



Review Article

Development and Implementation of Green Maritime Policy and Regulations in Singapore: Lessons for Vietnam

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Abstract: A prominent sector in Singapore's climate strategy is the maritime industry. Alongside its economic contributions, this sector is a major source of greenhouse gas (GHG) emissions. In response, Singapore has proactively implemented policies and regulations to foster a "Green Maritime Industry." Initiatives such as the Green Port Programme, the Green Ship Programme, and the Singapore Maritime Decarbonization Blueprint are designed to drive technological innovation, enhance energy efficiency, transition to clean fuels, and reduce emissions. These programs enable Singapore to maintain its status as a global maritime hub while asserting leadership in green shipping within the Asia-Pacific. Recently, Vietnam has also adopted measures to reduce maritime emissions and promote sustainable development. This study analyzes Singapore's experience in developing and enforcing green maritime regulations to derive practical lessons for Vietnam. The ultimate goal is to refine national maritime policies, accelerate the green transition, and work towards a sustainable maritime industry that adapts to contemporary international environmental trends and standards.

Keywords: Green Maritime Policy, Green Ship, Green Port, Green Maritime Corridor, Decarbonization.

1. Introduction

Singapore stands as one of the world's leading maritime hubs, serving as a strategic crossroads on the East-West shipping route [1]. It is home to over 170 international shipping groups operating across diverse sectors, ranging from container transport, bulk carriers, and traditional tankers to offshore services and

Liquefied Natural Gas (LNG) [1]. In 2025, the Port of Singapore recorded a record container throughput of 44.66 million TEUs, an 8.6% year-on-year increase from 2024 [2]. However, maritime activities are also a primary source of Greenhouse Gas (GHG) emissions in Singapore. Given the high volume of vessels calling at the port and bunkering at Singapore's terminals,

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substantial amounts of GHGs such as CO₂, NO₂, CO, O₃, along with fine particulate matter (PM_{2.5}), are released into the environment. This has resulted in severe air and water pollution zones around Singapore's port areas and along the vital sea lanes passing through its waters [3]. Furthermore, as one of the world's largest transshipment and bunkering hubs, Singapore indirectly accounts for a massive volume of emissions, leading to significant environmental degradation [4].

As a small island nation, Singapore faces significant climate-change risks, particularly rising sea levels. By 2150, sea levels in Singapore could rise by approximately 2m under the worst-case scenario. This would severely impact Singapore's critical infrastructure, such as seaports, airports, and industrial zones, exerting substantial pressure on the country's disaster prevention policies and urban planning [5]. For this reason, Singapore has taken climate change prevention very seriously. The country ratified the UNFCCC in 1997, acceded to the Kyoto Protocol in 2006, and signed and ratified the Paris Agreement in 2016 [6]. In 2025, Singapore submitted its 2035 Nationally Determined Contribution (NDC), aiming to reduce emissions to 45-50 MtCO_{2e} by 2035 and moving towards net-zero emissions by 2050 [7].

In 1996, the Singaporean government restructured its maritime agencies and established an independent statutory body dedicated to port and maritime development under the Ministry of Transport, known as the Maritime and Port Authority of Singapore (MPA). The MPA was established under the Maritime and Port Authority of Singapore Act 1996 to regulate, plan, and promote international maritime activities, including safety, security, and sustainable development [8]. Since 1996, the MPA has been at the heart of all Singaporean maritime initiatives, as nearly every maritime milestone has been channeled through the MPA, ranging from the digitalization of procedures and bunkering regulations to the development of maritime clusters and emission reduction strategies.

The MPA Act 1996 established the legal foundation for the MPA to introduce policies, programs, and initiatives to promote green maritime development while mitigating and managing the negative impacts of the traditional maritime industry on the environment in general and marine ecosystems in particular. This article will analyze Singapore's general maritime development policies and laws, then provide an in-depth evaluation of the "Maritime Singapore Green Initiative" (MSGI) policies, and ultimately derive valuable lessons for Vietnam.

So far, most relevant research has approached the topic of the Singaporean model for green shipping and the development of green maritime policy in Vietnam separately. For instance, on the Singapore model, Dong et al. (2022) provided a comprehensive review of shipping decarbonization law and policy, highlighting the MSGI launched by the MPA in 2011, its subsequent updates, and the Singapore Maritime Decarbonization Blueprint 2050 [9]. Alamoush et al. (2022) analyzed the role of ports in shipping decarbonization and specifically discussed Singapore's port incentive schemes under the MSGI [10]. Likewise, Khabir (2025) explored strategic pathways toward green digital shipping and cited Singapore's green port programs as notable examples of successful incentive-based approaches [11].

