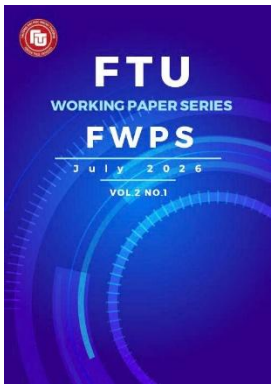

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CHUYỂN ĐỔI NHÀ KHO TRUYỀN THỐNG THÀNH NHÀ KHO XANH TRONG CÁC DOANH NGHIỆP LOGISTICS TẠI VIỆT NAM: NHỮNG BÀI HỌC RÚT RA TỪ DHL GROUP

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Tóm tắt

Bài nghiên cứu nhằm phân tích quá trình chuyển đổi từ kho bãi truyền thống sang kho bãi xanh trong các doanh nghiệp logistics tại Việt Nam thông qua nghiên cứu trường hợp của DHL Group. Bằng phương pháp nghiên cứu định tính, bài viết sử dụng dữ liệu thứ cấp từ các nghiên cứu học thuật, báo cáo ngành và tài liệu doanh nghiệp để làm rõ cơ sở lý luận về kho bãi xanh, đồng thời đánh giá thực trạng hoạt động kho bãi thực tiễn tại Việt Nam. Kết quả nghiên cứu cho thấy phần lớn doanh nghiệp logistics tại Việt Nam vẫn vận hành kho bãi theo mô hình truyền thống với mức độ ứng dụng công nghệ và các giải pháp tiết kiệm năng lượng còn hạn chế, đặc biệt trong nhóm doanh nghiệp vừa và nhỏ trong khi DHL đã triển khai chuyển đổi kho

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bãi theo hướng xanh hóa một cách có hệ thống thông qua thiết kế công trình tiết kiệm năng lượng, ứng dụng năng lượng tái tạo, tối ưu hóa vận hành và tiêu chuẩn hóa quản lý môi trường. Từ đó, nghiên cứu rút ra một số bài học kinh nghiệm cho doanh nghiệp logistics, cơ quan quản lý và các bên liên quan nhằm thúc đẩy quá trình chuyển đổi kho bãi xanh, góp phần nâng cao hiệu quả hoạt động logistics và hướng tới phát triển bền vững tại Việt Nam.

Từ khoá: Kho bãi xanh, logistics bền vững, kho bãi truyền thống, DHL, Việt Nam

TRANSFORMING TRADITIONAL WAREHOUSING INTO GREEN WAREHOUSING IN VIETNAM'S LOGISTICS ENTERPRISES: LESSONS LEARNT FROM DHL GROUP

Abstract

This study analyzes the transition from traditional warehousing to green warehousing in Vietnam's logistics enterprises through a case study of DHL Group. Using a qualitative research approach, the paper examines secondary data from academic literature, industry reports, and corporate documents to outline the concept of green warehousing and assess current warehousing practices in Vietnam. The research results show that most Vietnam's logistics enterprises still operate traditional warehouses with limited application of energy-efficient technologies, particularly among SMES. Meanwhile, DHL has systematically implemented green warehousing solutions through energy-efficient design, renewable energy integration, operational optimization, and standardized environmental management. Based on this analysis, the paper will key lessons and practical recommendations for logistics enterprises, policymakers, and other stakeholders to facilitate the adoption of green warehousing, enhance logistics performance, and promote sustainable development in Vietnam.

Keywords: Green warehousing, sustainable logistics, traditional warehousing, Vietnam

1. Introduction

In recent years, the transition towards green warehousing has become an important trend within sustainable logistics and supply chain management. As global efforts to reduce carbon emissions and resource consumption intensify, warehouses are increasingly recognized as critical facilities that require environmentally responsible redesign and operation. Academic research indicates that green warehousing has moved beyond voluntary or symbolic environmental initiatives and is now regarded as a strategic approach to achieving sustainability goals while enhancing logistics performance (Szalai et al., 2025). From an operational perspective, Kumar and Adil (2024) emphasized that energy-efficient warehouse design and optimized internal material flows are core elements of green warehousing that contribute to both environmental improvement and operational efficiency. These perspectives suggest that green warehousing has shifted from a peripheral concern to a strategic priority in modern supply chains.

This global trend is particularly relevant to Vietnam's logistics enterprises, where warehousing has become increasingly central due to rapid expansion of logistics activities and growth in e-commerce demand. Vietnam's warehouse market has experienced notable

expansion, with modern logistics and warehouse-related floor space reaching about 3.9 million square metres by the end of 2023, and a strong annual growth trend driven by commercial, manufacturing, and retail activities (Interesse, 2024; Hien, 2024). However, national logistics assessments indicate that warehouse operations in Vietnam remain largely traditional and energy-intensive. Specifically, 68.6% of surveyed enterprises reported that they have not adopted renewable energy in warehouse operations or do not lease warehouses equipped with renewable energy systems, primarily due to limited financial and technical capacity (65.3%) and high initial investment costs (29.2%) (Ministry of Industry and Trade, 2022). Research on green warehousing further highlights that the application of Energy Management Systems (EMS), efficient lighting and cooling solutions, and improved warehouse planning can reduce energy consumption and emissions while enhancing overall operational performance (Korra & Sadhana, 2024). These findings suggest that transitioning from traditional to green warehousing represents a timely and practical opportunity for Vietnam's logistics enterprises to improve both environmental and operational outcomes.

