Green transition of seaports in the Central region: current situation and solutions

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Abstract: *The Central region of Vietnam concentrates many strategic seaports, such as Tien Sa, Dung Quat, Quy Nhon, Nghi Son, and Van Phong. Acknowledging the inevitability of transitioning to a green development model in the international maritime sector, the Government has promulgated several important policies to promote the green transition of the seaport system, laying the foundation for developing a national green port system. However, implementation at Central seaports remains limited, particularly concerning specific criteria such as shore power, renewable energy, technology adoption, and environmental management. Based on an assessment of the degree of green transition, the author proposes several solutions to promote the development of green ports in the Central region, thereby contributing to realizing the goal of net-zero emissions by 2050 and enhancing the competitiveness of Vietnam's seaports within the global logistics chain.*

Keywords: *Seaport; green port; Vietnam green port criteria; sustainable logistics; Central Vietnam.*

1. Introduction

Amid the global uncertainty of climate change developments, transitioning to a green, circular, and sustainable development model has become an inevitable trend in the international maritime industry. According to the International Maritime Organization (IMO), maritime transport accounts for about 2.89% of global CO_2 emissions (IMO, 2020). Meanwhile, international policies - such as the IMO's strategy for reducing greenhouse gas emissions from ships and the agreements at COP26 (the 26th UN Climate Change Conference of the Parties) - have placed considerable pressure on coastal nations, compelling them to adjust their seaport development strategies toward emissions reduction, energy optimization, and the adoption of environmentally friendly technologies.

"Greening" seaports is a global trend, and Vietnam is no exception. Reducing emissions at seaports not only increases the efficiency of the maritime economy but also helps create opportunities for enterprises to replace outdated equipment with high-efficiency, energy-saving, and environmentally friendly technology. As seaport operations also negatively impact the environment and human

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health, developing a green port model with green criteria that ensure both economic development and environmental protection is an urgent requirement.

In Vietnam, the orientation for green port development has been concretized through documents such as: Decision No. 876/QD-TTg dated 22 July 2022 of the Prime Minister approving the Action Program on green energy transition and the reduction of carbon and methane emissions in the transport sector; Decision No. 2027/QD-BGTVT dated 29 October 2020 of the Ministry of Transport (now the Ministry of Construction) approving the Green Port Development Scheme; Decision No. 1909/QD-CHHVN dated 29 December 2022 of the Vietnam Maritime Administration announcing the Basic Standard on Vietnam's Green Port Criteria. However, actual implementation remains slow, especially in regions with significant potential such as the Central region.

In Vietnam, the Central region occupies an important geostrategic position with a long coastline and a system of key seaports such as Tien Sa (Da Nang), Dung Quat (Quang Ngai), Quy Nhon (Gia Lai), Van Phong, and Cam Ranh (Khanh Hoa). This region is considered the "backbone" connecting the East-West economic corridor and an international maritime logistics gateway. However, most seaports here are still at a traditional development level and have not achieved the green criteria as required. This creates environmental pressures and reduces competitiveness in attracting international shipping lines, especially as carriers increasingly prioritize ports with strong environmental metrics, renewable energy use, and clean technologies (UNCTAD, 2023). Therefore, assessing the current status of green transition at Central seaports and proposing appropriate solution sets is of special importance, not only helping localities and enterprises reposition development strategies but also contributing to realizing Vietnam's commitment to net-zero emissions by 2050, while enhancing the competitiveness of the Central port cluster within the global logistics chain.

2. Current state of seaport operations in the Central region from the perspective of "green transition"

2.1. Vietnam's commitments and criteria in the green transition of seaports in the Central region

In response to global environmental requirements, Vietnam has demonstrated strong determination to reduce greenhouse gas emissions and transition to green energy, particularly in the transport and seaport sectors. At COP26 held in the United Kingdom in 2021, the Prime Minister committed to achieving net-zero emissions by 2050, marking a turning point that underscores Vietnam's proactive role in the fight against climate change (Prime Minister, 2021).