On the Vietnamese green maritime policy, Nguyen Hoang Phuong, Nguyen Phuoc Quy Phong and Nguyen Thanh Phuong (2022) analyzed green port strategies in developed coastal countries and drew lessons for Vietnam's sustainable development path, emphasizing the need to adopt green port practices amid pressure from international regulations [12]. Hoang Thi Hong Hanh and Nguyen Xuan Son (2026) examined Vietnam's current policy and legal framework for shipping decarbonization in alignment with IMO standards, identifying existing gaps that require further policy development [13]. Similarly, Phan Van Huy (2026) proposed a conceptual framework for structuring a national approach to maritime decarbonization in Vietnam, highlighting the

need for a systematic, coordinated national strategy [14]. However, to date, no research has examined what the Singaporean model can offer to Vietnam.

The article uses three main research methodologies to reach its conclusion, namely documentary analysis, legal policy analysis, and comparative law. First, it conducts a thorough analysis of Singapore's green maritime promotion policies through its legal texts to evaluate their strengths and limits. It then compares this with Vietnam's current policy context to identify lessons Vietnam can learn from Singapore in developing its own green shipping policy.

2. Singapore's Green Maritime Promotion Policies

This section analyzes Singapore's maritime sustainability initiatives, specifically the MSGI and its key components: the Green Ship Programme, the Green Port Programme, and the Green Energy and Technology Programme. These initiatives share the common goal of promoting green shipping and decarbonization, aligning with the MPA's mandate to protect Singapore's strategic maritime interests under the Singapore Green Plan 2030 and the 2050 Net-Zero target.

2.1. Maritime Singapore Green Initiative

In 2011, the MPA launched the MSGI aiming to mitigate the environmental impact of the shipping industry and its related activities, while promoting green and clean shipping in Singapore [15]. The MSGI comprises voluntary programs designed to recognize and incentivize companies that adopt clean and green shipping practices and port operations. At its inception in 2011, the MSGI consisted of three programs: the Green Ship Program (GSP), the Green Port Program (GPP), and the Green Technology Program (GTP) [16]. These programs primarily focused on reducing local air pollution (SO_x, NO_x, PM), offering incentives such as

reductions in port fees for vessels using "clean" fuels with a sulfur content of 1.0% or less [17].

In 2016, the MPA introduced two additional programs: the Green Awareness Program (GAP) and the Green Energy Program (GEP). Concurrently, the GPP sulfur limit was tightened from no more than 1.0% to no more than 0.5% [18]. Vessels calling at the Port of Singapore that utilize marine fuel with a sulfur content of 0.5% or less are eligible for a 25% reduction in port fees throughout their stay. Since then, Singapore has shifted its focus to LNG as an alternative to sulfur, aiming to reduce SO_x, NO_x, and particulate matter emissions. This 25% port fees reduction also applies to LNG-fueled vessels at all Singaporean ports.

In 2019, the MPA issued a series of circulars to extend and enhance the MSGI. Specifically, under Shipping Circular No. 12 (dated 31 October 2009), the MPA announced the MSGI extension until the end of 2024 and expanded the GSP to incentivize vessels using low-carbon fuels such as LNG [19]. Port Marine Circular No. 21 (dated 5 December 2019) [20] updated the GPP incentives, offering a 25% reduction in port fees for vessels powered by LNG or those exceeding the International Maritime Organization's (IMO) Energy Efficiency Design Index (EEDI) standards [21]. Consequently, vessels that only use "clean" fuels with a sulfur content below 0.5% or utilize exhaust gas cleaning systems (scrubbers) to achieve equivalent levels are no longer eligible for this 25% reduction [20]. In the same year, the MPA issued Port Marine Circular No. 22, introducing two port fee incentive schemes to promote more strongly domestic adoption of LNG [22]. Under the first scheme, new domestic vessels (harbour craft) that are fully LNG-powered or utilize LNG fuel (either pure LNG or dual-fuel) are granted a 100% waiver on port fees for five years from their ship license commencement date. The second supplementary incentive applies to vessels participating in the GPP, both domestic and international; if they engage the services of these new LNG-powered harbour craft, they receive an extra 10% reduction in port fees. In

effect, vessels meeting the criteria in Circular No. 21 could benefit from a total discount of up to 35% for a maximum stay of five days.