Within this context, multinational logistics enterprises provide valuable reference cases for examining green warehousing transformation in Vietnam. DHL is selected as the primary case study because its publicly reported sustainability initiatives provide a clear and structured example of green warehousing practices. Although DHL's green warehouse implementation in the Vietnamese market remains limited and not yet widely documented, the company has articulated a comprehensive sustainability strategy targeting net-zero greenhouse gas emissions by 2050, positioning climate-neutral logistics facilities as a core pillar of its global operations (DHL Group, 2022). The rationale for selecting DHL, hence, lies in examining the strategic direction, long-term commitment, and implementation logic that underpin its green warehouse transformation. By analyzing these structured and well-documented practices at the managerial and operational level, the study seeks to extract transferable principles that can be critically evaluated and contextually adapted to Vietnam's specific economic and institutional conditions.

Therefore, this study selects the topic *"Transforming Traditional Warehousing into Green Warehousing in Vietnam's Logistics Enterprises: Lessons Learnt from DHL"* with the objective of examining green warehousing concepts, analyzing DHL's global practices, and deriving practical lessons and recommendations for contextual adaptation in Vietnam. The study adopts a qualitative approach based on secondary data from academic literature, sustainability reports, government publications, and reputable industry sources, which are analyzed through synthesis and comparative analysis.

2. Literature review

2.1. Definition of green warehousing

Green warehousing refers to the application of environmental sustainability principles in warehouse design and operations in order to reduce energy consumption, GHG emissions, and overall environmental impact (Bartolini et al., 2019). Kumar and Adil (2024) argue that green warehousing simultaneously pursues environmental objectives and operational efficiency

through improved resource utilization, waste reduction, and energy management within warehouse systems.

Recent literature further views green warehousing as a comprehensive and strategic approach rather than a set of isolated technical solutions. Based on a systematic literature review, Perotti and Colicchia (2023) argue that green warehousing stems from coordinated energy-efficiency and environmental impact reduction measures applied across multiple warehouse dimensions, including building design, utilities, lighting systems, and internal logistics processes. Similarly, Korra and Sadhana (2024) highlight that green warehousing represents a system-wide shift in warehouse planning and management, reinforcing its role as a strategic component of sustainable logistics and supply chain management

In practice, green warehousing is often implemented and assessed through internationally recognized green building certification systems. Frameworks such as Leadership in Energy and Environmental Design (LEED) and the Building Research Establishment Environmental Assessment Method (BREEAM) are widely used to evaluate the environmental performance of warehouse facilities based on criteria related to energy efficiency, carbon emissions, sustainable design, and resource management (Nicoletti & Appolloni, 2024). While these systems do not define green warehousing directly, they provide standardized benchmarks that translate sustainability principles into concrete design and operational requirements.

2.2. Definition of traditional warehousing

Traditional warehousing is defined as the conventional model of warehouse operations that supports core logistics functions such as storage, inventory holding, and order fulfillment. From an operations management perspective, traditional warehouses are characterized by fixed layouts, standardized storage arrangements, and routine material handling processes, with performance mainly evaluated based on cost efficiency, space utilization, and service reliability (Gu et al., 2010).

Empirical logistics studies further describe traditional warehousing as relying largely on manual or semi-mechanized operations and established management practices to ensure stable and predictable product flows within supply chains (Rai et al., 2011). In this sense, traditional warehousing represents the baseline operational model in warehouse management theory, providing the conceptual reference point for subsequent developments in warehouse systems (Rehman et al., 2018; Kamali, 2019).

2.3. Characteristics and practices of green warehousing

Green warehousing practices can be divided into three fundamental pillars (Bartolini et al, 2019). Each pillar addresses a specific dimension of sustainability, from hardware and infrastructure to operational intelligence.

