

The potential of Great Nicobar as a distribution hub for alternative marine fuels

ICCT INDIA



INTRODUCTION

To support national and global efforts to decarbonize shipping, India's Ministry of Ports, Shipping, and Waterways (MoPSW) has launched the *Maritime Amrit Kaal Vision - 2047*, a comprehensive strategy for developing sustainable maritime infrastructure and promoting India's blue economy. Developed through extensive consultations with stakeholders and analysis of international benchmarks, the vision outlines over 300 actionable initiatives to enhance India's ports, shipping, and waterways sector by 2047. This includes developing infrastructure for three alternative fuels: green hydrogen, ammonia, and methanol. These alternative fuels offer the potential for deep reductions in the well-to-wake greenhouse gas (GHG) intensity of marine fuels when produced with renewable energy: for instance, green hydrogen produced via water electrolysis, green ammonia made by combining hydrogen with nitrogen, and green methanol made from synthesizing hydrogen with captured carbon dioxide (CO₂). However, the climate benefits of these fuels can be limited by challenges in their production or use, such as hydrogen leaks and nitrous oxide emissions from ammonia production (International Transport Forum, 2023; Warwick et al., 2023).

The island of Great Nicobar is being developed by the Government of India as a major container transshipment hub along the East-West maritime trade corridor and could be a distribution point for alternative fuels for international shipping. This study investigates the addressable market for green ammonia and green methanol that could be supplied at the Great Nicobar port to container vessels that currently bunker in Singapore. We estimate both the volume of alternative fuels required under this market and the corresponding renewable energy demand and capacity needed to produce these fuels domestically. While we find that there is an opportunity for Great Nicobar to be a maritime fuel distribution hub, there remain meaningful barriers to deploying green fuels to the island, primarily due to their high production and distribution costs. Complementary policies to foster demand for green fuels and reduce their production costs are recommended to position Great Nicobar as a green fuel distribution hub. The results can help inform a variety of stakeholders, including MoPSW and the Ministry of New and Renewable Energy (MNRE), as they plan for the infrastructure needed for India to become a hub for green fuels.

BACKGROUND

India has an extensive coastline that spans over 7,500 km and is strategically positioned along major international shipping routes. This geographic advantage offers significant potential for India to emerge as a leader in the global market for supplying fuel to ships, known as bunkering. However, the *Maritime Amrit Kaal Vision - 2047* outlines several challenges for India's bunkering industry (MoPSW, 2023).

One challenge relates to location and capacity. Indian ports currently offering bunkering services, such as Jawaharlal Nehru Port, Cochin, and Chennai, are not situated on major international trade routes. This limits their appeal to international vessels, which prefer bunkering hubs along key shipping corridors. India's ports also currently struggle with infrastructure limitations, including related to berthing capacity, bunker barge availability, and dredging activities (MoPSW, 2023). These factors have constrained the development of India's bunkering industry. Indian ports collectively bunkered approximately 2 Mt of marine fuel in FY 2022–23 (MoPSW, 2024). By

Acknowledgments: Ketan Gore and Bryan Comer are co-authors of this paper. We thank reviewers Gonca Seber Olcay, Amit Bhatt, Chelsea Baldino, and Yuanrong Zhou for their insightful feedback and valuable contributions. Our appreciation also goes to the editorial and design teams for preparing this paper for publication.

comparison, the world's largest bunkering hub, Singapore, supplied 48 Mt of fuel in 2022 (Maritime & Port Authority of Singapore, n.d.).

The MoPSW report detailed another set of challenges related to India's tax and tariff policies. The cost of bunkering in India is substantially higher than in other markets due to taxes and duties imposed on bunker fuel. In India, bunker fuel is subject to a goods and services tax (GST) of 5% and is not eligible for input tax credit. By contrast, fuel is not subject to taxes in major bunkering hubs like Singapore and Fujairah.¹ There is also a lack of a uniform tariff policy across ports, which results in pricing inconsistencies. Customs procedures are often cumbersome and time-consuming: ship owners are required to place fuel orders at least 2 working days in advance, and a requirement for bunker barges to reload for each delivery rather than function as floating storage adds another layer of operational complexity and inefficiency. Such challenges are further intensified by limited private sector involvement, which has resulted in reduced competition.

The *Maritime Amrit Kaal Vision – 2047* identified Great Nicobar Island as a potential site for developing a major bunkering hub by 2030 (MoPSW, 2023). Great Nicobar, now officially the 13th “major” port of India, offers several advantages for this initiative, including its strategic location, transshipment potential, and national government support for its development.²

MoPSW is already developing Great Nicobar as a transshipment container terminal with the capacity to handle 16 million containers annually. In the first phase of development (by 2028), the port is expected to handle over 4 million containers (The Economic Times, 2024). This transshipment activity will generate significant demand for bunkering services, as vessels operating on the East-West maritime trade corridor will require refueling during their stopovers. Additionally, developing Great Nicobar as a bunkering hub aligns with India's broader economic and geopolitical goals, including the Sagarmala Programme, which aims to modernize India's ports and enhance coastal connectivity. The initiative is expected to not only enhance India's position in global maritime trade but also create employment opportunities and contribute to the economic development of the Andaman and Nicobar Islands.