On 22 April 2022, the MPA issued Shipping Circular No. 7 amending the GSP, effective from 1 May 2022 to 31 December 2024 [23]. Its objective is to encourage Singapore-registered ships to meet the IMO's EEDI Phase 3 standards under Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) and to promote the use of low-carbon or zero-carbon fuels, supporting maritime decarbonization under the Maritime Singapore Decarbonization Blueprint: Working Towards 2050 (Decarbonization Blueprint 2050). This circular also provides incentive schemes for three categories of vessels registered under the Singapore Registry of Ships (SRS). Depending on their performance and fuel type, these vessels are eligible for reductions in Initial Registration Fees (IRF), including both normal registration and the Block Transfer Scheme (BTS) [24], and Annual Tonnage Taxes (ATT). The three categories include: (1) Vessels newly registered or existing vessels modified to exceed the IMO's EEDI Phase 3 requirements by 10% or more will receive a 50% reduction in IRF and a 20% reduction in ATT; (2) Vessels using low-carbon fuels with a carbon emission factor (C_F) less than or equal to 2.75 (such as LNG) will receive a 75% reduction in IRF and a 50% reduction in ATT; and (3) Vessels using zero-carbon fuels (such as hydrogen or battery power) will be granted a 100% waiver on IRF and a 100% waiver on ATT.

In 2024, the MPA updated various green initiatives and incentives under the MSGI to encourage the early adoption of zero- and near-zero-emission technologies and fuels. Notably, Shipping Circular No. 12 of 2024 (dated 29 October 2024) superseded the 2022 Circular and is effective from 1 January 2025 to 31 December 2027 [25]. This circular focuses on incentivizing the maritime industry to reduce GHG emissions, aligning with the net-zero target by 2050. To achieve this, the circular requires vessels to comply with the Carbon Intensity Indicator (CII)

and adopt greener technologies under MARPOL Annex VI. The new incentives provided by the 2024 Circular for Singapore-flagged ships under the GSP include: (1) Zero-emission vessels (e.g., hydrogen or battery-powered) will receive a 100% waiver on IRF and a 100% waiver on ATT; (2) Near-zero emission vessels (such as ammonia-powered) will receive a 100% reduction in IRF and an 80% reduction in ATT; (3) Low-carbon fuel vessels with $C_F < 1.375$ (such as methanol) will be granted a 75% reduction in IRF and a 50% reduction in ATT; and (4) Conventional low-carbon fuel vessels with a C_F between 1.375 and 2.750 will receive a 50% reduction in IRF and a 20% reduction in ATT. In essence, the 2024 Circular's policy is "the greener the ship, the greater the incentive," ranging from moderate reductions for LNG vessels to full waivers for hydrogen or battery-powered ships. Furthermore, incentives apply to both ship design efficiency and operational performance. Vessels designed to exceed the IMO's EEDI Phase 3 standards by at least 10% receive a 20% reduction in both IRF and ATT. Additionally, vessels achieving a CII rating of A are eligible for an extra 5% reduction in ATT, provided the total ATT reduction does not exceed 100%.

2.2. Maritime Singapore Decarbonization Strategy Toward 2050

In March 2022, the MPA adopted a long-term strategic framework titled the Decarbonization Blueprint 2050. Its primary objective is to achieve Singapore's net-zero emissions goal and build a sustainable maritime sector to maintain the nation's status as a global maritime hub [26]. Under the 2030 targets, the MPA aims to reduce emissions from port operations by at least 60% compared to 2005 levels [27]. By 2050, the goal is net-zero emissions, meaning all GHG emissions from the port will be eliminated or offset. For Singapore-flagged vessels, the target is to transition entirely to low-carbon energy solutions by 2030 and adopt full-electric propulsion or net-zero fuels by 2050 [28]. Furthermore, the Decarbonization

Blueprint 2050 aims to transform Singapore into a global Research and Development (R&D) hub for maritime decarbonization, fostering a dynamic ecosystem with a highly skilled and specialized workforce [29]. Ultimately, the plan seeks to position Singapore as a green maritime finance hub by promoting green financing solutions, enhancing carbon awareness, and improving the quality of carbon accounting and reporting [30].

On March 10, 2025, Singapore announced the new Methanol Bunkering Standard (TR 129) [31]. The TR 129 standard focuses on three core areas, including custody transfer; operations and safety; and the use of Mass Flow Meters (MFM). The first area, custody transfer, mandates strict requirements for the accurate measurement of methanol quantity and quality throughout the bunkering process. The second area provides detailed operational guidelines to ensure the safe delivery and receipt of methanol, including mandatory training requirements and a competency framework for vessel crews. The third area specifies the use of MFMs to ensure precision in quantity management and requires digital documentation for all bunkering activities. These regulations were introduced to support Singapore's maritime industry in transitioning to methanol as a more sustainable fuel for marine bunkering operations.