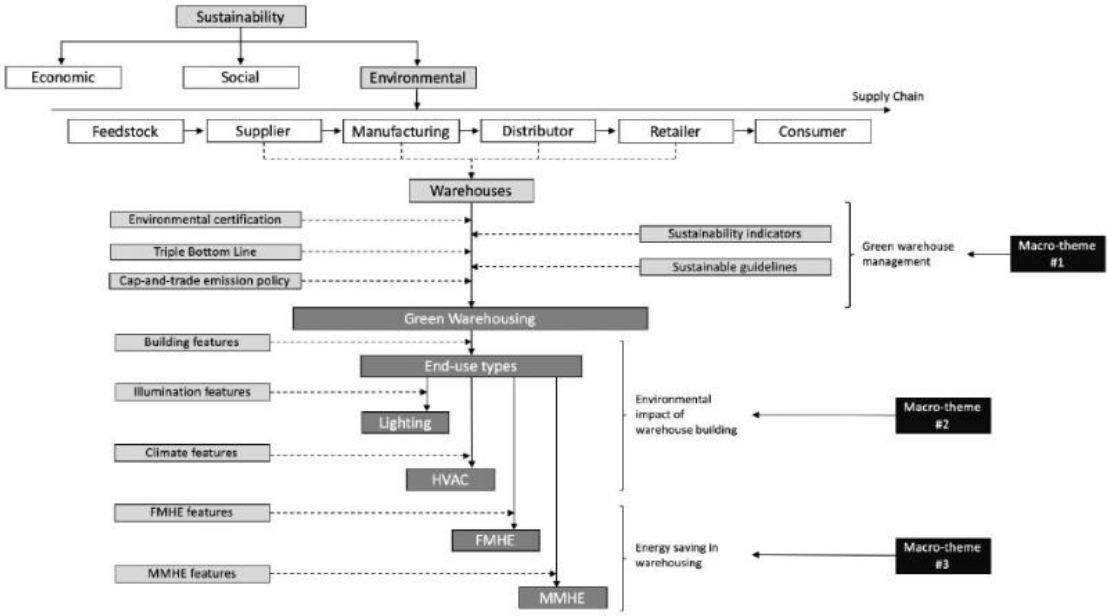

Figure 1: Classification framework of green warehousing practices

Source: Bartolini et al, 2019

The first pillar is green warehouse management, which is about the heart of the warehouse, using data and logic to ensure that every movement of a pallet or a person is necessary and optimized for the lowest environmental footprint. In reality, most enterprises implement Warehouse Management Systems (WMS) to optimize inventory control, travel distance and material flows and they also apply inventory slotting optimization to ensure fast-moving goods are easily accessible.

The second pillar is the environmental impact of warehousing building. The physical structure of a warehouse plays a critical role in reducing environmental impact by limiting energy demand for internal climate control. A green building approach treats the warehouse as an active contributor to energy conservation rather than merely a protective structure. Typical practices of enterprises include the use of skylights to maximize natural daylight and high-performance thermal insulation to reduce the energy load on Heating, Ventilation, and Air Conditioning (HVAC) systems.

The third pillar is energy saving in warehousing. Traditionally, warehouses were regarded as passive storage facilities with significant energy losses. However, rising energy costs and stricter carbon regulations have elevated the importance of improving the energy efficiency of warehouse equipment. This pillar of green warehousing focuses on replacing high-consumption machinery with energy-efficient systems. Common practices include upgrading to LED lighting equipped with motion sensors and optimizing material handling equipment, such as adopting electric or lithium-ion forklifts and adjusting the speed and acceleration profiles of automated systems like conveyors or Automated Storage and Retrieval Systems (AS/RS), to achieve energy savings without compromising productivity.

2.4. Transforming from traditional warehousing to green warehousing

Recent studies suggest that the shift from traditional warehousing to green warehousing is best understood as a gradual decarbonization and retrofitting process rather than a one-time replacement of facilities. Instead of abandoning existing warehouses, many firms begin by improving energy-intensive components such as lighting, HVAC systems, insulation, and material-handling equipment, then progressively integrate renewable energy and environmental monitoring into daily operations. This indicates that the transition is usually path-dependent and phased, especially in contexts where firms face financial and technical constraints (Ravikumar & Aarthi, 2025).

The literature also shows that transforming warehousing requires more than physical upgrades. Low-carbon warehousing depends on coordinated changes in operational routines, equipment choices, and performance management. Firms are more likely to achieve greener warehouse operations when retrofit measures are combined with better control of internal flows, energy consumption, and environmental indicators. In this sense, transformation involves both technological adaptation and organizational learning, as warehouse managers must gradually align cost, service, and sustainability objectives (Minashkina, 2024).

Therefore, the transition from traditional to green warehousing can be seen as a staged process in which firms first reduce environmental pressure in existing facilities and then move toward more integrated low-carbon warehouse models. This perspective is particularly relevant for logistics enterprises in emerging economies, where full greenfield investment may be less feasible than step-by-step warehouse greening through retrofit and operational improvement (Ravikumar & Aarthi, 2025).

3. Case study of DHL

3.1. Overview of DHL

DHL is a leading global logistics company and a part of the DHL Group, with the headquarters being located in Bonn, Germany. With about 395,000 employees in more than 220 countries and territories worldwide, and specialized solutions for growth markets and industries including technology, life sciences and healthcare, engineering, manufacturing, energy, automobility and retail, DHL is decisively positioned as “The logistics company for the world” (DHL Group, n.d.a).

With Strategy 2030: "Accelerate sustainable growth", DHL will strengthen the leading position in global logistics. DHL aims to achieve several key sustainability objectives. The company seeks to reduce GHG emissions to below 29 million metric tons of carbon by intensifying and accelerating decarbonization measures across all operations. In addition, DHL targets more than 30% Sustainable Aviation Fuel (SAF) and Sustainable Marine Fuel (SMF) blending in its Express and Global Forwarding businesses and plans to electrify 66% of its last-mile delivery vehicle fleet. In the shorter term, DHL aims to achieve a reduction of 2,000 metric kilotons of CO_2 by 2025. Furthermore, carbon-neutral design is intended to be applied to all new buildings (DHL Group, n.d.c).

