical smog.

Prolonged exposure to diesel exhaust increases the risk of lung cancer mortality by 26%, reinforcing the International Agency for Research on Cancer (IARC) decision to classify these emissions as a Group 1 carcinogen. This evidence underscores that transitioning transportation technologies is one of the most effective measures for mitigating environmental pollution and achieving sustainable development for nations, including Vietnam.

RESEARCH METHODOLOGY

This study employs a comprehensive data synthesis and indicator-based systematic analysis. A systematic review was conducted to gather empirical data from annual reports issued by the Hanoi People's Committee and the

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Department of Transport (2024-2026), alongside statistical databases from international organizations including the World Health Organization (WHO), the International Agency for Research on Cancer (IARC), and the Health Effects Institute (HEI).

To quantify greenhouse gas (GHG) emissions, the methodology integrates Descriptive Statistical Analysis with the IPCC [7] Tier 1 Sectoral Approach for mobile combustion. The environmental impact is calculated using the following fundamental equation:

$$E = \sum_{i,j} (V_{i,j} \times D_{i,j} \times EF_{i,j})$$

In which:
E (Total Emissions): Represents the total amount of greenhouse gases emitted into the environment.
Vij (Vehicle Stock): Refers to the number of vehicles belonging to category i (e.g., motorcycles, passenger cars, buses) utilizing fuel type (e.g., gasoline, diesel, electricity).
Dij (Average Annual Mileage): Represents the average distance traveled per vehicle in kilometers per year (also known as Vehicle Kilometers Traveled - VKT).
EFij (Emission Factor): Denotes the standardized emission factor for a specific vehicle category and fuel type. This factor represents the amount of gas emitted per kilometer traveled (e.g., g CO2/km).

RESEARCH RESULTS

Current State of Transportation in Hanoi

(i) Road Infrastructure

Hanoi, Vietnam, is currently grappling with immense traffic pressure. The capital's operational road network spans approximately 23,420 km, comprising a complex system of 05 expressways and orbital roads, 11 national highways, 128 provincial roads, and 1,220 urban streets. Furthermore, the infrastructure includes 2,310 intersections and 585 bridges and tunnels, excluding the extensive network of secondary alleys and narrow lanes. The land area ratio designated for transportation as of 2025 has reached 12.13%, with an average growth rate of 0.3% per annum. According to the master plan, this figure must reach 20–26% for the central urban area by 2030. Consequently, the timeframe to achieve this strategic objective is limited to the next five years. To meet the minimum target of 20%, the annual growth rate of transportation land area must reach approximately 1.57%, representing a fivefold increase compared to the current rate.

(ii) Transportation Infrastructure

The traffic volume within Hanoi is currently dominated by private vehicles, totaling approximately 9.2 million units [8].

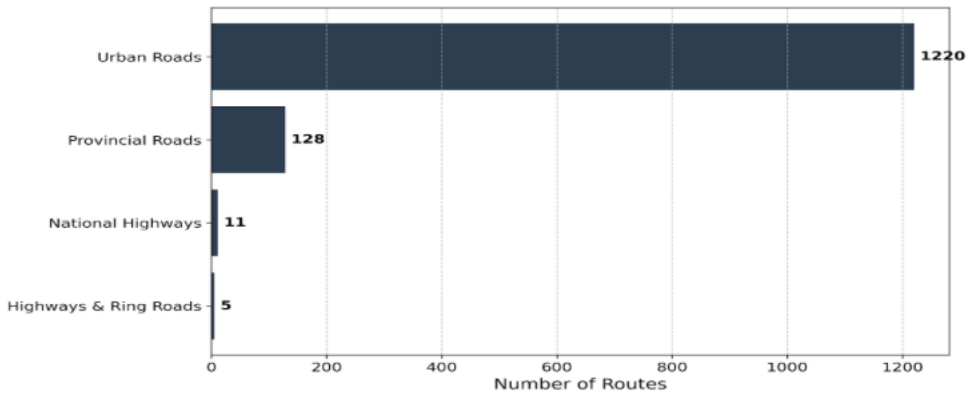

Figure 1. Hanoi road infrastructure breakdown

Within this composition, motorcycles account for the largest proportion at 6.9 million units, while automobiles number approximately 1.1 million units. Additionally, the daily influx of vehicles from other provinces circulating

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within the city is significant, estimated at 1.2 million units. This massive concentration of private vehicles exerts immense pressure on the city's existing transportation infrastructure.

