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**CHIẾN LƯỢC CẢNG XANH Ở CÁC QUỐC GIA VEN BIỂN:  
NGHIÊN CỨU VỀ TRUNG QUỐC VÀ BÀI HỌC CHO VIỆT NAM**

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**Tóm tắt**

Khi ngành hàng hải phải đối mặt với áp lực môi trường ngày càng tăng cao, "cảng xanh" nổi lên như một tia sáng hy vọng. Việc cân bằng giữa tăng trưởng kinh tế với bảo vệ môi trường mang đến một tương lai bền vững cho thương mại toàn cầu. Nghiên cứu này đi sâu vào các chiến lược tiên phong về cảng xanh của Trung Quốc, bao gồm tập trung vào giảm khí thải, sử dụng năng lượng tái tạo và quản lý chất thải. Bằng cách phân tích những thành công và thách thức của Trung Quốc, nhóm nghiên cứu đã rút ra những bài học giá trị cho Việt Nam, gồm có chú trọng đến việc áp dụng công nghệ xanh, xây dựng khuôn khổ pháp lý vững chắc và phát triển lộ trình chiến lược rõ ràng. Bằng cách học hỏi từ kinh nghiệm của Trung Quốc và giải quyết những thách thức riêng của Việt Nam, nghiên cứu này mở đường cho việc xây dựng các cảng xanh bền vững và thân thiện với môi trường, giúp thúc đẩy phát triển khu vực, góp phần vào một ngành hàng hải xanh hơn và có trách nhiệm hơn trong tương lai.

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**Từ khóa:** cảng xanh, chiến lược cảng xanh của Trung Quốc, giảm khí thải, năng lượng tái tạo, quản lý chất thải

## **GREEN PORT STRATEGIES IN COASTAL COUNTRIES: A CASE STUDY OF CHINA AND LESSONS FOR VIETNAM**

### **Abstract**

As the maritime sector faces mounting environmental pressure, "green ports" emerge as a beacon of hope. Balancing economic growth with environmental protection offers a sustainable future for global trade. This research delves into China's pioneering green port strategies, focusing on emission reduction, renewable energy adoption, and waste management. By dissecting its successes and challenges, the team extracted valuable lessons for Vietnam, a neighboring nation aiming for similar maritime sustainability goals. The analysis reveals key takeaways, emphasizing the adoption of green technologies, the creation of a robust regulatory framework, and the development of a clear strategic roadmap. By learning from China's experience and addressing Vietnam's unique challenges, this research paves the way for establishing sustainable and environmentally friendly ports. This not only fosters regional development but also contributes to a greener and more responsible maritime industry for the future.

**Keywords:** green port, China's green port strategies, emission reduction, renewable energy, waste management

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### **Introduction**

Over the past few years, there has been a noticeable surge in global awareness and commitment towards sustainability and environmental consciousness across a wide range of industries. Among these industries, the maritime sector has emerged as a prominent player in this movement, given its pivotal role in facilitating international trade and transportation. The escalating concerns surrounding climate change, air pollution, and ecological degradation have intensified the urgency for sustainable practices within the maritime industry, reaching unprecedented levels of importance. To find a balance between protecting the environment and supporting economic development by preventing pollution and creating an eco-friendly seaport (*Darbra et al., 2005*), the model of green ports has been embraced and implemented in various regions.

Developing green port strategies to mitigate environmental impacts and promote sustainable maritime operations has become increasingly crucial in many countries, yet faces obstacles such as limited investment capital, vehicle and network limitations, and outdated facilities that hinder effective emissions-related solutions. To solve the problem of how to overcome these barriers, the research group choose the topic of: *"Green Port Strategies in Coastal Countries: A Case Study of China and Lessons for Vietnam"*. This research will focus on coastal countries, specifically China, to evaluate its activities and strategies toward satisfying the green ports criteria such as

reducing ship emissions, using renewable energy, and waste management; therefore, taking lessons to improve the situation in Vietnam.

## **1. Theoretical framework**

### ***1.1. Definition and core concepts***

Wastes such as dust, oil residues, and noise pollution from daily port operations contribute to the degradation of the ecological environment, affecting the stakeholders of the ports and the long-term strategy to develop the ports within regions. To balance the profit from shipping businesses and the effects on the environment, pursuing the development of green ports is a must for all countries. Within the framework of the shipping industry's sustainable development strategy, the concept of a “green port” has emerged and evolved through research efforts focused on sustainability (*Wang et al., 2020*). Some previous research has shown that a sustainable port, also commonly referred to as a green port, is characterized by the proactive planning and implementation efforts of the port authority in partnership with port users. It relies on an economically viable strategic plan, aligns with principles of environmental stewardship, and actively involves stakeholders in its operations (*Vellinga, T., 2011*). The World Ports Sustainability Program (WPSP) defines a green port as a port that demonstrates leadership in promoting sustainable development, addressing climate change, and integrating social, environmental, and economic considerations into its operations and planning.