3.2. Detailed implementation of transitioning towards green warehousing

3.2.1. Analysis of DHL's green warehousing practices in the world

In terms of warehousing, DHL develops carbon-neutral warehouses following a net-zero approach, based on the definition of carbon-neutral buildings established by DHL Corporate Real Estate and the recommendations of the World Green Building Council. The emission reduction strategy is structured into two levels, with the first level targeting reductions of more than 75%, and the second level aiming for a full 100% reduction (DHL Group, n.d.c).

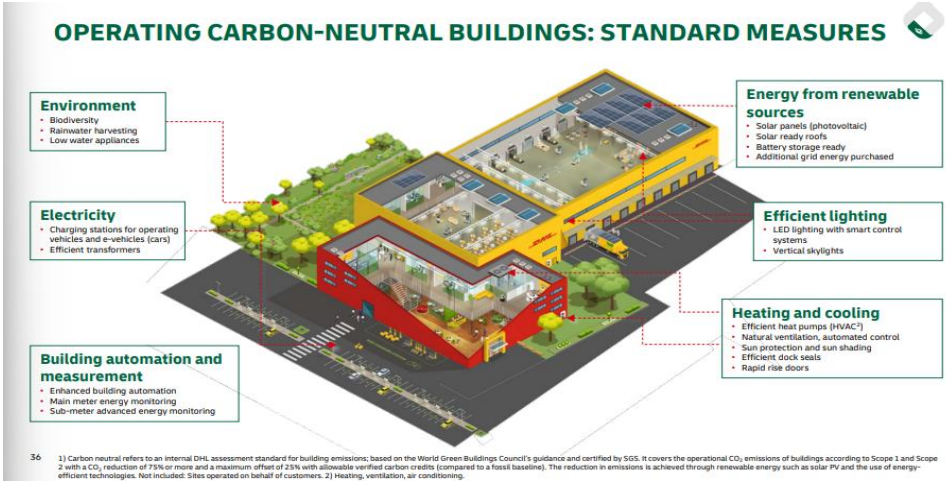

Figure 2: Standard measures of operating carbon-neutral buildings

Source: DHL Group, n.d.c

The image illustrates the standard measures for operating carbon-neutral buildings.

Regarding the first pillar of green warehousing practices which is green warehouse management, all DHL warehouses now have a system of WMS as well as EMS playing a role as the heart of analyzing the data included. These two systems will help to monitor energy consumption and provide recommendations to improve efficiency, reduce costs, and support sustainability goals.

From an environmental perspective, or more importantly, for fulfilling the requirements of the third pillar of energy saving in warehousing, the building integrates biodiversity considerations, rainwater harvesting, and low-water-consumption appliances. In terms of electricity, it includes charging stations for operating vehicles and electric vehicles, as well as efficient transformers. The building is powered by energy from renewable sources, such as photovoltaic solar panels, solar-ready roofs, battery storage readiness, and additional electricity purchased from the power grid. Efficient lighting is achieved through LED lighting with smart control systems and vertical skylights. Heating and cooling systems feature efficient HVAC heat pumps, natural ventilation with automated control, sun protection and shading, efficient dock seals, and rapid rise doors. In addition, building automation and measurement systems support enhanced building automation, main meter energy monitoring, and sub-meter advanced energy monitoring.

Regarding the prominent case of DHL Australia, which has fulfilled the second pillar of green warehousing - environmental impact of warehousing building, DHL Supply Chain

transformed its largest Life Sciences and Healthcare warehouse into a green facility by deploying Australia's first dynamic urban power station. The company began installing basic solar panel solutions on warehouse rooftops as early as 2017 and later expanded this initiative with the Urban Power Station at its Horsley Park 8 warehouse in Sydney. As a pharmaceutical - grade cold - chain facility that requires continuous high electricity consumption, the HP 8 warehouse now operates its own 1.7-megawatt Dynamic Urban Power Station, powered by 5,500 rooftop solar panels, which supply 40% of the site's electricity demand. The project was developed in partnership with Epho, a provider of commercial solar energy solutions. Beyond reducing the carbon footprint, the system delivers significant financial benefits, as the solar-generated electricity is substantially cheaper than coal-fired power, resulting in annual savings of over €180,000. Any excess electricity is fed back into the national grid, ensuring no electricity is wasted and contributing additional clean energy to the surrounding area. Approximately half of the electricity generated each day is consumed by the warehouse, while the remainder is exported to the grid. The installation is supported by smart power station software that manages electricity distribution and enhances energy security, while also supporting DHL's and its customers' sustainability ambitions and targets for sustainable warehousing (DHL Group, 2021).

In the case of Germany, DHL introduced a new carbon-neutral design for a life sciences facility at its warehouse in Florstadt, which operates as a sustainable warehouse meeting the highest GoGreen technology standards. The facility is equipped with a roof-mounted photovoltaic system and features efficient temperature management through air-source heat pumps, supported by rapid-rise doors, solar-assisted cooling, and predictive temperature controls. These modern technologies have met the second pillar of green warehousing. Energy efficiency is further enhanced by advanced lighting systems that incorporate daylight and occupancy sensors. The warehouse also utilizes a combination of lithium-ion batteries and high-frequency chargers for material handling equipment, along with recycled packaging and box-on-demand technology, which has fulfilled the third pillar requirements. As a result, the facility represents a low-carbon, highly energy-efficient warehousing solution, with reduced dependence on grid energy availability and pricing, thereby supporting the achievement of sustainability targets (DHL Group, n.d.b).