Public transportation in Hanoi comprises buses, urban rail, and taxi services. The bus network includes 154 conventional routes operating 2,279 vehicles, along with 01 Bus Rapid Transit (BRT) line, and 02 operational elevated rail lines. Currently, the public transport modal share accounts for approximately 19.5% of passenger travel. Furthermore, taxis and contract vehicles contribute significantly to urban passenger mobility. It is also estimated that approximately 13% of the regular traffic volume originates from other provinces.

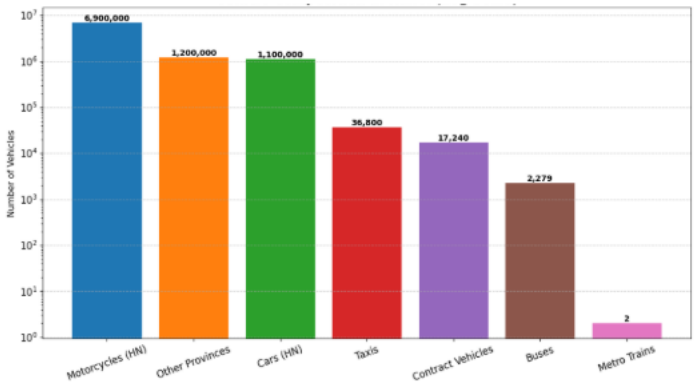

Figure 2. Vehicle Composition in Hanoi

The current growth rate of vehicles in Vietnam is 11 to 17 times higher than the rate of road expansion. Meanwhile, the growth rate of private automobiles is increasing by approximately 10% per annum, which is more than 30 times the growth rate of land area designated for transportation. This reality indicates:

(i) *Existential Systemic Imbalance.* A systemic imbalance currently exists within the urban structure. The urban land fund designated for transportation is finite, and the exorbitant costs associated with road expansion result in a sluggish pace of development. The land area for transportation increases by only approximately 0.3% per annum; consequently, for every new kilometer of road constructed, tens of thousands of new vehicles enter the system, correlating with rising income levels. Therefore, relying solely on road expansion will never resolve the issue of traffic congestion.

(ii) Furthermore, the excessive scale of private vehicles serves as an alarming indicator of resource inefficiency. Private transportation consumes a disproportionate amount of road surface area, while simultaneously encroaching upon public space for parking—including roadways, sidewalks, and urban green spaces.

(iii) *Pressure on Net Zero Objectives.* Traffic congestion causes CO2 emissions per kilometer to multiply significantly compared to standard operational speeds. Research indicates that a conventional passenger car emits approximately 250–252g of CO2 per kilometer. Annually, a single automobile releases an estimated 3 tons of CO2 into the environment [9]. According to the national greenhouse gas (GHG) inventory, the transport sector accounts for 30 million tons of GHG emissions, representing 11% of the total emissions across the economy. Over the past decade (from 2014 to the present), these emissions have surged from 30 million tons to 45 million tons. Projections suggest that by 2030, GHG emissions across Vietnam could reach nearly 90 million tons and will continue to escalate rapidly in subsequent years [10]. Furthermore, this situation results in billions of USD in annual losses due to lost labor hours, increased fuel consumption, and public health expenditures.

In 2021, at COP26, Vietnam committed to the United Nations to reach net-zero emissions by 2050—a profoundly challenging objective. Beyond international commitments, statistics from the Ministry of Health indicate that lung cancer is the second leading cause of death in Vietnam, with air pollution identified as a primary contributing factor [11]. This leads to severe consequences for families and directly impacts social welfare. Meanwhile, mechanical population growth remains an unaddressed reality. Consequently, Hanoi must simultaneously confront multiple complex issues. Reducing emissions through transportation is an urgent solution to achieve low-emission targets and eventually net-zero. Executing this requires an energy transition—shifting from high-emission energy

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sources to clean energy—and a systemic shift in transportation: moving from internal combustion engines to electric motors, and from private vehicles to public transit.