The overarching concept and research of ecological port revolved around the essential need to continuously decrease detrimental environmental effects without compromising economic growth. In a broader sense, it encompasses the notion of responsible conduct across all aspects of the port, from management to every individual employee (*Pavlic, B., et al., 2014*). According to Davarzani, H. (2015), through a network analysis of the existing literature on shipping, they identified four key indicators that received significant attention in the green ports and logistics: marine pollution, greenhouse gas emissions, energy eco-efficiency, and environmental conservation. Different countries will apply different strategies, but they share some similar features. Marine pollution can be controlled when green ports apply waste management strategies and build waste-to-energy plants. Shifting from conventional fuels to clean and sustainable energy, ports can significantly reduce their carbon emissions and decrease reliance on fossil fuels. Exploring and using modern and innovative technology in port operation is another characteristic of the strategy, as it enhances overall performance by adopting advanced management systems and transportation, and therefore improves the overall environmental footprint of ports. The final attribute is stakeholders who contribute their expertise, perspectives, and resources to develop and implement sustainable practices within port operations. Their involvement helps to address diverse interests, strengthen transparency, and ensure that the green port strategy reflects the needs and aspirations of all stakeholders. For a simpler understanding, the green port concept involves high

and green technologies and renewable alternatives to reduce carbon emissions and protect the environment, especially the marine environment, with the involvement of related stakeholders.

### ***1.2. The significance of green ports in coastal countries***

Green ports are believed to be the future aim of every coastal country in the world. They play an important role in promoting sustainability, like preventing environmental damage, as well as preserving natural resources and beings around. Furthermore, they can be beneficial to society, and economic aspects and avoid legal issues.

Green ports implement numerous environmentally friendly strategies, such as reducing greenhouse gas emissions. By replacing these gasses with renewable energy, such as adding solar panels and utilizing energy from the ocean tides, a green port helps decrease a significant amount of carbon footprint in the area. For instance, Shanghai Port, although having been recorded to have a gradual rise in CO<sub>2</sub> emissions, in particular, 950,100 tons in 2008 to 1.2295 million tons in 2022, is believed to pace more slowly in releasing the gas for the next 10 years (*Zeng et al, 2023*) because of green implementations.

The method of efficient waste management also helps reduce trash production, by minimizing waste generation and maximizing recycling. A green port can minimize waste by implementing an efficient plan, using prefabricated materials, avoiding cut-offs from extra sizes of materials, and reducing packaging. With regard to recycling, it is advised to develop an effective waste collection and classification system and increase the recycling of timber, concrete, bricks, cardboard, and aluminum (*Port Authority of New South Wales, 2017*).

Not only do they protect the environment, but green ports also guarantee the well-being of workers and residents. They create safer procedures for the employees, and at the same time improve the living conditions of local people. Additionally, by generating green jobs and assisting local communities, a green port may promote social inclusion and cohesiveness. In the case of Green Port Hull in England, from the first launch in 2010 to 2020, it had a total number of 3539 jobs created or secured through a set of thorough and efficient policies in training and supporting the locals (*University of Hull, 2020*). Based on current industry figures, 76 long-term jobless persons have found sustainable employment in allied businesses, mostly in the caravan sector, translating to an additional 75 supporting jobs.

In terms of economic benefits, a green port may boost production and efficiency by streamlining operations and cutting expenses. By satisfying the growing demand from clients and authorities for sustainable services, a green port may potentially acquire a competitive advantage. As businesses choose where to base their operations, they are increasingly considering sustainability. This might draw new investment and business to green ports. Moreover, the idea of a circular economy is one more step consolidated when green ports can apply waste-to-energy technologies and use waste for secondary industries' resources. Continuing to look through the Green Port Hull case, with the investment from Siemens Gamesa, the port's activities have been a game changer for the region's economy. Direct employment by Siemens Gamesa may contribute

up to £71.3m to the GVA of Hull. The creation of 76 sustainable employment opportunities mentioned above has resulted in benefits saved between £228,820 and £288,891. According to Councillor Martin Mancey, Portfolio Holder for economic investment, regeneration, and planning, “The city’s economy is on an upward curve and Hull registered the strongest growth rate in the country, 43 percent ahead of the UK as a whole. Unemployment is at its lowest on record and Green Port Hull, alongside being the UK City of Culture, has been the major influence on these positive trends. Investments from the private sector such as RB and Smith and Nephew have also contributed to changing the fortune of the city dramatically”.