2.3. Green Maritime Corridor Agreements

A Green Shipping Corridor (GSC) is a shipping route between two major port hubs (including intermediate stopover points) where public and private initiatives work together to promote the technological, economic, and regulatory feasibility of operating zero-emission vessels [32]. The establishment of zero-emission green shipping corridors between countries will help reduce CO₂ and GHG emissions, while moving the maritime transport industry closer to international targets, including those set by the IMO, the Paris Agreement, and the commitment to full decarbonization by 2050 [33].

In August 2022, Singapore and the Netherlands, home to some of the world's top-

ranked container ports [34], signed a Memorandum of Understanding (MOU) to cooperate and establish a sustainable shipping route known as the Green and Digital Shipping Corridor (GDSC) between the MPA and the Port of Rotterdam [35]. The objective is to accelerate decarbonization and digitalization in shipping, particularly along the Asia-Europe shipping route and between major transshipment and bunkering hubs [35]. The GDSC serves as an expansive bilateral cooperation corridor, engaging key stakeholders across the global value chain, including shipping lines, fuel suppliers, ports, financial institutions, and research institutes. On 20 September 2023, the MPA issued a press release confirming the support of approximately 20 global partners for the GDSC's emission reduction efforts [36]. During the 2023-2025 period, Singapore intensified its GDSC cooperation with major global ports. On 24 April 2023, Singapore signed an MOU with the Port of Los Angeles and the Port of Long Beach to establish a GDSC between Singapore and the San Pedro Bay port complex, a vital trans-Pacific shipping route [37]. The objective is to facilitate the adoption of low- and zero-emission fuels, develop bunkering infrastructure, and implement digital technologies.

On December 16, 2023, Singapore signed a Memorandum of Cooperation (MOC) on the GDSC with Japan. This agreement aims to support the development of common standards, green shipping practices, and digitalization, while facilitating the exchange of expertise on maritime cybersecurity risks and other aspects of maritime digital transformation [38]. In 2024, Singapore continued its momentum by signing MOUs with Australia on 5 March [39] and China on 9 October [40]. The MOU with Australia focuses on establishing supply chains for low- or near-zero-emission fuels and developing the necessary technology and infrastructure. Meanwhile, the MOU with China focuses on adopting new technologies, training personnel, and aligning common standards (such as onshore power supply and alternative fuels), alongside digital solutions. In the same year, Singapore and

Rotterdam signed a Cooperation Agreement to deepen their GDSC collaboration, bringing the total number of value chain partners to approximately 28 [41]. Notable participants include Hapag-Lloyd [42] (the world's fifth-largest container shipping line) [43], the ASTAR Centre for Maritime Digitalisation (Singapore) [35], and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping [37].

2.4. Evaluation of Singapore's Green Maritime Promotion Policies

Under the MPA's leadership, Singapore is one of the leading nations in the Asia-Pacific region for sustainable, low-emission maritime development. The MPA has actively driven the maritime industry's energy transition, emission reductions, and sustainability enhancements across the entire maritime supply chain. Key achievements include establishing a synchronized policy and technical framework, from incentivizing clean fuel adoption (LNG, methanol, ammonia, hydrogen) to establishing GDSCs with major global partners. Singapore has also invested heavily in modern infrastructure, such as LNG bunkering stations and smart port management systems, supported by financial mechanisms and incentives. Singapore also remains at the forefront of piloting eco-friendly fuels and applying clean energy within the maritime sector. Consequently, the nation not only maintains its position as a highly resilient global maritime hub but also plays a pivotal role in shaping global maritime connectivity strategies.

In comparison with other Asian models for green shipping, the Singaporean approach seems most suitable for Vietnam. For instance, Japan has adopted a finance-oriented approach through its inter-ministerial Climate Transition Bond Framework (2023) [44]. The Republic of Korea has established a comprehensive regulatory framework through the Framework Act on Carbon Neutrality and Green Growth, the Eco-friendly Ships Act, and the 2030 Greenship-K Promotion Strategy. China has adopted a port-centric approach through the Green Port

Evaluation Grade Standard, which integrates low-carbon and energy-saving performance into port grading through specific scoring methodologies [45]. Among these, Singapore offers the most suitable model for Vietnam. It aligns with IMO objectives while directly supporting port modernization, fleet upgrading, and the enhancement of domestic shipbuilding capacity—priorities that are highly relevant to Vietnam's current stage of development. This approach would improve the competitiveness of Vietnamese ports, support compliance with future IMO regulations, and promote sustainable growth in the ASEAN maritime sector.