3.2.2. DHL's transition from traditional to green warehousing via GoGreen solutions

DHL has successfully implemented green logistics practices and has now published "The DHL Green Logistics Toolkit" to share green logistics strategies that businesses can follow.

Implementing green warehousing is identified as a key element of sustainable supply chain management, as warehouses play a central role in reducing carbon footprints. DHL highlights several measures, including investing in WMS to improve space utilization and stock control, which helps reduce excess inventory and potential landfill waste, particularly for unsellable or perishable goods.

The identification of energy wastage is also emphasized through the use of EMS that monitors energy consumption and provides recommendations to improve efficiency, reduce

costs, and support sustainability goals. In addition, switching to eco-friendly lighting such as LED bulbs can significantly lower electricity use, while rooftop solar panels are presented as a renewable energy solution that requires initial investment but delivers long-term financial benefits.

Efficient waste management is another priority, with dedicated recycling points helping to reduce landfill waste. DHL also notes that businesses can research available energy grants, as some governments provide funding to support sustainability initiatives such as the installation of electric vehicle charging points.

Beyond transportation, green logistics also encompasses more sustainable storage practices. Measures such as insulating warehouses can reduce energy consumption for heating and lower emissions, while reducing water waste, potentially through rainwater harvesting systems, further supports sustainability efforts. Smart technologies and automation are identified as enablers of these improvements.

Warehouse location is another important consideration. Positioning warehouses closer to customer demand can reduce emissions associated with last-mile delivery. Where main warehouses are located far from customers, introducing pop-up warehouses for high-demand products is presented as a potential solution. Additionally, for businesses with physical retail stores, delivering orders directly from stores rather than from centralized warehouses may further reduce transport emissions, depending on proximity to customers.

Overall, DHL focuses on the importance of ensuring that warehouses are environmentally friendly in terms of energy use, operational efficiency maximization to minimize emissions and waste, and careful consideration of warehouse locations to reduce last-mile transport emissions, including the option of fulfilling orders from nearby physical stores (Van Delft, 2024).

3.2.3. Evaluation of DHL's transformation

DHL's transformation from traditional to green and carbon-neutral warehousing can be evaluated as a strategic, systematic, and implementation-driven transition rather than a symbolic sustainability commitment. Through its GoGreen strategy and the Zero - Carbon Warehousing initiative, DHL has redesigned warehouse operations by integrating renewable energy systems, LED lighting, energy management technologies, and warehouse automation, significantly improving energy efficiency and reducing GHG emissions. Large-scale developments such as the carbon-neutral warehouse portfolio in Europe and the Life Sciences & Healthcare warehouse in Australia demonstrate DHL's ability to translate sustainability goals into measurable operational outcomes. Furthermore, the achievement of carbon-neutral warehousing across selected ASEAN markets indicates that this model is scalable beyond developed economies.

However, in Vietnam, DHL's green warehouse transformation remains largely at the strategic and operational improvement level, with limited public disclosure of certified green warehouse facilities. One major limitation lies in the high initial investment costs associated with green technologies, such as renewable energy systems, automation, and energy - efficient

infrastructure, which can affect short - term financial performance. In addition, the implementation of green initiatives has not been uniform across all regions, with developing markets often facing greater challenges due to limited infrastructure and regulatory support.

3.2.4. Analysis of DHL's green warehousing practices in Vietnam

DHL is implementing its green transformation roadmap in Vietnam with many significant milestones.

According to Mr. Drew Duncan, General Director of DHL Supply Chain (Vietnam), DHL has made strong investments in Vietnam and recently announced that it has been granted an Investment Registration Certificate (IRC), especially along with plans to develop green warehouses in Northern Vietnam, specifically located at Yen My I Industrial Park, Hung Yen. This demonstrates DHL's long-term and sustainable commitment to the Vietnamese market. DHL is implementing its green transformation roadmap in Vietnam with many significant milestones. Currently, all DHL warehousing operations in Vietnam have achieved carbon neutrality, with zero CO_2 emissions. Transportation is now the next key focus in DHL's green transformation roadmap. To achieve this, DHL requires support from the government, including the removal of inefficient and outdated vehicles and their replacement with fuel-efficient or electric vehicles (Tạp chí Diễn đàn Doanh nghiệp, 2024).

The second case of DHL's green application in Vietnam is that on December 12, 2023, DHL Express inaugurated a new international gateway facility near Noi Bai International Airport in Hanoi. The center is equipped with 275 rooftop solar panels, generating approximately 120 kWh of electricity per hour and reducing up to 70 tons of carbon emissions annually. DHL Express invested EUR 11.7 million in this new facility. With a total usable area of 4,500 m^2, it is twice the size of the previous facility in Bac Tu Liem District, while having up to four times greater handling capacity thanks to more advanced operating technology, according to the Group. DHL utilizes high-efficiency equipment such as IE3 electric motors for conveyor systems, 100% LED lighting, electric forklifts, and air-conditioning systems using variable refrigerant technology (inverter technology). To conclude, in Vietnam, DHL Express is currently operating 10 service points, 2 international gateways, 9 operational centers (including 5 centers that have achieved TAPA certification from the Transported Asset Protection Association - the "gold" standard for security in the transportation and logistics industry), 4 transit stations, and 211 delivery vehicles nationwide, and these are all working towards green solutions (Thế giới tiếp thị, 2023).