Government Actions and Initial Results

(i) Government Actions

The Vietnamese government and Hanoi authorities have launched strategic frameworks to accelerate the green transport transition. Hanoi targets 100% of its public bus fleet running on electric and green energy by 2030, with a phased conversion starting from 2025 and reaching 34–79% by 2027–2029 [12]. A policy package supports enterprises and citizens to shift from internal-combustion vehicles to electric and public transport, including 100% exemption of registration and license-plate fees for green vehicles [12]. The city has embedded "Low Emission Zones" (LEZ) into the Capital Law, piloted from 1 January 2025 in Hoàn Kiếm and Ba Đình and expanded to nine wards inside Ring Road 1 from 1 July 2026, where older, high-emission vehicles are restricted and EVs, buses, walking, and cycling are prioritized [13]. Hanoi is also investing in charging and refueling infrastructure and expanding a multi-modal public transport network (buses, metro, cycling, walking) to reduce dependence on private cars and motorcycles (VOV, 2026).

(ii) Current Results of the Transportation Transition in Vietnam

As of March 2026, the capital's transportation system has recorded breakthrough transformations, signaling positive progress in the roadmap to "green" the city's vehicle fleet.

No	Category	Unit	Results
1	Increase in bus ridership	%	1.2
2	Urban rail daily ridership	Passengers/day	80.000
3	Green conversion rate of taxis	%	47,4
4	Green conversion rate of contract vehicles	%	46.5
5	Public bicycle-sharing network	Vehicles	1100

Table 1: Statistics on Green Transportation Transition Results in Hanoi

Source: [14], [15], [16].

Notably, the green conversion rate for taxis and contract vehicles has exceeded 46%. This figure demonstrates that Hanoi's passenger transport companies and contract drivers are responding rapidly to the policies and strategic plans initiated by the Hanoi People's Committee. This index serves as clear evidence of the agility and adaptability of transport enterprises and ride-hailing drivers in aligning with the city's strategic vision. Furthermore, it confirms that charging infrastructure development and supportive government policies have begun to deliver tangible practical results.

The daily ridership of the urban rail system, which has reached 80,000 passengers per day, indicates a significant shift in public behavior. This trend reflects a growing transition from private vehicle usage to green, modern, and punctual public transportation alternatives.

Bus ridership has also recorded an upward trend. Although the figures remain relatively modest, the continued growth in bus passenger volume—even as it shares market share with the Metro system—is a positive indicator. This suggests that the bus network is effectively fulfilling its role in passenger collection and network connectivity.

In addition, the public bicycle-sharing network has contributed to diversifying public transportation options, providing residents with greater mobility flexibility while encouraging a green and active lifestyle.

Despite the emergence of positive signals regarding behavioral shifts, the reality of the transportation transition remains far from simple. Several critical bottlenecks continue to obstruct the progress of "greening" the transportation sector in Vietnam.

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Transition Category	Units	Scale of Transition	Emission Reduction (Tons CO2/day)
Electric contract vehicles	Vehicles	17443	659.3
Electric taxis	Vehicles	8017	303
Urban Rail (metro)	Passengers/day	80000	12
Public Bicycle - sharing	Vehicles	1100	1.5
Total			975.8

Table 2: Estimated CO2 Emission Reductions from Green Transition Initiatives in Hanoi

The high green conversion rates in the taxi (47.4%) and contract vehicle (46.5%) sectors demonstrate a successful initial phase of implementing Government policies. While the direct emission reductions from the Metro and public bicycles appear lower in magnitude, their primary value lies in improving urban space efficiency. By shifting 80,000 passengers to the Metro, the city significantly mitigates "emission compression"—the localized spikes in pollution caused by idling engines during heavy traffic congestion.
Public Health Implications: The cumulative reduction of nearly 1,000 tons of CO2 per day serves as a vital proxy for the reduction of associated pollutants such as Nitrogen Oxides and Particulate Matter. This reduction is directly linked to mitigating long-term health burdens, including respiratory diseases and lung cancer, particularly for outdoor laborers and residents living near high-density traffic corridors in areas like Ha Dong Ward.

(iii) Challenges and Obstacles

Barriers to Public Transport Adoption. Despite the modern and clean nature of electric trains and buses, several systemic barriers prevent a full-scale transition. The requirement to walk 1–2 km under extreme heat to reach stations—compounded by inconsistent schedules and a lack of seamless synchronization between buses, trains, and public bicycles—frequently drives commuters back to private vehicles. Furthermore, the operational frequency remains insufficient, leading to excessive waiting times at transit points. The limited reach of the current rail network, characterized by short route lengths and a lack of connectivity to diverse destinations, ensures that urban rail currently only serves a small segment of the population within a restricted geographical scope.