Great Nicobar is located approximately 40 nm from the Malacca Strait, an international shipping channel that handles approximately 35% of global sea trade and serves as a key segment of the East-West maritime trade corridor. Bunkering at Great Nicobar would allow vessels to refuel without deviating substantially from their routes. Additionally, Great Nicobar is close to Singapore, the world's largest bunkering hub. Figure 1 shows Great Nicobar's location along the East-West Maritime Corridor.

1 Singapore's exemption requires that fuel be delivered directly to a vessel bound for a destination outside the country.

2 Major ports are those owned and managed by the Indian national government, specifically under MoPSW. These ports are governed by the Major Port Authorities Act, 2021.

Figure 1

Location of Great Nicobar and India's other major ports



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://theicct.org)

The Government has proposed several measures to establish Great Nicobar as a bunkering hub. These include the provision of night navigation for 24/7 bunkering services, development of dedicated bunker oil loading points, treatment of bunker barges as floating storage, competitive pricing through fiscal incentives such as GST exemptions for international vessels, reduction in port charges, and integration of multiple bunker service providers to enhance service quality and competition (MoPSW, 2023).

GLOBAL AMBITIONS AND INDIA'S NATIONAL GREEN HYDROGEN MISSION

The International Maritime Organization (IMO) has set a near-term goal of achieving at least a 5% uptake of fuels with zero or near-zero GHG emissions by 2030 and a long-term target of achieving net-zero emissions by or around 2050 (IMO, 2023). Ships running on alternative fuels currently represent a small but growing segment of the global fleet. According to April 2025 data from Clarksons Research (2025), liquefied natural gas (LNG) is the most widely used alternative fuel (used by 1,344 vessels, or 1.2% of the fleet), followed by methanol (55 vessels; 0.1%). The orderbook shows greater uptake of alternative fuels, with LNG accounting for 15.1% of new orders and methanol 4.4%. Alternative fuels will primarily be utilized in ships with purpose-designed engine and fuel systems, as they are not drop-in replacements for conventional fuels in existing engine systems. While retrofitting existing vessels is technically possible, it presents challenges that include space constraints and complex engine system modifications. Implementing alternative fuel systems is most optimal in newly constructed vessels designed to accommodate the unique storage, handling, and combustion requirements of these fuels (Gore et al., 2022).

The ICCT previously found that LNG does not qualify as a zero- or near zero-GHG fuel due to upstream and downstream methane emissions (Pavlenko et al., 2020). Methane is a potent GHG with a significantly higher global warming potential than CO₂. This makes LNG unsuitable for achieving the IMO's long-term emission reduction targets; as a result, LNG is not assessed in this paper.

Among the cleaner alternatives being explored globally, green hydrogen and its derivatives have emerged as promising solutions. India is taking ambitious steps to develop its hydrogen economy. In 2023, MNRE (2023) launched the National Green Hydrogen Mission (NGHM) to establish the country as a major hydrogen producer and exporter. The mission sets a target of producing 5 Mt of green hydrogen per year by 2030, with the potential to scale up to 10 Mt as global demand grows. This is supported by an estimated ₹19,744 crore (\$2.32 billion) in government spending, of which ₹17,490 crore is allocated to the Strategic Interventions for Green Hydrogen Transition programme, which aims to support domestic manufacturing of electrolyzers and incentivize the production of green hydrogen, and the remaining ₹2,254 crore is dedicated to pilot projects, research and development initiatives, and other activities.

The NGHM prioritizes replacing hydrogen produced from fossil fuel sources with green hydrogen in ammonia production and petroleum refining, producing steel with green hydrogen, and substituting green hydrogen derivatives (green ammonia and green methanol) for fossil fuels in various sectors, including mobility, shipping, and aviation. This will include efforts to develop hydrogen hubs and modernize port infrastructure, with an additional 125 GW of renewable energy capacity expected to be deployed by MNRE by 2030 to help achieve the production target. According to the NGHM, scaling up hydrogen infrastructure in India would avoid 50 Mt of CO₂ emissions by 2030, create 600,000 full-time jobs, and considerably reduce the nation's dependence on imported fossil fuels.

For the maritime sector, the NGHM has outlined a comprehensive strategy to decarbonize shipping and port operations through the adoption of green hydrogen and its derivatives, including green ammonia and green methanol. This initiative aims to transform maritime transport and port activities by developing bunkering hubs at Indian ports, retrofitting vessels to operate on green fuels, and establishing supply chains to support both domestic utilization and future exports. In alignment with the NGHM's objectives, the state-owned Shipping Corporation of India is mandated to retrofit at least two ships to run on green hydrogen or its derivatives by 2027. Additionally, India's oil and gas public sector undertakings, which currently charter approximately 40 vessels for transporting petroleum products, are required to charter at least one ship powered by green hydrogen or its derivatives by 2027, with a commitment to add at least one such vessel each year thereafter.