The third case is that on November 28, 2025, Agribank officially increased its adoption of the GoGreen Plus service to 90% for international document shipments. This marks an important milestone, affirming a shared commitment to reducing CO_2 emissions through the Sustainable Aviation Fuel solution based on DHL's in-setting approach (DHL Group, 2025).

3.2.5. Lessons learnt for Vietnamese enterprises from DHL stories

There are the key conditions required for a successful transition to a green warehouse model. These include adequate financial resources to support high upfront investments, access

to appropriate technologies and infrastructure, strong commitment from top management, and a supportive institutional and regulatory environment. In addition, organizational readiness, such as skilled human resources and the ability to integrate sustainability into operational strategies which plays a crucial role in ensuring an effective transformation process.

Furthermore, although DHL is a big corporation with huge capital and investment, Vietnamese firms, especially small and medium enterprises (SMEs), can gradually apply the "GoGreen Tookit Solutions" in order to tranform their warehouses into green ones. As mentioned above, Agribank has recently used this service to ship 90% of their international documents by SAF fuels. It is suggested that adopting a gradual and strategic approach to green transformation rather than implementing changes all at once, prioritizing initiatives with the highest environmental and economic impact, and leveraging digital technologies to improve efficiency. The first step can begin with installing rooftop solar panels or using electric forklifts.

4. Current warehousing status in Vietnam's logistics enterprises

4.1. Overview of warehousing in Vietnam's logistics enterprises

Vietnam Logistics Research and Development Institute (2025) indicates that although green logistics has been included in the strategic agendas of 73.2% of logistics firms, practical implementation remains fragmented and limited. This gap is mainly caused by the absence of clear operational guidelines, inadequate financial incentives, and weak internal capabilities, resulting in a slow and uneven green transition across logistics activities in Vietnam.

In warehousing, green transformation lags behind sectoral growth. Vietnam has over 4 million square meters of leasable warehouse space, expanding at an average rate of 23% annually during 2020 - 2023, yet 68.6% of enterprises do not use renewable energy in warehouse operations. The main barriers are insufficient technical and managerial resources (65.3%) and high investment costs (29.2%). Among the 31.4% of firms using renewable energy, solar power dominates (81.8%), followed by hydropower (18.2%) and wind energy (12.1%), demonstrating only a modest shift toward sustainable warehousing (Tạp chí Cộng sản, 2025).

In packaging, market growth contrasts with limited green adoption. Plastic packaging is projected to increase from 10.07 million tons in 2023 to 15.09 million tons in 2028 (8.44% annually), while paper packaging is expected to grow from USD 2.37 billion to USD 3.77 billion (9.73% annually). Currently, 42.9% of enterprises use eco-friendly materials such as paper and carton, and only 1.2% use wooden packaging. Regulatory measures under Decree No. 08/2022/ND-CP are expected to accelerate change, with bans on single-use and non-biodegradable plastics after 2025 and a complete phase-out targeted after 2030 (Huong & Hai, 2025).

In logistics information systems, digitalization remains low, limiting green efficiency gains. Approximately 90% of logistics firms are still at the initial stage of digital transformation, with 97.8% relying on basic tools such as Excel and Google Sheets, and 94.8% using Vietnam Automated Cargo Clearance System (VNACCS) due to regulatory

requirements. Advanced systems with high optimization potential remain underutilized, with adoption rates of 34.3% for Freight Management Software (FMS), 32.1% for Customer Relationship Management (CRM), 11% for Transportation Management System (TMS), 10.1% for Warehouse Management System (WMS), and 6.3% for Order Management System (OMS), constraining the effectiveness of green logistics initiatives (Huong & Hai, 2025).

Overall, despite rapid growth in infrastructure and market scale, Vietnam's logistics sector shows a significant lag in green transformation due to high investment barriers, a reliance on traditional packaging, and a low level of digitalization.

4.2. Opportunities in the transition to green warehousing in Vietnam's logistics industry

There are a range of opportunities regarding the transformation to green warehousing in Vietnam, including internal firm factors, market and stakeholder factors and policy and regulatory factors.

Regarding internal firm factors, the transition to green warehousing presents significant opportunities for Vietnamese logistics firms to enhance both operational efficiency and long - term competitiveness. By investing in digital solutions such as Warehouse Management Systems (WMS) and automation technologies, firms can optimize space utilization, reduce inventory waste, and improve overall productivity. In addition, adopting energy - efficient equipment, such as LED lighting or better insulation, can lower operating costs over time.

Regarding market and stakeholder factors, from a market perspective, increasing demand for sustainable supply chain solutions, especially from multinational corporations and export - oriented clients will creates strong incentives for Vietnamese logistics providers to adopt green warehousing practices. Many global partners are now requiring compliance with environmental standards as part of supplier selection, which opens up opportunities for firms that can demonstrate green capabilities.