A series of important legal documents have been promulgated to realize this commitment, laying the groundwork for developing a national green port system. Specifically, Decision No. 876/QD-TTg dated 22 July 2022 of the Prime Minister on the Action Program for green energy transition and reduction of carbon and methane emissions in the transport sector. In the maritime field, Decision No. 2027/QD-BGTVT dated 29 October 2020 of the Ministry of Transport on the Green Port Development Scheme in Vietnam clarifies the strategic direction for the sector. At the same time, the Basic Standard on Vietnam's Green Port Criteria, code TCCS 02:2022/CHHVN, compiled and announced by the Vietnam Maritime Administration, has established a system of green port evaluation criteria consisting of three pillars: Commitment and Readiness; Action and Implementation; Effectiveness and Efficiency (Vietnam Maritime Administration, 2022). At

the Vietnam Logistics Forum 2023, representatives of the Ministry of Transport and the Vietnam Maritime Administration continued to emphasize the requirement to "prioritize green port implementation first at strategic port clusters such as the Central and Southern regions" to create pilot models that lead the transition across the industry (Ministry of Transport, 2023) *(Table 1).* This is an important legal foundation for gradually forming and developing green seaports in accordance with international standards.

Table 1. Summary of Vietnam's commitments

Document/Forum	Main commitments/directives	Issuing authority/Organization	Year issued
COP29	Promote the updating of NDCs (nationally determined contributions), requiring concretization of the emission-reduction roadmap in transport and port infrastructure	Member states (including Vietnam)	2024
Vietnam Logistics Forum	Prioritize green port implementation in strategic areas such as the Central region	Ministry of Industry and Trade - Ministry of Transport	2023
Decision No. 876/QD-TTg	Action Program for green energy transition in the transport sector	Prime Minister	2022
TCCS 02:2022/CHHVN	Green port criteria comprise 3 groups: Commitment - Action - Effectiveness	Vietnam Maritime Administration	2022
COP26	Vietnam commits to net-zero emissions by 2050	Government of Vietnam	2021
Decision No. 2027/QDBGTVT	Approval of the Green Port Development Scheme in Vietnam	Ministry of Transport	2020

Source: Compiled by author (2025).

The Basic Standard on Vietnam's Green Port Criteria (TCCS 02:2022/CHHVN) is built on an integrated foundation of the International Maritime Organization's (IMO) standards, clean energy orientation, and the specific characteristics of port operations in Vietnam. The three main criteria groups include: (1) Commitment and Readiness (30%): green port development strategy, budget allocation, periodic reporting, and awareness training; (2) Action and Implementation (50%): application of renewable energy, shore power, fuel consumption reduction, information technology applications, and waste classification; (3) Effectiveness and Efficiency (20%): emissions reduction, air quality improvement, and results of noise and wastewater control *(Table 2).*

Table 2. Major and specific criteria for green port evaluation

Major critera	Specific criteria	Referenced content
Commitment and Readiness (30%)	Awareness and readiness regarding green ports (60%)	Green port strategy, budget allocation, annual reporting
	Promotion of green ports (40%)	Training, communication, and outreach campaigns promoting green ports
	Clean energy (10%)	Renewable energy, liquefied natural gas (LNG), shore power, zero-emission vehicles
	Energy saving (20%)	Energy-saving equipment, operational optimization
Action and Implementation (50%)	Information technology applications (25%)	Automation, e-port, mobile apps, port operation software
	Resource use (10%)	Material reuse, eco-friendly materials, water conservation, plastic reduction
	Environmental protection (25%)	Control of air pollution, noise, port and ship waste
	Green management (10%)	Environmental and safety ISO, green performance assessment, green supplier selection
Effectiveness and Efficiency (20%)	Energy saving (50%)	Reduced energy consumption, increased use of renewable energy
	Environmental protection (50%)	Air quality improvement, control of noise and waste, climate change adaptation

Source: Vietnam Maritime Administration (2022)

Applying these criteria in practice is not only a requirement for compliance with national policy but also a prerequisite for Vietnam's seaports to maintain and enhance competitiveness in a context where international logistics increasingly prioritizes ESG (Environmental - Social - Governance) standards in transport and logistics operations (UNCTAD, 2023). However, based on pilot implementation, the green criteria for Vietnam's seaports need to be further refined.

The Vietnam Maritime Administration (Ministry of Construction) has issued a plan to implement the Green Port Development Scheme in Vietnam, whereby during 2021 - 2025, efforts have focused on researching and proposing mechanisms and policies to support enterprises in advancing "green port" development; researching, applying, and transferring clean, environmentally friendly technologies in seaport operations. From 2023, the "green port" model at several Vietnamese seaports began pilot implementation and is under evaluation. In 2023 - 2025, research and proposals to revise and supplement regulations related to port planning management, investment, seaport construction, and port operation business conditions in alignment with Vietnam's "green port" criteria will be carried out. In 2025 - 2030, national technical standards on "green port" criteria will be officially developed and promulgated. The voluntary application of "green port" criteria in Vietnam will be implemented in this period, proceeding toward proposing and promulgating mandatory application for newly developed seaport systems in Vietnam. After 2030, "green port" criteria will be mandatorily applied in the planning, investment, construction, and business operation of seaports in Vietnam.