REGULATORY CONTEXT

At the 83rd session of the Marine Environment Protection Committee (MEPC 83) in April 2025, the IMO adopted its Net Zero Framework (IMO, 2025). This framework introduced two pivotal mechanisms: a global fuel standard that requires phased reductions in GHG intensity starting in 2027, and a global emissions pricing mechanism that includes the creation of the IMO Net Zero Fund. The fuel standard sets GHG intensity reduction targets with two compliance pathways: a base target of 8% by 2030 and 30% by 2035, and a direct compliance target of 21% by 2030 and 43% by 2035, all relative to 2008 levels. The pricing mechanism, expected to take effect in 2028, imposes a levy of \$380 per tonne of CO₂ equivalent (t CO₂e) on ships exceeding the base target (Tier 2), and \$100/t CO₂e on ships that meet the base target but fall short of the direct compliance target (Tier 1). The IMO Net Zero Fund will collect these revenues and allocate them to reward low-emission ships, support innovation,

and assist developing countries in transitioning to low- and zero-emission shipping (DNV, 2025). It is expected that this pricing mechanism will accelerate the shift toward cleaner propulsion alternatives.

Though India has primarily focused on deploying biofuels in its road sector fuels policies thus far, the maritime sector may be a viable sector to deploy second-generation biofuels and hydrogen derivatives. While there are no demand-side policies in place at the national level, IMO's Net Zero Framework may provide greater market certainty for these types of fuels. Thus far, regions such as the European Union have struggled to deploy green hydrogen and hydrogen derivatives due to a combination of high costs, market uncertainty, and perceptions of investment risk (Navarrete et al., 2025).

MoPSW has initially identified the Deendayal, Paradip, and V.O. Chidambaranar (Tuticorin) ports for development as green hydrogen hubs by 2030 (ET Online, 2023). These will be equipped for the handling, storage, bunkering, and generation of green hydrogen and its derivatives. Looking ahead, the Ministry envisages that all major ports will have green ammonia bunkering facilities by 2035 and has a long-term goal of establishing green hydrogen hubs at all major ports by 2047 (MNRE, 2023; MoPSW, 2023).

Although the *Maritime Amrit Kaal Vision – 2047* report also envisions a hydrogen production and storage hub in the Andaman and Nicobar Islands (which include Great Nicobar Island), the islands have limited existing renewable energy capacity to support local green hydrogen production. This poses a meaningful implementation challenge and may introduce additional costs and complexity associated with distributing green fuels to the island. As the development of Great Nicobar as a container terminal and bunkering hub is still in its early stages, further policy-related announcements are expected concerning the expansion of renewable energy capacity and the future production and storage of green hydrogen and its derivatives at the port. In the meantime, this analysis anticipates that the requisite fuels will be sourced from established ports designated for development into hydrogen production, storage, and handling hubs by 2030, namely Deendayal, Paradip, and V.O. Chidambaranar (Tuticorin). These strategically located ports could play a vital role in supplying alternative fuels to Great Nicobar through the deployment of bunker barges, which serve as floating storage and enable barge-to-ship bunkering operations. This supply chain approach could allow refueling to occur either at berth or at sea while anchored and provide operational flexibility to vessels operating in and around Great Nicobar.

TECHNICAL AND SAFETY CONSIDERATIONS AND THE ECONOMICS OF GREEN HYDROGEN DERIVATIVES

It is highly unlikely that green hydrogen could be distributed and bunkered at Great Nicobar due to the efficiency losses and added expense associated with liquefaction and boil-off during distribution. However, the distribution of derivatives may be more feasible. There have been several recent demonstrations of technical advancement in alternative marine fuels. In May 2024, Singapore successfully completed a ship-to-ship methanol bunkering operation when it transferred 1,340 Mt of blended methanol (Maritime & Port Authority of Singapore, 2024a). A similar demonstration was conducted at the Port of Point Lisas in Trinidad and Tobago by Methanex and its partners (Methanex, 2024). The world's first ship-to-ship ammonia transfer at anchorage was achieved in September 2024 at the Port of Dampier in Australia, when 2,715 t of ammonia were transferred between vessels (Global Centre for Maritime Decarbonisation, 2024).

There are certain safety considerations associated with the production and use of alternative marine fuels. Methanol, while compatible with existing fuel infrastructure with

minor modifications, is toxic to humans and requires careful handling. It can cause severe health effects such as blindness or death if ingested, inhaled in high concentrations, or absorbed through the skin. To mitigate such risks, bunkering systems must be designed to prevent direct contact, and crew must be trained in safety procedures in line with IMO's low-flashpoint fuels code (Methanol Institute, 2023).

Ammonia bunkering also requires stricter safety protocols due to its toxic and corrosive nature. Guidelines emphasize the need for comprehensive risk assessments, proper training, and adherence to international safety standards (Duong et al., 2023).