In compliance with industry standards and state regulations, green ports also avoid the possibility of getting entangled in legal issues in terms of environmental protection. This is because laws, while unfavorable, often include costs for disobeying them, and these penalties have been demonstrated to be a powerful motivator for adopting sustainable norms. Consequently, in an effort to adhere to environmental regulations, this legislation penalizes financially and even criminally for actions that impair the marine environment. In developing countries, regulation is crucial in helping ports achieve green port sustainability standards, which supports the results of the earlier research. Any company that wants to operate legally must first do this.

### ***1.3. Current Situation of Green Ports Strategy in Coastal Countries***

#### ***1.3.1. Developed countries***

Developed coastal nations are leading the way in building green ports by adopting sustainable techniques to reduce their negative environmental effects. These ports hope to attain zero-emission operations and further contribute to a more sustainable future by using decarbonization methods and cultivating collaborations.

Here are some specific cases of developed countries applying green ports:

##### ***a. Los Angeles Port, United States***

At the biggest commerce entry point in the country, employers of the port are aware of the difficulties in balancing economic boost and protecting the environment at the same time. The port has been leading globally to come up with strategies to ensure environmental quality, such as lowering air pollution, enhancing the quality of the water, updating infrastructure, and developing cutting-edge technology.

In 2023, the port formed a partnership with Yokohama Port and Tokyo Port to work together to cut pollution at seaports and establish green shipping corridors (GSC). This effort aims to promote low- and zero-carbon ships and fuels while lowering emissions along their respective trade routes. It has already established GSC partnerships with the ports of Shanghai and Singapore.

##### ***b. Project MAGPIE***

Magpie is a Horizon2020 research and demonstration project, under the Green Deal Program. In this large-scale project, the Port of Rotterdam takes up the lead position and collaborates with

the port authorities of HAROPA PORT and Sines (Portugal) DeltaPort (Germany), furthermore with 10 research institutions and more than 30 companies from the Netherlands, Germany, France, Portugal, Denmark, and Sweden. This mass collaboration aims to enforce a breakthrough in the supply and use of green energy carriers in transport to, from, and within ports, as well as turn Europe into a leading region for sustainable shipment.

### *1.3.2. Developing countries*

With obvious disadvantages compared to developed countries in most aspects, applying green technology in ports of developing nations can be a challenge. The question of which measures to use will become a conundrum when geographical, regulatory, and technical factors are brought into the picture.

Take African countries, for example, limited electrical supplies and economic constraints are great obstacles. Poor institutional frameworks and inadequate environmental management systems, the insecurities of automation taking over are also elements limiting these countries from taking further steps to protect the environment. However, there are few ports in Africa that are making efforts to sustainable development and protect aquatic natural resources. By taking an ecologically conscious approach to the preservation and protection of the environment, the Port of Tanger Med is dedicated to a persistent approach to sustainable growth. The Kenya Ports Authority (KPA) also implemented the acquisition of energy-efficient mobile port cranes, the development of a waste management plant, and the installation of solar panels (2019).

It is clear that developing countries must rely on the funding and support of developed countries in order to implement green strategies in seaports. Another key factor is an efficient institutional framework and right leadership from governments in these coastal cities.

## **2. The case of China**

### ***2.1. Background of China's Coastal Development***

Driven by globalization and economic reform, China significantly integrated its ports with global trade needs. Throughout the 1990s and early 2000s, they focused on specialized deep-water berths for larger vessels, developing a tiered port system with key, regional, and medium/smaller ports. This strategy fueled impressive growth, with coastal port throughput averaging 16.25% annually and reaching 5.48 billion tons by 2010, alongside an increase in large berths (*Ze Zhou et al., 2016*).

However, the rapid development of seaports has also created challenges for China, particularly the growing environmental concerns, requiring a delicate balance between economic strength and ecological responsibility. Therefore, in 2013, China launched the construction of a green port system with the policy of building "resource-saving and environmentally friendly" ports by implementing a series of measures to save energy and reduce emissions at ports, which Shanghai Port has made good progress in building a green port. With these efforts, in 2021, the total annual

cargo volume transported through Chinese seaports increased to over 10 billion tons and the cargo volume of inland river ports increased to 5.6 billion tons (*Statista, 2023*).

Until 2023, according to statistics, China has 76 berths that can accommodate large ships that can carry more than 14,000 standard containers, while the total number of such ports in South and Southeast Asia is only 31 (*Hua Xin, 2023*). During this period, China has actively built a clean and low-carbon energy system and strongly promoted the use of shore power in key areas, key routes, and key ships calling at ports to achieve a green transition. In particular, in September 2023, some Chinese ports, including Tianjin, Guangzhou, and Ningbo, used shore power for a total of 769,000 ships and 90.945 million kilowatt-hours at ports, an increase of 39% and 67%, respectively, from the same period in 2022 (*Li Lu, 2023*). This infers that over the years, China's coastal seaports have witnessed remarkable development and become important nodes in the global supply chain, concurrently China's coastal ports are also focusing on the comprehensive development of green ports to balance economic development and sustainable environmental protection.