2.2. Current state of seaport operations in the Central region from the perspective of "green transition"

The Central region of Vietnam currently comprises 11 provinces and municipalities (according to Resolution No. 202/2025/QH15 dated 12 June 2025 of the 15th National Assembly and the commencement of provincial-level administrative mergers from 1 July 2025), stretching from Thanh Hoa to Lam Dong, and plays a pivotal role in the national maritime transport corridor and international connectivity. With major seaports such as Tien Sa and Chu Lai (Da Nang City); Chan May (Hue City); Dung Quat (Quang Ngai province); Quy Nhon (Gia Lai province); and Van Phong and Cam Ranh (Khanh Hoa province), this region holds a strategic position in supporting import-export, heavy industry, oil refining and petrochemicals, and multimodal logistics.

Surveys indicate that seaports in the Central region differ markedly from those in other regions in terms of scale, function, cargo structure, and readiness for green transition, specifically: Tien Sa port (Da Nang City) is the largest container port in the Central region, has implemented a TOS (Terminal Operating System), made initial investments in energy management technologies, and rolled out an e-port model; Quy Nhon Port (Gia Lai province) plays a transshipment role for bulk commodities such as clinker, coal, and woodchips; despite high throughput, it has not deployed shore power or equipment using clean energy; Dung Quat port (Quang Ngai province) mainly serves the petrochemical industrial zone, with a specific cargo structure and significant potential for investment in renewable energy (solar, biomass) due to large port land areas; Cam Ranh port (Khanh Hoa province) has ideal channel depths (-22m to -30m), suitable for large vessels and deep-water port services, but has yet to invest systematically in green transition infrastructure; Nha Trang port and other local ports are smaller, focused on domestic cargo, and have potential to develop medium-scale model green ports.

This diversity in roles and scale necessitates the urgent classification and design of appropriate green transition

roadmaps for each port group, avoiding blanket application that would waste resources and reduce effectiveness. The operational performance of key Central seaports is shown in the tables below (Tables 3 and 4).

Table 3. Cargo throughput at Da Nang and Cam Ranh port, 2023 - 2025

Unit: 1 TEU = one 20-foot container

Indicator	Unit	2023	2024	First 5 months of 2025
Da Nang port				
Total throughput	Tons	12,208,291	14,031,086	5,993,389
- of which containers	TEU	675,254	762,191	327,752
Cam Ranh port				
Total throughput	Tons	2,224,622	2,416,292	1,416,031

Source: Business performance reports of Da Nang and Cam Ranh port (May 2025).

Table 4. Cargo throughput at Quy Nhon port in 2024 and the first 5 months of 2025

Indicator	Unit	2024	First 5 months of 2025
Total throughput	Tons	11,768,779	4,228,514
1. Container throughput	TEU	174,603	79,010
- Export-import	TEU	148,342	69,880
- Domestic	TEU	26,261	9,130
2. Non-container cargo throughput	Tons	9,324,337	3,122,374

Source: Business performance report of Quy Nhon port (May 2025).

From the above data, annual cargo growth in the Central - Central Highlands region is sound and promising, averaging about 12-15% per year. However, in terms of cargo structure, except for Da Nang port, the remaining ports in the Central region mainly handle breakbulk, especially bulk cargoes (including woodchips, sand, stone, mineral ores, clinker, cement, etc.). These are low-value commodities handled and transported by rudimentary methods, with low service prices and high competition among ports. This leads to difficulty in investing in and renewing technology to improve service quality and mitigate environmental impacts. Such factors directly affect the green transition process and the region's seaport system requirements. Therefore, developing cargo sources (through industrial park development, free trade zones, etc.) and changing the cargo structure by promoting containerization are both constraints and an urgent requirement to accelerate the green transition in the region.