Technical and Safety Risks. Technical reliability and safety concerns remain significant hurdles. As electric vehicles (EVs) have only gained traction in recent years, the duration has been insufficient to instill full public confidence in their long-term safety. Incidents of EV fires and explosions—whether during charging or from undetermined causes—have heightened anxiety among Hanoi residents. Given Hanoi's urban morphology, characterized by high-density "tube houses" in narrow alleys and concentrated apartment living, any fire incident poses a catastrophic risk to both lives and property due to limited access and rapid spread. Furthermore, frequent urban flooding presents a constant threat of battery damage and electrical short-circuits during transit. Users also face practical operational concerns, such as battery degradation from overnight charging or prolonged use, which significantly restricts travel range. Moreover, the support ecosystem remains underdeveloped; finding replacement components is difficult, and there is a notable lack of convenient maintenance and repair services compared to the ubiquitous network of traditional "mechanic shops" serving internal combustion engines.

Economic and Income Barriers. Given that a significant majority of the population consists of middle- and low-income earners—particularly the informal labor group in Hanoi—the cost of transition is an undeniable burden. Beyond the initial purchase price of a new vehicle, the expenses associated with battery replacement and specialized electronic component repairs for electric or hybrid models remain prohibitively high. This financial reality conflicts directly with the "saving-oriented" mindset of the average consumer. Furthermore, the psychological concern regarding rapid depreciation acts as a major deterrent. For many Vietnamese citizens, a vehicle is not merely a means

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of transportation but a significant personal asset acquired after a long period of accumulation. The perceived high rate of value loss, combined with an unstable and underdeveloped secondary market for used electric vehicles, leaves potential buyers deeply concerned about the recovery value of their investment.

Infrastructure and Behavioral Barriers. The habit of utilizing internal combustion engine (ICE) vehicles has been deeply ingrained for decades due to their unparalleled convenience, characterized by rapid refueling and an easily accessible repair ecosystem. Transitioning to a technology that lacks a long-term track record of proven safety—and requiring residents to adopt entirely new behaviors, such as frequent or weekly charging—presents a significant psychological and practical challenge. Furthermore, the existing shortage of public charging stations, battery-swapping points, and designated parking spaces for charging near residential areas remains a major obstacle. For a population accustomed to the "refuel and go" model, the logistical friction of finding and waiting at charging points creates a substantial barrier to the widespread adoption of green transportation.

Policy and Awareness Barriers. The government has introduced various policies to promote the transition to green transportation. However, current tax and fee incentives remain insufficient to persuade the public to abandon internal combustion engine vehicles. A lack of distinct priority regulations for green vehicles—such as dedicated lanes or free parking—results in a lack of competitive advantage during transit. Furthermore, public awareness regarding the environmental significance of this transition remains limited. Specifically, concerns regarding the potential for increased pollution from the disposal of expired or damaged batteries constitute a significant barrier to adoption.

CONCLUSION

Transitioning to green transportation in Hanoi has become an absolute necessity. However, this process remains a complex challenge characterized by inherent contradictions: safety concerns, income barriers, and long-standing habits continue to be unresolved bottlenecks. The lack of connectivity within the multi-modal ecosystem, coupled with anxieties over technical risks, is decelerating the green transition. This transition is not merely a matter of vehicle replacement; it is a comprehensive reform of infrastructure, mechanisms, and social perception. To realize a green transportation system, regulatory authorities should focus on the following key issues:

(i) Completing the Connectivity Ecosystem: Priority should be given to last-mile infrastructure by expanding bicycle and bus networks around transit stations. The development of integrated applications to track public transport schedules across different areas is essential to help residents plan their commutes and manage their time effectively.

(ii) Standardizing Safety and Technical Infrastructure: It is crucial to issue specialized fire safety and prevention standards for charging systems, particularly those located within apartment complexes, narrow alleys, and "tube houses."

(iii) Enhancing Communication and Awareness: Public outreach should emphasize the environmental benefits and long-term economic advantages of green vehicles. Simultaneously, providing clear protocols for the disposal and treatment of waste batteries is vital to alleviate public concerns regarding battery-related pollution.

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