## ***2.2. The Implementation of China's Green Port Strategies***

### ***2.2.1. Green port strategies for reducing ship emissions***

The strength of China's coastal ports is not only in terms of cargo volume but also in the adoption of sustainable environmental solutions. Despite the rapid development of the Chinese economy, with a vast network of over 2,000 ports in operation, the country's maritime dominance comes at an environmental cost. Shipping emissions contribute significantly to carbon emissions, with Chinese shipping companies emitting about 78 million tons of CO<sub>2</sub> each year (*Peng, 2022*). This caused serious air pollution and indirectly caused more than 5.5 million premature deaths worldwide in 2013, causing global welfare losses of 5.11 trillion USD (*World Bank, 2016*).

Recognizing these negative impacts, national green port strategies have been developed, including the active promotion of combating marine ship emissions, using a multi-pronged approach to reduce environmental concerns. In the context of "dual carbon", China has made positive progress in promoting the application of carbon reduction technologies, innovating "low-carbon and non-carbon and diversified" fuels for transport ships to promote the kinetic energy conversion of ships when docking and reducing emissions from ships.

Through the green port strategy, China has implemented the production and construction of Liquefied Natural Gas (LNG), and refueling infrastructure for transport ships. With the world's largest LNG fleet, over 1,000 LNG-powered ships navigate its waters, refueled by over 100 domestic stations, with Shanghai leading the way. This station was built in 2017 and is the first LNG refueling station in China with a refueling capacity of 120,000 cubic meters of LNG per day. It is estimated that the station has helped to reduce emissions from ships at this port by about 100,000 tons each year (*Du Yanfei, 2023*). In the operation of providing external LNG clean energy supply services for international shipping companies, Shanghai Port has integrated many resources, and scientific management, striving to achieve excellence and complete each refueling service, winning valuable shipping schedules for international shipping companies and winning

full recognition and praise from France from international container shipping companies such as CMA CGM and ZIM Lines, while helping shipping ships to reduce emissions, aiming to protect the environment sustainably. This shift towards cleaner fuels reflects China's commitment to greener port operations.

Furthermore, China is also researching and developing other clean fuels for shipping, including biofuels, hydrogen fuels, and nuclear fuels. These fuels have the potential to significantly reduce emissions from ships in the future. Some Chinese ports, such as Shanghai and Guangzhou, are actively implementing pilot projects for electric container ships and other electric vessels, exploring the use of electric propulsion instead of batteries. Consequently, China is gradually emerging as a major player in the greening of ports and has achieved significant accomplishments in its green port strategy, particularly in reducing emissions from maritime transportation (*People's Daily*, 2023).

#### 2.2.2. Green port strategies in using renewable energy

With the globalization of the economy, ports have been taking on increasingly diversified functions, and their impact has been growing immensely. However, the negative externalities associated with ports have also become more prominent. China has soon realized the importance and as of late, they have been exploring many solutions to the issues relating to the environment and resources, one of which being the world's first "zero-carbon terminal", consequently reducing investment by 30% and increasing efficiency by 20% overall.

According to a news release, the state-of-the-art zero carbon technologies are the result of 76 patents and 13 world-level breakthroughs, and they have boosted innovation for the upgrading of container terminals elsewhere. The terminal is powered by wind and solar energy, achieving zero-carbon emissions for energy consumption and production. The terminal generates electricity through multiple wind turbines and a power station with the largest single installed capacity of the national port, and the whole process has zero carbon emissions. The port area has been awarded the industry's first carbon neutrality certificate (*Yang Jiemin*, 2021).

Furthermore, China has led the world in showcasing the capability of ports to provide shore power to ships at berths. Shore power refers to the power supply that connects to the power supply on the dock and turns off the ship's generator when the ship docks so that the power load on the ship can be transferred to the shore seamlessly. It can not only effectively reduce ship emissions by approximately 48-70% during the ship's stay in port but also eliminate the noise and vibration caused by the operation of the ship's generator. In particular, by harnessing the power of wind and solar energy, Tianjin Port has generated impressive 28,000-kilowatt hours of clean energy with wind and solar power that saves 18,000 tons of coal and reduces CO<sub>2</sub> emissions by 50,000 tons annually (*Fan Jingmin*, 2021).