Due to the high expense associated with producing hydrogen derivatives, it is unlikely that these fuels would be cost viable absent strong policy intervention. The cost of producing green hydrogen is affected by multiple factors, including the cost of renewable electricity, the electrolyzer, and financing (Navarrete & Zhou, 2024; Zhou & Searle, 2022). Green hydrogen has been estimated to cost roughly \$4.1–\$7.0/kg to produce in India (Raj et al., 2022). A previous ICCT analysis projected green hydrogen production costs in India in 2030 to be \$5–\$6/kg, with projections for 2050 being \$3–\$3.5/kg (Kelly & Zhou, 2022). In the European Union, green hydrogen costs ranged from €4.1–€9.3/kg (\$4.4–\$10.1/kg) in 2023 (European Hydrogen Observatory, n.d.). India's prices are competitive with China's electrolysis hydrogen production price range of \$4.6–\$14.8/kg, which is projected to fall below \$3/kg by the mid-2030s, and with Brazil's current estimated green hydrogen costs of \$3.4–\$7/kg, which are projected to decrease slightly to \$2.66–\$5.56/kg by 2030 (Agora Industry, 2024; Carvalho et al., 2023; Fan et al., 2025; Hierhammer, 2023; S. Mao et al., 2021; Yin, 2022). Converting hydrogen into derivatives such as e-ammonia and e-methanol requires additional infrastructure and results in conversion losses, raising production prices further.

Across all of these estimates, the cost of hydrogen and the implied cost of derivatives is significantly more expensive than the cost of low-sulfur heavy fuel oil and is likely to remain so through 2050.

METHODOLOGY

Our analysis examines the potential scale of alternative fuel and renewable energy capacity demand that could be captured by Great Nicobar annually based on recent ship activity patterns. We assess the potential addressable market for alternative fueled container ships that currently refuel in Singapore and use 2023 data for to estimate bunker fuel demand and associated alternative fuel and renewable energy requirements. Note that this is a point-in-time assessment; by 2030, when India's NGHM target to produce 5 Mt of green hydrogen annually comes into effect, actual shipping patterns and fuel demand may have evolved considerably. The key objectives of the research are as follows:

1. Estimate the bunkering demand for container ships that refueled in Singapore in 2023;
2. Calculate the addressable market for green ammonia and green methanol from these container ships if they were to switch to Great Nicobar for bunkering in the future; and
3. Estimate the potential renewable energy demand if those quantities of hydrogen derivatives were produced to supply the distribution hub.

ESTIMATING BUNKERING DEMAND

To estimate the bunkering demand, we adopted the methodology from a previous ICCT study that identified bunkering events and evaluated the mass of fuel bunkered (X. Mao et al., 2022). In Singapore, bunkering primarily occurs through barge-to-ship

operations in which bunker barges deliver fuel to receiving vessels at designated berths or anchorages. A bunkering event is defined as the period when a bunker barge and a receiving vessel are in close proximity (within 100 m) for at least 2 hours.

Our identification process began with analyzing the bunker barge fleet. We focused on container ships that berthed or anchored at the Port of Singapore in 2023. Container ships were selected because nearly 35% of global containerized trade occurs along the East-West trade corridor and because MoPSW has set out an aim to develop Great Nicobar into an “international container transshipment port” (Press Information Bureau, 2023). As of November 2024, there were 205 licensed bunker barges operating in Singapore (Maritime & Port Authority of Singapore, 2024b). Of these, we matched 199 with S&P Global’s (2023) ship characteristics database, meaning they were also active in 2023.³ Barges that were inactive or not used for bunkering in 2023 were excluded from the analysis.

We identified container ships requiring bunkering services using the Systematic Assessment of Vessel Emissions (SAVE) model, a Python-based model developed by the ICCT (Olmer et al., 2017). The SAVE model integrates ships’ Automatic Identification System (AIS) data with vessel characteristics to assess operational behavior, voyage pattern, routing network, energy consumption, emissions, and the environmental and climate impact of the global shipping industry.

Bunkering events were identified using AIS-based proximity data (Spire, n.d.). This method identifies events only when a bunker barge and container ship are co-located within the defined spatial and temporal bounds. Events were confirmed when vessels met the proximity and duration criteria. If multiple bunker barges met the criteria for the same receiving vessel, the barge with the longest bunkering duration was selected as the primary supplier for that event. For each confirmed bunkering event, we assumed that 65% of the receiving vessel’s fuel tank capacity was refilled, consistent with prior ICCT analysis (X. Mao et al., 2022). The S&P Global ship characteristics database was used to retrieve vessel fuel tank capacities. The results were aggregated to provide an estimate of total bunkering demand for container ships refuelling in Singapore in 2023.

Calculating alternative fuel addressable market

To estimate the addressable market for green ammonia (RE-NH₃) and green methanol (RE-MeOH) as alternatives to residual (0.5% sulfur compliant) fuel, we adapted the methodology from another ICCT study (Comer, 2019). This approach accounts for the energy density differences between conventional and alternative fuels, and ensures that the same amount of propulsion energy is provided. Given the IMO’s 2020 sulfur regulation, residual fuel with maximum 0.5% sulfur content was assumed as the primary bunkered fuel.

We considered two modeling scenarios. In the Total Replacement scenario, we assumed a complete shift in bunkering activity from Singapore to Great Nicobar for container vessels, with 100% substitution of residual fuel by a single alternative fuel type. In the IMO 2030 scenario, we assumed that zero- or near-zero fuels comprise 5% of the energy used by international shipping in 2030, in line with IMO targets. Each alternative fuel scenario within these frameworks represents replacement by a single fuel type—hydrogen, ammonia, or methanol—rather than cumulative adoption of multiple fuels. While neither scenario reflects the current policy or market reality, this analysis is intended to illustrate the potential alternative fuel market that could be captured by the new port.