However, the MSGI still faces several significant limitations. First, Singapore is highly dependent on global clean energy and technology. The market for alternative fuels, particularly green methanol, green ammonia, and hydrogen, remains immature [46]. Using these fuels in the shipping industry requires massive investments in engines, bunkering infrastructure, and fuel logistics; as a result, operational costs remain prohibitively high [47]. Furthermore, international standards for safety, bunkering procedures, and operational regulations remain unharmonized, posing a substantial challenge for Singapore in achieving synchronized implementation of its green maritime strategy [48].

Second is the constraint of domestic space and capacity. With a total land area of just over 730 km², it is virtually impossible for Singapore to produce renewable energy at scale, leading to a heavy reliance on clean fuel imports [49]. This dependency poses potential energy security risks during Singapore's long-term decarbonization process. Finally, while Singapore plays a leading role in policy and technology, the actual effectiveness of these initiatives depends heavily on the participation level of international shipping lines [35]. The commercial interests of these carriers are not always aligned with environmental objectives. Therefore, the transition remains contingent upon the investment capabilities of both vessel operators and fuel suppliers [50].

3. Lessons for Vietnam

Shipping plays a foundational role in Vietnam's international trade, as evidenced by the country's significant position on the global maritime map and the robust growth of its logistics activities in recent years. According to Resolution No. 36-NQ/TW dated 22 October 2018 of the Central Committee of the Communist Party of Vietnam on the Strategy for Sustainable Development of Vietnam's Maritime Economy to 2030, with a Vision to 2045 [51], the shipping sector is identified as a key pillar of Vietnam's maritime economy. This sector is expected to contribute to transforming Vietnam into a strong, modern, and sustainable maritime state. As of 2025, Vietnam possesses 34 seaport areas with 306 berths [52]; the total cargo throughput across the national seaport system has reached approximately 864.4 million tons [53].

3.1. Vietnam's Green Maritime Measures

In recent years, Vietnam has implemented programs to promote digitalization and emission reductions in the maritime sector, aiming for a green, smart, and sustainable seaport development model in line with international trends. In 2020, the Ministry of Transport approved the Project for Green Port Development in Vietnam via Decision No. 2027/QĐ-BGTVT (dated 29 October 2020) [54]. The project aims to establish a green port model and conduct pilot programs at selected ports suited to Vietnam's conditions. This involves adopting clean, low-carbon, and eco-friendly technologies to meet the requirements of sustainable development, ecosystem protection, and climate change adaptation. On 2 June 2021, the Vietnam Maritime Administration, now the Vietnam Maritime and Waterway Administration (VINAWA), adopted the Implementation Plan for the Green Port Development Project. The main objective is to implement a green port model suitable for Vietnam's conditions, thereby promoting the application of clean, low-carbon, and

environmentally friendly technologies to ensure sustainable development, protect ecosystems, and respond to climate change [55].

On 22 July 2022, the Prime Minister approved Decision No. 876/QĐ-TTg, endorsing the Action Program on Green Energy Transition and Carbon and Methane Emission Reduction for the Transport Sector [56]. Under this program, Vietnam commits to reducing GHG emissions from maritime transport by at least 20% by 2030 and achieving net-zero emissions by 2050. The decarbonization roadmap is divided into phases with increasingly stringent requirements: (1) 2022-2030 Phase: Primarily encourages compliance with the MARPOL Convention and the conversion of port equipment; (2) 2031-2050 Phase: Requires mandatory compliance and comprehensive transition; (3) 2035: All new vessels must utilize green energy; (4) By 2040: Existing ports and signaling equipment must be transformed; (5) By 2050: 100% of domestic vessels and port equipment must operate on green energy.

On 29 December 2022, VINAWA released Base Standard (TCCS) No. 02:2022 on Green Port Criteria under Decision No. 1909/QĐ-CHHVN [57]. Section 1.2.1.1 of TCCS 02:2022 defines "Green ports" as "seaports that meet the green port criteria specified in this standard and are assessed and published by seaport enterprises." Section 1.2.1.2 stipulates that "Green Port Criteria" are developed to encourage and guide enterprises to invest in, manage, and operate seaports in a green manner, conserve natural resources, improve management capacity, and ensure sustainable development.