Regarding policy and regulatory factors, the policy environment in Vietnam is increasingly supportive of green transformation, offering favorable conditions for logistics firms to adopt sustainable warehousing practices. Government initiatives promoting green growth, energy efficiency, and emissions reduction provide both strategic direction and potential financial incentives, such as tax benefits or access to green financing.

In practice, several logistics companies in Vietnam have already begun implementing elements of green warehousing. For instance, Gemadept has invested in modern warehouse infrastructure and operational optimization to improve efficiency, while Transimex has applied advanced warehouse management systems and energy - saving solutions in its logistics centers. Although these efforts are still at varying stages, they demonstrate a growing trend among Vietnamese logistics enterprises to move toward greener and more sustainable warehousing models.

4.3. Challenges in the transition to green warehousing in Vietnam's logistics industry

There are three main challenges regarding the transformation to green warehousing in Vietnam, including internal firm factors, market and stakeholder factors and policy and regulatory factors.

Regarding internal firm factors, most logistics enterprises are SMEs with limited financial capacity, which restricts their ability to implement green logistics despite recognizing its benefits. While large and foreign-invested firms are more active in adopting low-energy warehouses and electric delivery vehicles, SMEs, although dominant in Vietnam, lack the resources to invest and therefore slow the diffusion of green logistics.

Regarding policy and regulatory factors, current green logistics policies mainly provide strategic orientation rather than concrete incentives. The lack of effective financial support and enforcement mechanisms limits their ability to motivate enterprises to undertake substantial green investments.

With respect to market and stakeholder factors, Vietnamese customers show a low willingness to pay for green add-up costs. This weak demand reduces firms' incentives to invest in environmentally friendly solutions and hinders the development of a sustainable logistics market. From the supply side, this market constraint is further reinforced by technological factors, as the high costs of electric trucks, batteries, charging infrastructure, and green warehouse facilities significantly increase initial investment requirements. These costs widen the technological gap between large firms and SMEs, limiting the availability and diffusion of green logistics solutions in the market. As a result, the market for green warehousing equipment and services remains underdeveloped.

5. Recommendations for Vietnam

5.1. For logistics companies

Vietnam's logistics enterprises should transition towards green warehousing step by step, rather than pursuing full carbon neutrality from the beginning. The case of DHL shows that green warehousing does not require an immediate transformation, but can be structured into two levels by initially targeting reductions of more than 75% before moving to net-zero carbon emissions. This approach is suitable for Vietnam's context in which most logistics companies are SMEs with capital limitations that make large-scale green investments difficult.

In the first phase, Vietnamese warehouse operators should start with low-cost, high-impact measures such as replacing conventional lighting with LED systems equipped with motion and daylight sensors. The installed cost of LED lighting may cost USD 3 - 4,5 per square foot based on international benchmarks, meaning that a large-sized warehouse in Vietnam (500 - 1000m²) may require around USD 16,000 - 49,000 for LED retrofits, although actual costs in Vietnam could be lower due to cheaper labor (Delta Wye, n.d.; Eimskip, 2025; Vietnam News, 2025). Despite higher upfront costs, LEDs provide a better return on investment (ROI) due to lower energy usage and fewer replacements (Guinto, 2024). According to Shop Energy Prices (n.d.), LED retrofits can reduce lighting energy consumption by 55 - 75% compared to traditional fixtures, with typical payback periods of 1 to 2 years. At the same time, companies should

optimize existing digitalization as the fundamental foundation for green warehousing, especially when weak digital capacity remains a main problem in Vietnam's logistics sector. Instead of making immediate large-scale investments, firms can begin with simple or cloud-based WMS solutions for basic tasks and gradually upgrade them with advanced functions like labor and equipment tracking, improved slotting rules, and energy monitoring. Meanwhile, larger warehouses can integrate energy data into WMS or dashboards to measure efficiency indicators like energy use per pallet or order. These help reduce internal travel distance, idle time, and energy consumption while keeping investment costs manageable.

In the next phase, cost savings made previously should be reinvested into larger upgrades, namely rooftop solar panels and cleaner material-handling equipment. According to Logistics Vietnam 2026 Report by the Ministry of Industry and Trade, solar power is most dominant in Vietnamese warehouse operations (U&I Logistics, 2023). FBC Asean (n.d.) states that average solar panel pricing in Vietnam was USD 280 per kWp in 2024 with further reductions forecast as production scales increase, so a Vietnam's medium warehouse installing a 500 kWp system would now require an investment of roughly USD 150,000. This is capable of supplying around 30 - 40% of annual electricity demand, consistent with DHL's global practices as seen in Australia or Thailand. Leasing models or power purchase agreements (PPAs) could reduce upfront payment to below 20%, improving feasibility for SMEs in Vietnam (IRPC Green Energy, n.d.). Gradual replacement of diesel forklifts with lithium-ion electric forklifts is also recommended. Similarly to LED lighting, lithium-ion forklifts require higher upfront costs but reduce operating energy costs by up to 35% compared with internal combustion engines with lower maintenance costs and longer lifespan (HELI Forklift, 2025; GoodSense Forklift, 2025). In parallel with infrastructure upgrades, logistics firms in Vietnam should develop green transport services similar to DHL's GoGreen Plus model. DHL Group introduced GoGreen Plus to reduce Scope 3 emissions by using SAF, allowing customers to directly lower emissions from air shipments. In Vietnam, Agribank increased its use if GoGreen Plus to 90% of its international document shipments in 2025, so Vietnamese providers can cooperate with airlines and fuel suppliers to offer similar SAF-based or carbon-insetting services.