³ This document includes content supplied by S&P Global; Copyright © S&P Global, 2023. All rights reserved.

The addressable market for each alternative fuel was estimated by adjusting the total residual fuel consumption of container ships refueling in Singapore using the ratio of energy densities. The energy density values for alternative fuels were obtained from the IMO (Resolution MEPC.364(79), 2022; Resolution MEPC.391(81), 2024). The aggregated alternative fuel addressable market was calculated as follows:

$$FC_r = \frac{FC_j \times \frac{LHV_r}{LHV_j}}{1,000}$$

Where:

- FC_j is the aggregated fuel demand for alternative fuel j , in t;
- FC_r is the fuel consumption of container ships operating on residual fuel, in kg;
- LHV_r is the lower heating value of residual fuel (42 MJ/kg); and
- LHV_j is the lower heating value of alternative fuel j (H_2 = 120 MJ/kg, NH_3 = 18.6 MJ/kg, MeOH = 19.9 MJ/kg).

In addition to estimating alternative fuel market, we further calculated the implied hydrogen demand, which represents the total green hydrogen required to produce the equivalent amounts of green ammonia and green methanol. The requisite conversion efficiency values for ammonia and methanol were obtained from Brynolf et al. (2018) and Moritz et al. (2023). This was determined using the following equation:

$$FC_{H2-i} = FC_j \times \frac{LHV_j}{\eta_j \times LHV_{H2}}$$

Where:

- FC_{H2-i} is the implied mass of hydrogen required for ammonia or methanol production, in t;
- FC_j is the aggregated fuel demand for alternative fuel j , in t;
- LHV_j is the lower heating value of alternative fuel j (NH_3 = 18.6 MJ/kg, MeOH = 19.9 MJ/kg);
- η_j is the conversion efficiency (NH_3 = 84%, MeOH = 79%); and
- LHV_{H2} is the lower heating value of hydrogen H_2 (120 MJ/kg).

Calculating renewable energy demand and capacity

For the estimated green hydrogen addressable market to produce derivatives, the total renewable energy demand required for green hydrogen production was determined by considering the electrical energy input needed for water electrolysis, the primary method for producing green hydrogen. The renewable energy demand was calculated by accounting for electrolysis efficiency, which determines the amount of electricity required to produce 1 t of hydrogen (Vives et al., 2023). By applying this factor to the hydrogen demand, an estimate of the total renewable energy required to support alternative fuel production for container ships bunkering in Great Nicobar was obtained using the following equation:

$$RE = \frac{FC_{H2} \times 1,000 \times LHV_{H2}}{\eta_{electrolysis} \times 1,000,000}$$

Where:

- RE is the total renewable energy demand (GWh);
- FC_{H2} is the aggregated hydrogen fuel demand, in t;
- LHV_{H2} is the lower heating value of hydrogen (33.3 kWh/kg); and
- $\eta_{electrolysis}$ is the electrolysis efficiency (considered to be 70%).

To estimate the total renewable energy generation capacity required to meet the electricity demand for green hydrogen production, the total renewable energy demand must be adjusted based on the capacity factor of a renewable energy plant (Hunt & Bloomfield, 2024). We then estimated the capacity as follows:

$$C_{RE} = \frac{RE}{CF \times 8,760}$$

Where:

- C_{RE} is the required renewable energy capacity (GW);
- RE is the total renewable energy demand (GWh);
- CF is the capacity factor (considered to be 30%); and
- 8,760 are the total hours in a year.

RESULTS

SINGAPORE BUNKER ESTIMATE

Table 1 presents estimated bunkering activity and fuel volumes for container ships refueling in Singapore in 2023, based on barge-to-ship interactions. The analysis identified 908 unique container vessels that received fuel during the year, with a total of 3,027 bunkering events recorded. These events were determined using spatial and temporal thresholds applied to AIS data, with each event representing a confirmed transfer between a bunker barge and a container ship. To estimate total fuel volumes, it was assumed that vessels took on 65% of their fuel tank capacity during each confirmed bunkering event. Using this method, the total estimated bunker volume for 2023 was approximately 11.1 Mt. Additional details on average fuel volumes per ship and bunkering frequency patterns are presented in Table 1.