As Vietnam enters the phase of implementing COP26 commitments and prepares to update its NDCs at COP29, the readiness of Central seaports for greening remains significantly limited (UNCTAD, 2023;

Ministry of Transport, 2024). Based on the TCCS 02:2022/CHHVN evaluation criteria, from the "green" perspective, the current operation of Central seaports reveals several limitations: (1) Most have not implemented shore power systems - one of the basic requirements for reducing emissions from berthed ships; (2) Adoption of renewable energy remains very limited: except for certain adjacent industrial zones such as in Dung Quat where pilots exist, the remainder are mainly at the orientation stage, with some ports - such as Son Duong - Vung Ang, Ky Ha, and Nha Trang - even lacking a stated orientation; (3) Digitalization and information technology applications such as e-port, smart gate, and management software remain at a rudimentary level: only Tien Sa port has implemented e-port; Quy Nhon port is actively deploying e-port; the rest have implemented only parts of e-port, with Ky Ha port having none; (4) In environmental management, most ports have ISO 14001 certification; however, some major ports (Dung Quat port, Nam Van Phong port) do not; (5) Internal green port programs have begun to receive attention, but most are at the orientation or planning stage; notably, Ky Ha port and Dung Quat port have neither an orientation nor a plan; (6) On the waterside, large quay cranes have been converted from diesel to electric. On the landside, some ports (Da Nang and Quy Nhon) are only now investing in infrastructure and electrical equipment to convert certain equipment from diesel to electric, such as RTGs (rubber-tired gantry cranes) and conveyor lift tables (in lieu of excavators and loaders) *(Table 5).*

Table 5. Current state of green port development in the Central region

Seaport	Renewable energy	Information technology & automation	ISO 14001	Internal green port program
Cua Lo port	Orientation in place	Partial (e-port)	Yes	Orientation in place
Son Duong - Vung Ang port	No	Partial (e-port)	Yes	Orientation in place
Tien Sa port	Orientation in place	e-port	Yes	Orientation in place
Ky Ha port	No	None	None	None
Dung Quat port	Partial within the industrial zone	Partial (e-port)	None	None
Quy Nhon port	Orientation in place	e-port	Yes	Orientation in place
Cam Ranh port	Orientation in place	Partial (e-port)	Yes	Orientation in place
Nha Trang port	No	Partial (e-port)	Yes	Orientation in place
Nam Van Phong port	Partial in planning	In planning	None	Under development

Source: Compilation from Central seaports' reports (2025).

Delays in transitioning to a green port model stem from the following reasons: (1) Infrastructure constraints; (2) High upfront investment costs, particularly for shore power systems and renewable technologies, exceeding the financial capacity of port enterprises; (3) Local grid infrastructure limitations that do not meet port enterprises' electricity needs as usage scales up; (4) Lack of government incentives and financial support; (5) Shortage of digital technical personnel and specialized environmental management in the maritime logistics industry.

Recent positive moves by the Vietnam Maritime Corporation (VIMC) have provided clearer direction for the transition. At Tien Sa, Quy Nhon, Cam Ranh, and Cua Lo ports, VIMC is proactively developing phased green transition roadmaps focusing on pillars such as digital technology application, grid upgrades, renewable energy deployment, and integrating green port criteria into operational procedures.

Thus, it can be affirmed that VIMC's resolute guidance at these strategic Central ports helps close the gap with TCCS 02:2022/CHHVN and serves as a green development model across the national seaport system during 2025 - 2030. This is a prerequisite for realizing the Government's net-zero emissions goal by 2050 as committed at COP26, while raising the competitiveness of Central seaports as the global logistics sector pivots strongly toward sustainable development.

3. Tasks and solutions to promote the green transition of seaports in the Central region

3.1. Objectives and tasks for green port development

Within the roadmap to realize net-zero emissions by 2050, the maritime sector and Vietnam's seaport system are identified as priority areas for green transition. Based on the orientation in Decision No. 876/QD-TTg, the green port development scheme under Decision No. 2027/QD-BGTVT, and the basic standard on green port criteria TCCS 02:2022/CHHVN promulgated by the Vietnam Maritime Administration, and grounded in the current status of Central seaport operations from the "green transition" perspective, several specific transition targets have been set for strategic seaports in the Central region. These orientations were also emphasized at the Vietnam Logistics Forum 2023, which called for accelerating pilots at clusters such as Quy Nhon, Tien Sa, Van Phong, and Cam Ranh. Accordingly, implementing green transition tasks is not merely an optional goal for each port; it is gradually becoming an industry orientation and a condition for enhancing competitiveness, attracting international carriers, and accessing green capital.