In the process of switching from fossil fuel to renewable energy, China ports have been actively utilizing digital transformation as well. With the goal of applying advanced technologies such as AI, big data, cloud computing, and 5G to improve operational efficiency and ultimately



reduce fees and costs, in June 2020, Tianjin Port Group Co., Ltd. and Huawei Technologies Co., Ltd. together jointly built a port demonstration project and created a green and smart hub with 14 implementation projects across six fields, including ships, goods, container trucks, security protection, operations, and equipment. Tianjin Port has introduced the innovative "Port Intelligent Twins" concept and focused on intelligent port scheduling through various scenarios to optimize port scheduling using AI technologies, existing personnel experience data, etc.

### *2.2.3. Green port strategies in waste management*

As China's economy thrives, waste management takes center stage. Recognizing the environmental, social, and economic impacts, China prioritizes preventing and minimizing waste generation during port operations. Green strategies, waste management systems, and recycling initiatives aim to tackle this challenge. Additionally, they actively reduce energy use through cleaner vehicles and renewable energy sources. Notably, China established three emission control zones in key regions, highlighting their proactive approach to managing waste within port infrastructure. These efforts underscore China's commitment to tackling the waste issue head-on.

The operation of China's waste control zones has yielded significant results. There has been a substantial reduction in waste, pollution, and greenhouse gas emissions. Recycling initiatives have promoted resource conservation and economic growth. Moreover, the green port strategy has improved air and water quality, safeguarded ecosystems, and enhanced environmental quality. Using a daily panel of China's major e-waste disposal hubs from 2017 to 2019, local air pollution was found to have decreased by 15%–28%. (*Xiaoli Zheng, 2022*)

China has also implemented various measures to manage clean vehicles, particularly port trucks and containers, in an environmentally friendly manner. One approach is the promotion of electric and hybrid vehicles. By transitioning from traditional diesel trucks to cleaner alternatives, the reliance on fossil fuels is reduced, leading to a significant decrease in air pollution and greenhouse gas emissions. This has driven up the production of natural gas vehicles in the past years. There has been an estimated 200,000 LNG power trucks on Chinese roads in 2018, up from 96,000 in 2016. (*Jason Hawkins, 2019*) In addition, several ports in China have stepped up their drive for a cleaner future and have stopped receiving coal transported in diesel trucks.

Furthermore, China has invested in the development of refueling and charging infrastructure for clean vehicles within port areas. This transition has not only reduced environmental impact but has also contributed to energy efficiency and the conservation of natural resources. The increased adoption of electric and hybrid trucks has led to a substantial reduction in emissions, contributing to improved air quality and reduced pollution-related health risks. As the proportion of renewable electricity generation continues to increase at such a rate, by 2050, replacing traditional fuel vehicles with electric vehicles can reduce greenhouse gas emissions by at least 22.32% and fossil energy consumption by 29.94% in all regions of China (*Yan and Sun, 2021*).

### **3. Evaluation of China's green port strategies and lessons for Vietnam's green port strategies**

#### **3.1. Evaluation of China's Green Port Strategies**

##### **3.1.1. Positive aspects**

China's green port strategies bring many advantages to the coastal industry of the nation. One of the most notable achievements is the reduction of air and water pollution. As a hub of the global supply chain, greenhouse gas emissions from ports account for about 3% of global greenhouse gas emissions (*Rico Salgmann et al., 2023*). China plays a particularly important role in this regard, as it holds 7 of the 10 largest ports in the world. Therefore, the country's efforts to reduce emissions from its ports play a vital role in global greenhouse gas reduction achievements. Through the development and use of wind and solar power systems, Tianjin Port, one of China's largest ports, alone has saved about 18,000 tons of standard coal and reduced carbon dioxide emissions by 50,000 tons per year, equivalent to planting 140,000 trees (*Zhang Ke, 2023*). The port also achieved its goal of zero carbon emissions throughout the process and was awarded the industry's first carbon neutrality certification (*Vice President of the Tianjin Port Safety and Environmental Protection Bureau, 2023*).

Additionally, Chinese ports are gradually improving wastewater treatment systems, increasing the use of recycled water, and reducing the use of chemicals in port operations, leading to promising results in controlling water pollution levels. For example, at Huanghua Port, the world's largest coal import port and the main port for transporting coal from north to south China, dust removal, water use, and intelligent manufacturing technologies have also been developed and successfully applied, helping to prevent 98% of electrostatic dust emissions and filter out 90% of the freshwater that the port consumes, saving over 19 million yuan, equivalent to 2.65 million USD per year, and making the port's operations greener (*Yan and Wang, 2023*).