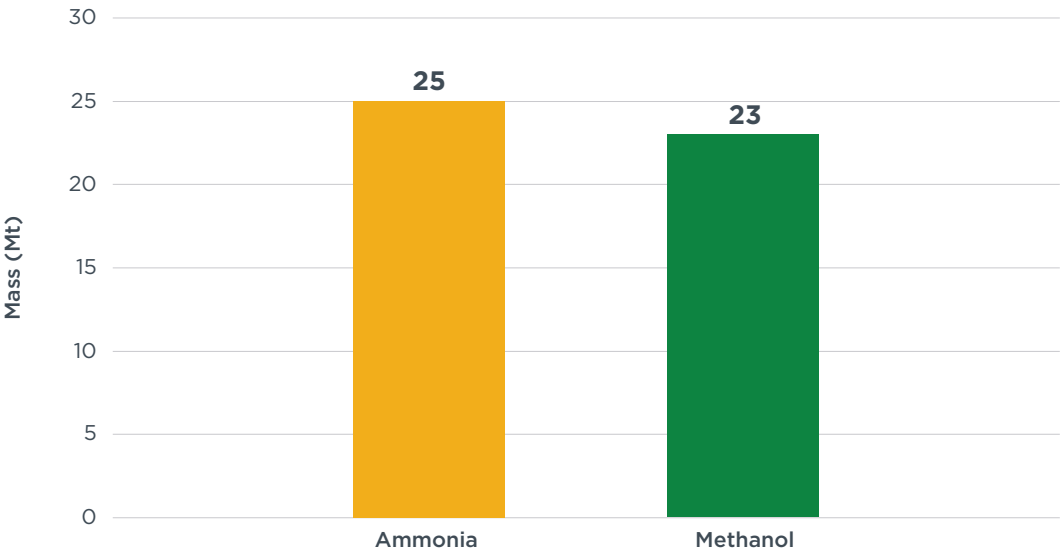
Table 1
Estimated bunkering activity and volume for container ships in Singapore in 2023

Metric	Value
Total number of ships	908
Total number of bunker events	3,027
Total bunker volume (Mt)	11.1
Bunker events per ship	3
Bunker volume (tonnes per ship)	12,244
Bunker volume (tonnes per event)	3,673

ALTERNATIVE FUEL MARKET

Building upon the residual fuel bunkering estimates from Singapore, we examined the theoretical equivalent fuel market under our two scenarios. Because ammonia and methanol have lower energy densities than residual fuel, larger volumes are needed to provide the same propulsion energy. Figure 2 shows that meeting this energy demand would require ammonia supplies of approximately 25 Mt, while methanol demand would be approximately 23 Mt. (Values displayed in Figures 2–6 represent rounded estimates.)

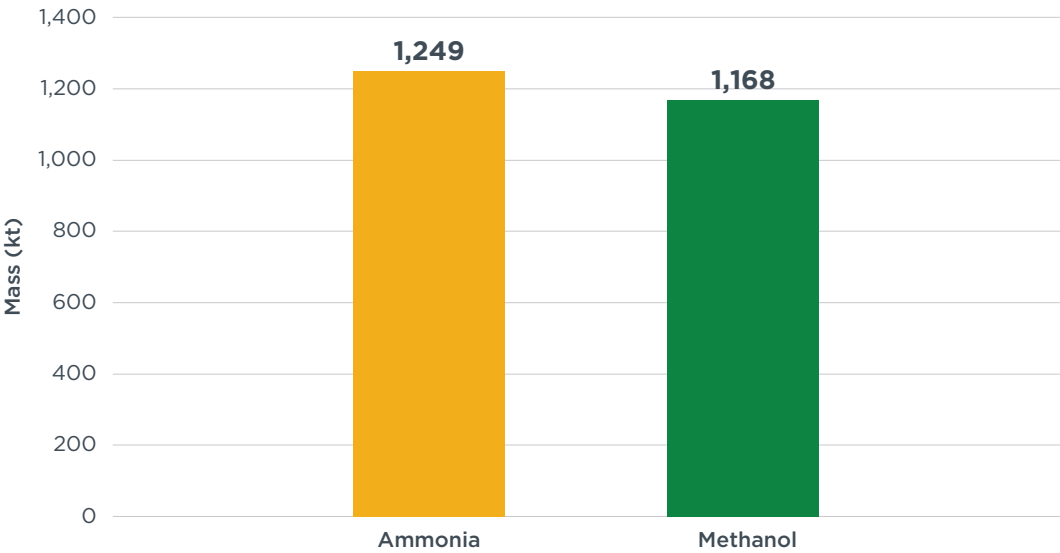
Figure 2
Estimated bunker volume for total replacement of residual fuel with a single type of alternative fuel



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://www.theicct.org)

Because the IMO 2030 scenario targets at least 5% of international shipping’s energy to come from fuels with zero or near-zero GHG emissions, we assumed that 5% of the energy demand from container ships operating on the East-West corridor is met with alternative fuels, with these ships choosing to bunker in Great Nicobar instead of Singapore. Under this condition, Figure 3 outlines that the addressable market is estimated to be at 1,249 kt for ammonia and at 1,168 kt for methanol.