The pilot program for green ports in Vietnam has yielded many positive results. By the end of 2024, two ports in Hai Phong, Nam Dinh Vu Port and Tan Cang Hai Phong Port, were recognized as green ports according to the criteria of VINAWA. Notably, 100% of their primary equipment, including ship-to-shore (STS) cranes, yard cranes, and tugboats, has transitioned to electric power [58]. As a result, these ports saved over 3.5 million kWh of

electricity (equivalent to 7.7 billion VND/year), complemented by further cost reductions from LED lighting systems and solar energy usage. Tan Cang Cat Lai Port also implemented comprehensive green initiatives, including energy conservation, clean energy adoption, digitalization, waste management, and environmental stewardship [59].

Most recently, VINAWA has submitted to the Ministry of Construction the Project for the Development of Inland Waterway Transport in the period 2026 - 2035, with a vision to 2050. One of the Project's key purposes is to apply the "Green Port – Green Line – Green Ship" approach to Vietnam's inland water transportation (including inland sea areas) to reduce CO₂ emissions from shipping by at least 10% compared to 2020 [60].

3.2. Lessons learned for Vietnam from Singapore's Experience

Based on the analysis of Singapore's green maritime policies and the current state of Vietnam's maritime sector, Vietnam can draw several key lessons regarding the formulation and implementation of green maritime policies: *i) Refining specialized and unified management institutions for green maritime*

A cornerstone of Singapore's success in promoting green maritime is the establishment of a centralized regulatory body with clear authority and high coordination capacity: the MPA. Established in 1996 under the MPA Act and operating under the Ministry of Transport, the MPA does more than just regulate licensing and maritime safety. It actively leads the industry's innovation, decarbonization, and digital transformation. Almost every major initiative, from the MSGI and the Decarbonization Blueprint 2050 to the 2030 Maritime R&D Strategy and the establishment of GDSCs, has been initiated and coordinated by the MPA.

Vietnam could consider granting VINAWA greater autonomy, proactivity, and stable financial resources. Simultaneously, Vietnam should establish a cross-sectoral coordination

mechanism among the Ministry of Construction, Ministry of Agriculture and Environment, Ministry of Industry and Trade, and the Ministry of Science and Technology to plan, monitor, and evaluate green maritime policies. Furthermore, Vietnam could consider establishing a National Maritime Green Transition Coordination Center, operating under the Government or the Ministry of Transport, which is modeled after the MPA. This center would serve as the focal point for implementing R&D programs, technical standards, international cooperation, and carbon emission monitoring within the maritime sector.

ii) Developing long-term decarbonization strategies and roadmaps with clear quantitative targets

Singapore has published the Decarbonization Blueprint 2050, a strategic roadmap that explicitly sets a target to reduce GHG emissions by 50% by 2050 (relative to 2008 levels), while striving toward net-zero emissions. This plan is concretized through seven focus areas: port terminals, domestic harbor craft, future marine fuels, ship registry, international engagement at the IMO, R&D, and green finance. Consequently, Singapore integrates all its programs and initiatives into a single framework of quantitative targets, enabling effective monitoring, reporting, and policy adjustments.

While Vietnam has introduced the Green Port Development Project (2020) and various emission reduction plans for the transport sector, it still lacks a comprehensive green maritime strategy with a clear roadmap and specific indicators. Vietnam should consider establishing the Vietnam Green Maritime Strategy toward 2050, aligned with the National Green Growth Strategy and the NDC. This strategy should set clear mid-term milestones (for 2030 and 2040) on the percentage of vessels using clean fuels, port emission-reduction targets, and the adoption of renewable energy.

iii) Implementing financial incentives, fee reductions, and tax exemptions for green vessels and ports

A standout feature of Singapore's policy is its use of fiscal instruments to drive corporate behavioral change. Under the MSGI, the MPA offers port fee concessions of 25-35%, waivers of initial registration fees, or 100% rebates on annual tonnage taxes for vessels that exceed energy design standards (such as IMO's EEDI Phase 3) or utilize low-carbon fuels like LNG, methanol, ammonia, or electric batteries. The latest programs (2024-2027) have further extended incentives to vessels achieving a Category A CII rating and provide grants covering up to 70% of costs for small and medium-sized enterprises (SMEs) to adopt energy-efficient equipment.

In contrast, Vietnam currently lacks a clear economic incentive mechanism for maritime enterprises to adopt green technologies. Vietnam should consider establishing a National Maritime Green Transition Fund to provide preferential credit, corporate income tax exemptions, or port fee reductions for green vessels. Such policies would not only incentivize investment in clean technology but also create pressure on entities slow to transition, eventually moving toward an internal carbon pricing mechanism within the maritime sector.

iv) Promoting Research, Development (R&D), and Green Maritime Innovation

Singapore consistently views research and technological innovation as its central driving force. The Maritime R&D Roadmap 2030: Maritime Transformation focuses on automation, digitalization, and decarbonization. Meanwhile, the Global Centre for Maritime Decarbonization (GCMD) in Singapore has successfully piloted biofuels, LNG, methanol, and carbon capture technologies. In 2024, biofuel sales in Singapore increased sixfold (reaching 880,000 tonnes), demonstrating the tangible impact of R&D on policy outcomes.