To realize green port development in the Central region, clear targets should be set: reduce CO_2 emissions from port operations and maritime services by at least 20%; raise the share of vehicles and equipment powered by electricity or clean energy to 30 - 50%; ensure that 100% of main ports deploy an energy management system (EMS) and are evaluated under TCCS 02:2022/CHHVN; and strive for at least three ports to be recognized as "green ports" by domestic or international organizations. To achieve these targets, Central seaports need to implement five key task groups:

(1) *Infrastructure and equipment:* comprehensively survey electrical systems and port rooftops to install rooftop solar at warehouses, yards, and offices. Simultaneously, the plan is to replace diesel equipment such as RTGs (rubber-tired gantry cranes), forklifts, and terminal tractors with electric or hybrid equipment. Investment in shore power systems - including quay electrical cabinets, substations, inverters, and charging stations - must be prioritized at Quy Nhon port and Da Nang port, accompanied by sensor systems for monitoring energy consumption by each piece of equipment.

(2) *Management and operations:* adopt real-time EMS to monitor energy, develop energy performance indicators (EnPIs) integrated with national measurement systems and business operations, and establish collection points for waste recycling and internal wastewater treatment at each area.

(3) *Technology and automation:* intensify IoT applications in lighting, pumping, and cooling to save energy; synchronize the port

operating system (TOS) with enterprise resource planning (ERP) and energy monitoring software; and deploy a "digital and paperless port" model to reduce indirect energy consumption.

(4) *Waterway transport services:* study the conversion of tugboats to clean fuels such as liquefied natural gas (LNG), biodiesel, or hydrogen; invest in environmentally friendly support equipment; replace watercraft using old engines with engines meeting Euro IV emissions standards or higher; promote connections to inland container depots (ICDs) by hybrid barges; and cooperate in operating inland waterway logistics routes using electric or hybrid barges.

(5) *Internal policy and control:* stratify specific targets for each port cluster, prioritizing rapid deployment at key ports, while smaller ports implement in suitable phases. Preparing semi-annual reports and organizing cross-inspections among units will strengthen oversight, ensuring transparency and effectiveness in the green transition.

3.2. Solutions to promote the green transition of seaports in the Central region

First, refining the green criteria for seaports and improving institutions and policy mechanisms to provide synchronized support for greening the seaport system.

Under Decision No. 876/QD-TTg and TCCS 02:2022/CHHVN, applying green port criteria during 2025 - 2030 remains voluntary. However, to ensure effective enforcement, the Government needs to implement synchronized measures: (1) Promptly promulgate mandatory regulations for port planning, investment, management, and operations; (2) Adopt a strategy to select and invest in pilot green port models in advantageous locations - with Central seaports being a feasible choice - thereby drawing lessons and scaling up model examples; (3) Apply public-private partnership methods in port infrastructure investment, using state budget as "seed capital," and establish policies to attract domestic and foreign private investment, particularly "flagship enterprises" with strong finance and technology and extensive experience and prestige in seaports and maritime logistics; (4) Introduce tax incentives for equipment using renewable energy, shore power, and digitalization software for port operations. Ports such as Tien Sa and Dung Quat - with high container ship density - should be required to deploy shore power in accordance with national technical standards, compatible with both domestic and international vessels.

In addition to refining the green criteria, several policy mechanisms are proposed to provide synchronized Government support for greening Central seaports:

(1) *Supporting cargo source development:* The Government should strongly develop industrial parks in the Central region, with particular emphasis on chain connectivity and production networks from shippers to ports to ensure local cargo sources. On the other hand, the Government should develop convenient transport and transshipment solutions (road, rail, sea) from nearby domestic regions (e.g., the Central Highlands) and leverage the region's strategic geoeconomic role as an international maritime gateway serving cross-border trade for Laos, Cambodia, and Northern Thailand.

(2) *Issuing "Green Berth" certification:* To promote compliance with green container berth criteria, "Green Berth" certificates should be issued to container berths that meet all green criteria. Such certification will encourage and differentiate green berths from others, while enhancing their reputation and competitiveness. Given global shipping trends, container ports with "Green Berth" certificates will be prioritized destination choices by international shipping lines, compared with other competitive factors across the port system. At the same time, these seaports will be priority partners for international ports and shipping lines.

(3) *Adopting policies to incentivize and strengthen international cooperation:* Vietnam needs to deepen international cooperation to learn from and adopt advanced green port models from other countries. This will not only accelerate effective development and implementation of green ports - shortening the

greening process - but also open up many opportunities for cooperation and linkages with international seaports and shipping lines, while mobilizing resources in markets, technology, management, and finance from foreign partners.

Second, using technology and engineering as the key solutions to realize the transition to green ports.