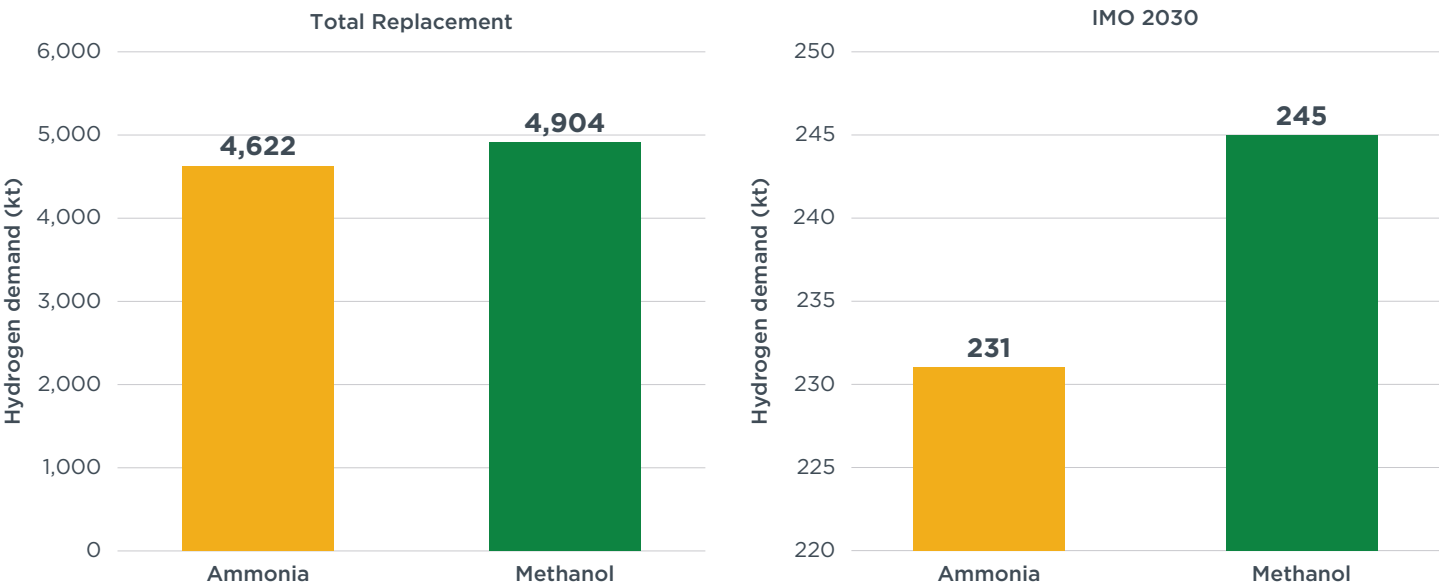
Figure 3
Estimated alternative fuel bunker addressable market in the IMO 2030 scenario



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://www.theicct.org)

The implied alternative fuel market analysis (Figure 4) quantifies the renewable hydrogen required for producing ammonia and methanol. To produce the necessary ammonia volumes, hydrogen demand is estimated at 4,622 kt. Methanol production would require 4,904 kt of hydrogen. The hydrogen demand for methanol is higher than for ammonia because of its lower conversion efficiency and slightly higher lower heating value, both of which are accounted for in the methodology. Under the IMO 2030 scenario, the corresponding implied hydrogen demand for ammonia production is 231 kt; for methanol production, hydrogen demand is 245 kt.

Figure 4
Estimated implied hydrogen demand to produce ammonia and methanol

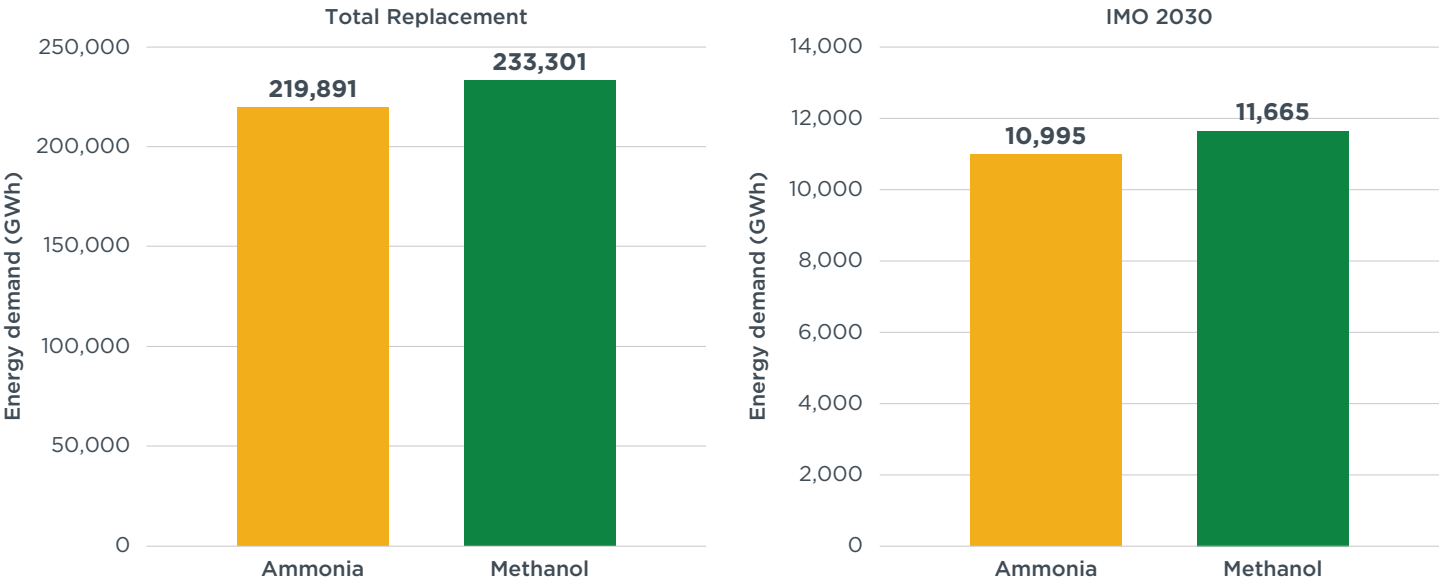


THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://theicct.org)