Vietnam should consider establishing a national green maritime R&D ecosystem comprising three key pillars: i) specialized research institutes and universities; ii) shipping, shipbuilding, and energy technology enterprises; and iii) coordinating regulatory bodies.

Establishing a Vietnam Green Maritime Innovation Center, under the Ministry of Construction or through partnerships with Singapore, Japan, and South Korea, would strengthen national capacity to research alternative fuels, energy storage technologies, port automation, and emission-treatment solutions.

v) Developing smart ports and clean energy infrastructure

Singapore has constructed the Tuas Port, a world-leading model of a smart and sustainable "mega-port." The project is designed for fully automated operations, utilizing Automated Guided Vehicles (AGVs), remote-controlled cranes, artificial intelligence systems, and renewable energy. By 2040, the port is projected to reach a capacity of 65 million TEUs – double its current capacity – while serving as a premier hub for clean bunkering fuels such as LNG and methanol.

Vietnam should consider adopting this model in the strategic planning of key gateways like Cai Mep - Thi Vai, Lach Huyen, and Lien Chieu. This approach involves transitioning toward "green and smart ports" that integrate solar power, energy management systems, carbon monitoring, and clean refueling capabilities. At the same time, it is essential to issue national technical standards for green ports, stipulating requirements for emission levels, water recycling, waste treatment, and renewable energy use to align with international standards under the MARPOL 73/78 and IMO frameworks.

vi) Establishing and enforcing clean fuel standards and fueling transparency

Singapore became the first country in the world to mandate the use of MFM systems in bunkering operations in 2017. This measure completely eliminated volume-based measurement fraud and ensured absolute transparency in fuel transactions. In 2025, Singapore further introduced the Methanol Bunkering Standard TR 129, which sets out three key groups of requirements: i) accurate measurement for the transfer of custody, ii)

operational safety and workforce training, and iii) mandatory use of MFM and electronic documentation.

This represents a highly practical experience for Vietnam, where marine fuel supply and vessel inspection activities remain fragmented and lack transparency. Vietnam may consider issuing a national standard on clean marine fuels (LNG, methanol, and ammonia) along with a standardized mass measurement system to better regulate fuel delivery and receipt. At the same time, the country should promote the use of electronic documentation in bunkering operations to reduce costs, enhance transparency, and align with IMO trends.

vii) Promoting digitalization and smart carbon governance

One of Singapore's pioneering approaches is integrating digitalization with decarbonization. Through the Digital Bunkering Initiative, starting in 2025, Singapore will fully implement electronic documentation for all bunkering operations, thereby saving time and reducing administrative errors. In addition, Singapore and the Netherlands have successfully piloted port-to-port data exchange, sharing vessels' arrival and departure times to reduce waiting times and lower fuel consumption and emissions.

Vietnam can adopt this model in the digitalization of port operations management, vessel voyage tracking, and emissions monitoring by integrating real-time data from the Automatic Identification System (AIS), ports, and shipping companies. A national green maritime data platform could enable VINAWA to monitor carbon intensity indicators, help shipping enterprises prepare emission reports in compliance with the IMO Data Collection System and the European Union's Monitoring, Reporting and Verification standards, and serve as a powerful evidence-based tool for policy formulation and decision-making.

viii) Establishing Regional and International Green Maritime Corridors

Singapore has taken a leading role in developing GDSC. From 2022 to 2025, the country has signed MOUs with the Netherlands,

the United States (the U.S), Japan, Australia, China, and India. These corridors aim to reduce greenhouse gas (GHG) emissions by 20-30% on the Singapore-Europe and Singapore-Asia-Pacific routes. The initiative also standardizes safety standards for bunkering, digital data protocols, and zero-emission vessel operations.

Vietnam could consider proactively cooperating with Singapore, Japan, South Korea, or other ASEAN countries to establish an ASEAN Green Maritime Corridor, particularly on the key routes of Vietnam-Singapore, Vietnam-South Korea, and Vietnam-Japan. This would involve adopting common standards for fuels, safety, data exchange, and emissions monitoring. Such a corridor would serve as a strong foundation for Vietnam to integrate more deeply into the global green shipping supply chain and attract international investment.

ix) Developing human resources and raising green awareness

The MPA considers workforce training and community awareness-raising fundamental pillars of all its green maritime programmes. Through the Green Awareness Programme and the Sustainability Action Package under the Singapore Cooperation Programme, the country has trained nearly 150,000 officials and professionals from more than 180 countries in climate adaptation and green finance.