In addition to reducing air and water pollution, China's green port strategies have also achieved significant success in improving energy efficiency. Through the development of large-scale wind turbines and photovoltaic power systems, major Chinese ports have accelerated the use of shore power. From 2018 to 2020, the market size of China's shore power system industry maintained an average annual compound growth rate of 13.2%, and if it continues to develop at this rapid pace, China's shore power market is projected to reach a market size of US\$366 million by 2030 (*Interface News, 2023*). Accordingly, in an interview in 2023, the Vice President of the Tianjin Port Safety and Environmental Protection Bureau stated that the port area has achieved full shore coverage for all container and bulk berths, 100% of its ships use shore power, and 100% of berthed ships are connected to shore power. In addition, along with the development of renewable energy sources and the strengthening of energy management and monitoring at ports, the consumption of fossil fuels at Chinese ports has been gradually declining since the summer of 2021, bringing about positive changes to the energy environment (*Centre for Research on Energy and Clean Air, 2022*).

The achievements of China's green port strategies in reducing air and water pollution and improving energy efficiency have resulted in significant cost savings and performance

improvements. For example, Tianjin Port has 60% fewer employees than a traditional container port of the same size. In recent operations of large container ships with a capacity of 24,000 TEU, the average efficiency of a berth increased by 20% compared to the same period of the previous year, and the berthing efficiency broke the global record for this route. These results have made China's green port strategy a leading model that is being studied and emulated by the international community.

### *3.1.2. Negative aspects*

Despite the positive results, China's green port strategies still have some limitations that need to be addressed. First, although China has made efforts to adopt green and clean technologies for ports, the level of adoption still needs to be improved, especially in small and medium-sized ports. According to the CAA's "Blue Port Pioneer 2022" report, the shore power coverage rate of typical inland ports in China reached 100% in 2021, and the average shore power usage rate of inland ports was 43%. However, the shore power usage rate of three coastal ports in China that have published data was only 24%, 11%, and 4%, respectively (CAA, 2021).

To explain these disparities, the Water Transport Bureau of the Ministry of Transport analyzed the reasons for the low shore power usage rate at that time, mainly from three aspects, including economic difficulties led to the lack of enthusiasm for equipping ships with shore power receiving equipment, some places had not paid enough attention to shore power work, and relevant supporting policies are not yet in place, some transportation bureaus and maritime authorities have not fully coordinated to promote the installation of shore power receiving equipment on ships and monitoring has not been carried out carefully. To use shore power, ports need to be equipped with power supply facilities, and ships need to be equipped with power receiving facilities.

On the other hand, the lack of comprehensive environmental protection regulations for port operations in China is a major limitation of the country's green port strategy. China has a system of regulations that is not highly harmonized. In other words, environmental protection regulations for port operations in China are issued by multiple agencies, including the Ministry of Transport, the Ministry of Natural Resources, and the Ministry of Ecology and Environment (*Ke Du et al., 2019*). This leads to a lack of consistency in the regulatory system, which makes it difficult to implement.

Environmental protection regulations for port operations in China are also not yet fully in line with reality, especially for emerging port operations. Specifically, the current environmental protection regulations for port operations in China focus on a few key port activities, do not cover all other port activities, and are not updated promptly with the development of port operations, especially for emerging port operations. The regulations also lack specific enforcement measures, which leads to a low level of enforceability. This result leads to the ineffectiveness of applying such regulations in reducing the environmental impact of port operations.

### ***3.2. Lessons for Vietnam's Green Port Strategies***

#### ***3.2.1. Overview of Green Port Strategies in Vietnam***

Vietnam is actively pursuing green port development to reduce pollution, optimize resources, and minimize its ports' ecological footprint. Following a recently issued plan, the Vietnam government is currently piloting the green port model at several locations based on established criteria. By evaluating these pilots, Vietnam aims to revise and strengthen port regulations and business conditions to align with green port standards by 2025.

Vietnam sets sail on a multi-step plan to transform its ports into eco-friendly havens. The Green Port Development Project starts by testing the "green port" model at key locations from 2023, using established criteria to gauge its impact. Lessons learned will refine regulations and support mechanisms for clean technology adoption. By 2030, Vietnam aims to set national "green port" standards, initially voluntary, with a long-term vision of mandatory implementation. Six key criteria, with environmental quality as the top priority, define a "green port".

In addition, in the initial steps of applying the green port strategy to domestic ports, Vietnam has also achieved certain achievements. Notably, Tan Cang-Cat Lai Port became the first in the region to earn APEC's Green Port recognition in 2018 for its investments in clean tech and operational efficiency. This achievement highlights Vietnam's commitment to sustainable port development.

Besides, Vietnam's embrace of green port strategies opens doors to a brighter future for its maritime sector. These eco-friendly havens offer a multitude of advantages, both economic and environmental. By attracting environmentally conscious shipping lines and cargo owners, green ports can increase trade volumes and bolster economic growth. Additionally, they promise reduced energy consumption and operational costs, leading to improved port profitability. Beyond economic benefits, green ports enhance Vietnam's competitive edge.