In implementing the green port model, there are specific criteria related to clean energy, energy savings, information technology applications, resource use, environmental protection, and green management. Port enterprises need specific plans and roadmaps to transition to green port models. For instance, staged investments to transition to renewable energy sources (wind, solar); use of liquefied natural gas, hydrogen, ammonia, etc.; use of shore power; and use of intra-port vehicles powered by electricity or clean fuels with no greenhouse gas emissions.

Additionally, enterprises need to perfect port commercial and production processes. Investments should be made to replace and deploy energy-saving equipment and optimize electrical supply systems or other energy sources. Gradually upgrading and replacing high-consumption loads and operating equipment with energy-saving devices and new energy sources such as electricity, liquefied natural gas, and solar energy is a prerequisite. At the same time, to make seaport operations more environmentally friendly, enterprises should prepare plans and roadmaps to reduce energy consumption and greenhouse gas emissions; increase renewable energy; improve air quality; control noise; and control liquid and solid waste pollution.

In the digital economy context, enterprises should strengthen information technology applications in high-interaction, high-connectivity activities to improve operational efficiency such as online payments and electronic documents; using mobile apps for transport vehicles (terminal tractors, barges); applying electronic port software (e-port); and using planning and operation software and container management software.

According to the national roadmap, from 2031, vehicles and equipment at ports must transition to green energy, proceeding toward 2050 when 100% of equipment must meet zero-emission standards. In addition, enterprises should deploy smart port models, applying digital technologies, shared e-port systems, IoT, and automated operational management software. This approach not only improves efficiency but also significantly reduces fuel consumption and traditional paperwork. Experience from implementation at Hai Phong and Can Tho ports under the Vietnam Maritime Corporation (VIMC) shows that process digitalization shortens procedure times by 30 - 40% and reduces logistics costs by an average of 15%.

Third, adopting financial solutions, developing tax and tax-incentive policies, and establishing mechanisms to mobilize capital for developing green berths, with particular emphasis on public-private partnerships (PPP) as a condition to ensure feasibility in implementing green ports.

Investing in green ports requires large capital outlays and a staged implementation. Establishing attractive tax policies and incentives to encourage investment from domestic and foreign private investors is necessary. The Government should establish mechanisms for banks to provide concessional loans for green berth projects. The Government can also support the issuance of green bonds to attract professional investors in the environmental sector. Investment costs for shore power, solar energy systems, and green port infrastructure are substantial, exceeding the financial capacity of most domestic port enterprises. Therefore, the State should study the establishment of a Green Transition Fund for the maritime sector, combining state budget resources with revenues from the carbon market (when operational in 2028). In parallel, PPP models should be widely encouraged for deploying electric charging stations, green cold storage, and digital operation platforms. Furthermore, Vietnam should proactively access international green finance sources such as the

Green Climate Fund (GCF), the World Bank (WB), and the Asian Development Bank (ADB) to co-finance pilot projects at Van Phong or Lien Chieu - two ports with breakthrough potential in transshipment models and renewable energy.

Fourth, developing human resources and communication to raise awareness of green ports and the necessity of the green transition in seaports.

This is a factor ensuring the sustainability of all solutions. Raising awareness of green ports, the necessity of green transition in seaports, and training human resources is crucial. Port enterprises should proactively organize training programs and awareness-raising activities for employees on the importance of green ports and environmental protection measures. Specialized training programs on green logistics should be developed, in cooperation with universities, research institutes, and international organizations, to update smart port models, environmental standards, and methods for monitoring emission performance; this will train a workforce with digital capabilities and knowledge of ESG standards, green operating procedures, and data analysis skills, ensuring effectiveness in implementing green port transitions. At the same time, internal communication campaigns within enterprises and across the entire sector should be deployed to raise awareness among frontline personnel and leadership about the role of green seaport development in national strategy.

4. Conclusion

In the context of global efforts to reduce greenhouse gas emissions, developing green ports is no longer a choice but a necessity for countries with maritime economies, including Vietnam. Vietnam's commitment at COP26 and subsequent concretization through a series of strategic policy documents affirm a consistent orientation toward transitioning to green, sustainable, efficient, and environmentally friendly seaport models.

The research results show that the Central seaport system - despite its pivotal role in the national supply chain and the East–West economic corridor - is still at an early stage in the greening process. To realize the goal of net-zero emissions by 2050, developing green ports in the Central region is not merely a sectoral strategy but must be integrated into regional and national development strategies. Selecting pilots at ports with high transition potential, such as Lien Chieu, Tien Sa, and Van Phong, will be a practical step to create model examples, which can then be scaled across Vietnam's entire port system in the coming period.

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