Vietnam needs to invest more strongly in developing a green maritime workforce by incorporating topics such as carbon management, new fuels, electric-LNG-hydrogen vessel technologies, and port environmental governance into the curricula of maritime universities and training institutions. At the same time, government agencies should organise awareness campaigns targeting shipping enterprises and port communities to highlight the economic and environmental benefits of green transformation.

x) Mobilizing public-private partnerships and green finance

Singapore has successfully fostered collaboration among the government, businesses, and research institutions through the

Singapore Maritime Fund to support the maritime sector's energy transition. Programmes such as the Energy Efficiency Grant (EEG) provide direct financial support to enterprises investing in emission-reduction technologies.

Vietnam could consider developing a public-private partnership (PPP) model for green maritime transformation. For example, enterprises investing in green technologies could receive co-financing or loan guarantees from the Environmental Fund, commercial banks, and Official Development Assistance (ODA) sources. At the same time, Vietnam should actively encourage international financial institutions, such as the Asian Development Bank, World Bank, and Green Climate Fund, to participate in these programmes. This would give businesses financial leverage to invest in low-emission technologies, enhance competitiveness, and better integrate with international standards.

xi) Lessons for Vietnam to overcome limitations in implementing green maritime policies

Vietnam can draw important strategic lessons from the challenges Singapore has faced, particularly the need to prioritize developing domestic clean fuel production capacity from the early stages of maritime decarbonization. With a coastline of over 3,260 km, an estimated offshore wind potential of 600 GW [61], and average solar radiation of 4.5-5.5 kWh/m²/day [62], Vietnam has significant potential to develop green hydrogen and its derivatives, such as green ammonia and green methanol, at major port clusters and economic zones like Cai Mep-Thi Vai [63]. Localizing a substantial portion of the clean fuel supply chain would not only significantly reduce long-term operating costs for the shipping fleet, but also strengthen energy security, enhance national energy autonomy, and minimize disruption risks in global supply chains.

4. Conclusion

Singapore's experience demonstrates that developing green maritime transport is not merely an environmental requirement, but also a comprehensive national development strategy that integrates economic growth, energy transition, and technological innovation. Singapore's success stems from a long-term policy vision, a strong central coordinating mechanism, and an effective public-private partnership model. These factors have enabled the country to maintain its position as a global maritime hub while delivering substantive progress on its climate commitments.

First, Singapore's green maritime policy development is driven by its unified institutional framework and the MPA's strong executive capacity. This agency not only oversees daily maritime operations but also leads strategic planning, coordinates research and development, and promotes international cooperation. Initiatives such as the MSGI and the Decarbonization Blueprint 2050 clearly reflect a systematic, science-based approach with clear timelines and concrete pathways toward achieving net-zero emissions.

Second, Singapore has successfully integrated environmental objectives with economic development, transforming decarbonization requirements into a competitive advantage. Programmes such as "Green Port", "Green Ship", "Green Technology", and "Green Craft" have not only reduced emissions but also improved productivity, operational efficiency, and the international image of the Port of Singapore. The promotion of clean fuels, the adoption of mass flow metering technology, electronic documentation, and port digitalization have enhanced transparency, lowered costs, and helped establish new operational standards for the entire industry.

Thirdly, the linkage between energy transition and digital transformation is a prominent feature of Singapore's green maritime policy. Pilot projects on low-carbon fuels (LNG,

methanol, and ammonia) have been implemented alongside the development of green shipping corridors and real-time data exchange systems between major ports such as Rotterdam, Los Angeles, and Shanghai. This dual-track approach has enabled Singapore to take the lead in building a global network of green and smart ports.

For Vietnam, these experiences are particularly valuable as it implements the Green Port Development Project and the Sustainable Blue Economy Strategy. Vietnam could consider establishing a dedicated coordinating agency, improving the legal and regulatory framework, encouraging technological innovation, digitalizing port management, and promoting international cooperation on green shipping corridors. Vietnam could consider shifting its mindset: decarbonization should not be viewed merely as an environmental obligation, but as a strategic opportunity to enhance national competitiveness. If Vietnam can effectively combine an efficient institutional framework, green technologies, and sustainable finance, it can develop its own distinctive green maritime model. This would contribute significantly to the goals of building a modern, resilient blue economy, adapting to climate change, and achieving net-zero emissions by the mid-21st century.

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