However, this journey does not come without its challenges. The high cost of green technologies and infrastructure upgrades can be a significant barrier, especially for smaller ports and private investors. Limited access to cutting-edge technologies and expertise further complicates the implementation process, particularly for smaller players.

#### ***3.2.2. Main lessons for Vietnam's green port strategies***

##### ***a) Adopting green and sustainable technologies***

China's success in green ports offers valuable lessons for Vietnam. Prioritizing technology adoption should be central to Vietnam's strategy. Investments in renewable energy like wind and solar power can mirror China's approach, reducing emissions and reliance on fossil fuels. Implementing shore power systems, as China has done, allows docked ships to tap into clean power sources.

However, the high cost of investing in green technologies and infrastructure upgrades could pose a significant challenge for Vietnamese ports, particularly to smaller ports and private investors. According to Invest Vietnam, to overcome this, Vietnam can tap into indirect funding like ODA, which has already supported port upgrades. Additionally, attracting FDI is crucial, as Vietnam prioritizes sustainability in its maritime sector (*Le and Nguyen, 2023*).

Since innovative financing mechanisms and government support are key in overcoming the high costs associated with green port investments, public-private partnerships (PPPs) can also be taken into account, to share investment burdens and risks between public and private sectors.

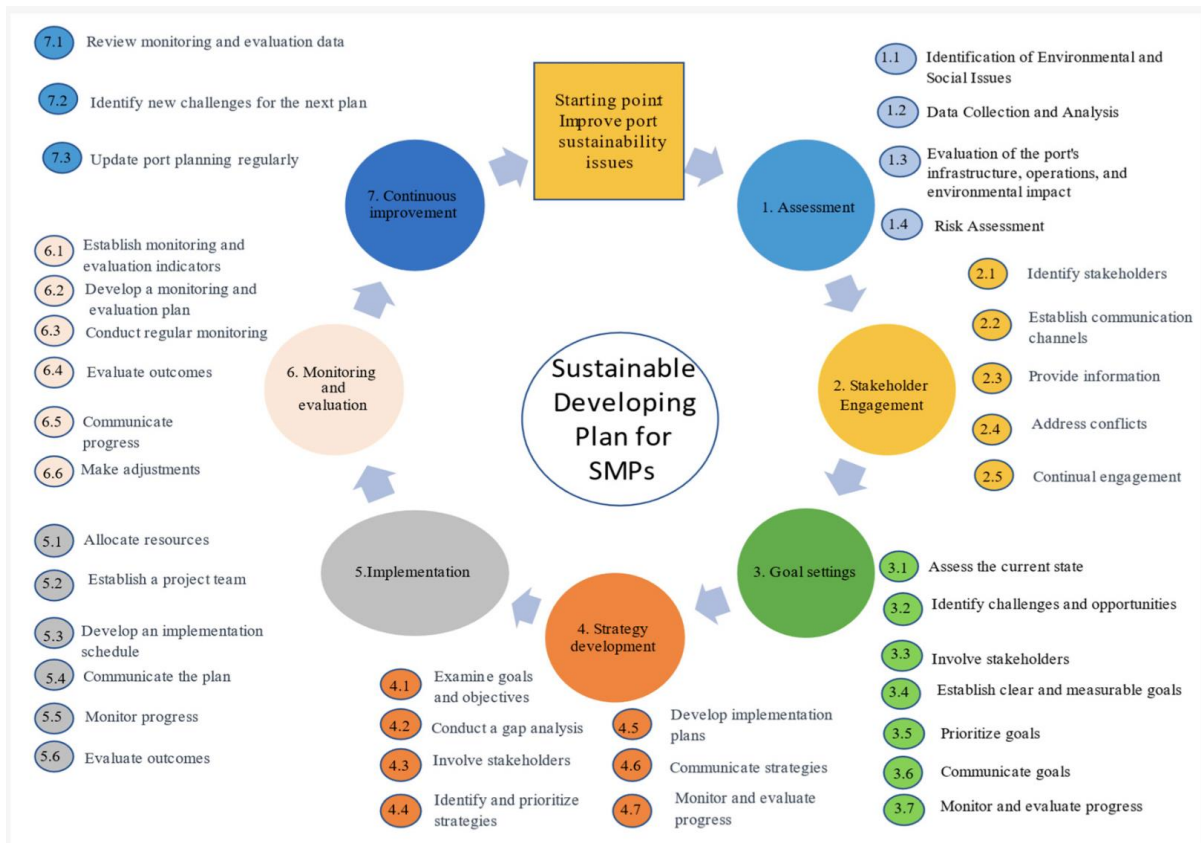
*b) Building a harmonized and consistent regulatory framework*

As mentioned, China's regulatory framework for environmental protection in port operations is fragmented, with regulations issued by multiple agencies such as the Ministry of Transport, the Ministry of Natural Resources, and the Ministry of Ecology and Environment, inhibiting consistency in policies, and making it challenging to implement and enforce regulations effectively. Based on this, Vietnam should work towards harmonizing its regulatory framework for environmental protection in port operations by consolidating regulations issued by different agencies. Since effective implementation of green port strategies requires strong coordination between government agencies, port authorities, and private stakeholders; streamlining regulations and providing clear incentives are essential to encourage wider adoption of green practices and ensure consistency in enforcement across different ports.