After these two phases, larger firms then should integrate EMS modules or energy-monitoring sensors into warehouse operations to track energy use and standardize green practices, while selected warehouses in Hanoi, Ho Chi Minh City, and Hai Phong can serve as pilot green facilities for the industry, similar to DHL's Hung Yen green development strategy. Over time, this phased road map allows Vietnamese logistics companies to reduce energy consumption and emissions in a realistic and affordable way.

5.2. For policymakers

To accelerate the transition from traditional to green warehousing, Vietnamese policymakers should move beyond general strategies and introduce financial incentives specifically focusing on warehouses. The government could launch a Green Warehouse Incentive Fund offering preferential loans or interest rate subsidies for warehouse green upgrades and partial investment grants for LED lighting, solar panels, and energy monitoring

systems. Vietnam is currently drafting a decree to provide a 2% annual interest rate subsidy for private businesses implementing green and circular economy projects (Saigon Giai Phong News, 2025). Given that modern warehouse space in Vietnam reached about 3.9 million square meters by 2023, even modest efficiency improvements across a portion of this area thanks to financial incentives could generate significant emission reductions. Pilot incentive programs therefore should be launched in major logistics hubs, like Ho Chi Minh City, Binh Duong, and Hai Phong, where warehouse concentration and energy use are greatly high.

Moreover, policymakers should develop a Vietnam-specific green warehousing guideline, inspired by DHL's Green Logistics Toolkit but adjusted to local conditions. Although international certification systems like LEED and BREEAM are useful references, they are often costly and complex for many Vietnamese SMEs. A national guideline should instead concentrate on practical and measurable criteria, including minimum energy efficiency standards for lighting, recommended levels of renewable energy use, and suggested technologies by warehouse size and industry.

5.3. For other stakeholders

It is highlighted that Vietnamese customers generally show a low willingness to pay more for green services, which weakens firms' incentives to invest in sustainable warehousing. DHL's experience shows that this can be effectively implemented when sustainability goals are aligned across supply chain partners. It can be demonstrated by the case of DHL's GoGreen Plus Service adopted by Agribank, which has reduced its carbon emission by 90% SAF-based shipment. In Vietnam, therefore, large manufacturing companies and retailers should collaborate with logistics service providers by jointly investing in green warehouse infrastructure, such as solar power systems and energy-efficient equipment, in exchange for long-term service contracts or shared cost savings. This approach helps lower financial pressure on logistics SMEs while ensuring more stable and sustainable supply chain operations.

Commercial banks should expand green credit lines aligned with Vietnam's Green Growth Strategy. Although the State Bank of Vietnam has already encouraged green credit development, it should further promote progress by developing the expertise of the employees taking charge in green credit appraisal and look for long-term funding beyond international funds (Tạp chí Công thương, 2024). In this way, firms are encouraged and supported to go towards green practices.

6. Conclusion

Green warehousing has become an essential element of sustainable logistics, marking a fundamental shift from conventional warehouse operations toward environmentally responsible and efficiency-oriented models. This study highlights that warehouses play a strategic role in lowering carbon emissions, optimizing resource use, and enhancing logistics performance. In the context of Vietnam, where logistics activities and warehouse capacity are expanding rapidly, the transition to green warehousing is both environmentally necessary and economically relevant, particularly given the dominance of SMEs with limited financial and technological capacity. The case of DHL illustrates that this transformation can be systematically achieved through energy-

efficient building design, renewable energy adoption, digital warehouse management systems, and standardized sustainability practices, positioning green warehousing as a long-term strategic investment rather than a short-term compliance effort.

Despite these insights, the study faces several limitations. The research relies primarily on secondary data, which restricts the assessment of firm-level operational challenges. Moreover, DHL represents a large multinational enterprise with extensive financial and technological capabilities, which may not fully reflect the constraints experienced by SMEs in Vietnam. In addition, publicly available data on green warehousing practices in Vietnam remains limited, as many logistics firms have not yet systematically reported environmental performance indicators. These limitations suggest that future research could benefit from primary data collection and comparative case studies to provide a more comprehensive understanding of green warehousing adoption in Vietnam.

Based on the findings, several key lessons and recommendations can be drawn for Vietnam. First, logistics enterprises should adopt a phased approach toward green warehousing, starting with low-cost and high-impact solutions such as LED lighting, warehouse layout optimization, and basic digital systems before advancing to more capital-intensive technologies. Second, digitalization should be recognized as a foundational enabler of green warehousing, as systems such as WMS and EMS support both operational efficiency and environmental performance. Third, at the policy level, supportive regulations, targeted financial incentives, and practical national guidelines are needed to reduce investment risks. Finally, stronger collaboration among logistics firms, investors, and industry associations is essential to facilitate knowledge sharing and accelerate the diffusion of green warehousing practices. By adapting international best practices to local conditions, Vietnam can effectively advance green warehousing as a pathway toward sustainable logistics development.

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