Another problem regarding China's framework is that the existing environmental protection regulations for port operations in China focus on a few key activities, and are not updated promptly to address emerging port operations. Vietnam therefore, must focus on updating its environmental protection regulations for port operations to cover all activities comprehensively. Regulations should be regularly reviewed and revised to address emerging port operations and technological advancements. Only when the government succeeds in filling existing gaps in regulations and ensuring that all environmental aspects of port operations are adequately addressed; then Vietnam can apply Green Port Strategies among relevant entities effectively.

*c) Developing a comprehensive roadmap and strategic planning*

China's success with green ports underscores the critical role of clear policies and strategic planning. For Vietnam, replicating this success necessitates prioritizing the development of well-defined and coherent policies that address environmental concerns while simultaneously fostering economic growth within its maritime sector. A potential guiding framework for Vietnam is the Sustainable Maritime Spatial Planning (SMSP) approach. This structured framework offers a three-pronged strategy: 1) reducing environmental impacts, 2) encouraging collaboration among stakeholders, and 3) guaranteeing both environmental and economic sustainability (*Ioannis & Theocharis, 2023*). By leveraging the principles of SMSP, Vietnam can chart a clear roadmap for achieving green ports that seamlessly align with national development goals while safeguarding the marine environment for future generations.



**Figure 1:** Phases and Steps of SPDP methodology

**Source:** Ioannis Argyriou and Theocharis Tsoutsos, 2023

*Firstly*, environmental conservation is a fundamental aspect of SMSP that aims to preserve marine ecosystems and biodiversity. By ensuring responsible resource use, SMSP initiatives seek to minimize negative impacts on the environment while promoting sustainable infrastructure development. To achieve this, Vietnam should adopt eco-friendly practices in port construction and operation, such as utilizing renewable energy sources and implementing effective waste management systems to reduce pollution.

*Secondly*, enhancing stakeholder engagement is crucial in SMSP, to ensure that the interests and concerns of all relevant parties are all taken into account. Consultative processes can help ensure that regulations are practical, feasible, and effectively address the environmental concerns of all relevant stakeholders. Therefore, Vietnam should involve industry associations and port operators in the regulatory development process, to foster a sense of ownership and compliance with environmental standards.

*Thirdly*, Vietnam's green port journey, like many developing nations, faces the challenge of balancing environmental with economic goals. While green ports offer long-term environmental benefits, short-term trade-offs like higher costs might arise. Vietnam can navigate this by adopting

policies that prioritize both conservation and economic growth, securing benefits for both the ecosystem and the local economy.

## **Conclusion**

Green ports are formed to promote the implementation of sustainable and environmentally friendly strategies into ports' activities and operations in all coastal cities. By "greening" a seaport, its local area, or sometimes even the country, may gain substantial benefits from many aspects. Although the concept of green ports is no longer new, developing countries still have a long way to go to catch up with developed countries' outstanding achievements in the field.

The development of China's ports throughout the years has been remarkable. They have been making efforts to prevent devastating environmental consequences from dramatic economic boosts. China's seaport system has become one of the most important links in global supply chains and at the same time, the role model of sustainable development for other countries in the region.

China implemented green port strategies the most prominently in reducing emissions, using renewable energy and waste management. First, by using LNG, green methane, and other clean fuels, such as biofuels, hydrogen fuels, and nuclear fuels, China has been able to reduce a considerable amount of emissions from maritime transports. Meanwhile, by using renewable energy, China ports have become one of the world's first "zero-carbon terminals". China realized that waste management would be performed best by preventing the generation of waste and avoiding its spread. Although China's green port strategies have reduced air and water pollution as well as increased energy efficiency significantly, there are still some certain expectations, such as limitations on green technology and shore power and lack of state regulations.

Vietnam has been planning and implementing a lot of strategies to enhance ports' quality to reach global levels and consequently has gained many achievements. However, the budget and investment are still not enough for Vietnam to push further the application of the "green port" concept. The lessons that can be learned from China are: adopting green and sustainable technologies, building a harmonized and consistent regulatory framework, and developing a comprehensive roadmap and strategic planning.

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