RENEWABLE ENERGY DEMAND

The renewable energy demand for hydrogen production is directly influenced by the estimated alternative fuel demand in Great Nicobar. As hydrogen serves as the primary feedstock for ammonia and methanol, the total electricity required depends on direct hydrogen use and its conversion into derivatives. Figure 5 illustrates these estimates for each scenario. In the Total Replacement scenario, the estimated electricity requirement for direct hydrogen production is 184,233 GWh. Considering the implied hydrogen demand for ammonia and methanol, the energy demand increases to 219,891 GWh for ammonia-derived hydrogen and 233,301 GWh for methanol-derived hydrogen, highlighting the additional energy requirements when producing derivatives. Under the IMO 2030 scenario, the energy requirements are estimated at 9,212 GWh for hydrogen, 10,995 GWh for ammonia-derived hydrogen, and 11,665 GWh for methanol-derived hydrogen.

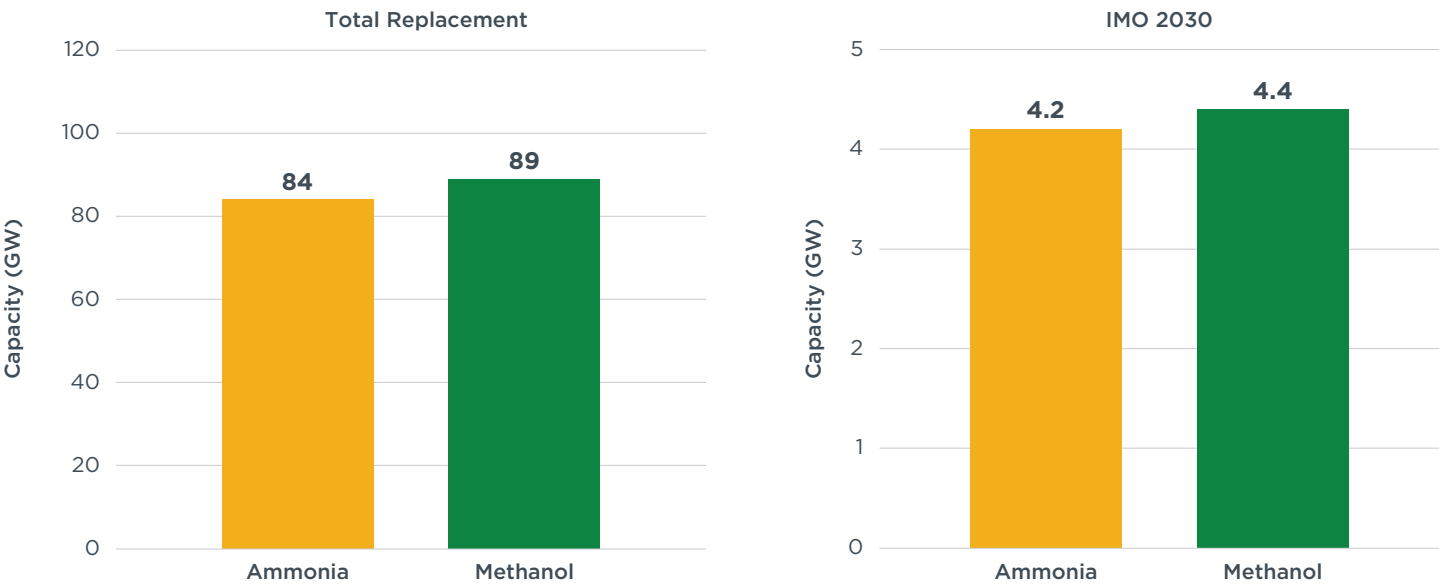
Figure 5
Estimated renewable energy demand to produce renewable ammonia and methanol



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://theicct.org)

Based on the outlined renewable energy demand estimates, Figure 6 presents the estimated renewable energy capacity required to support hydrogen as an input for ammonia and methanol synthesis. After accounting for the implied hydrogen demand for ammonia and methanol, ammonia-implied hydrogen requires 84 GW and methanol-implied hydrogen requires 89 GW. In the IMO 2030 scenario, the capacity is estimated at 4.2 GW for ammonia and 4.4 GW for methanol.

Figure 6
Estimated renewable energy capacity needed to produce renewable ammonia and methanol



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://theicct.org)

DISCUSSION

In addition to economic and strategic opportunities (Press Information Bureau, 2023), the Great Nicobar Island transshipment port and bunkering hub development presents several socio-environmental challenges due to its location in an ecologically sensitive region that is home to vulnerable groups. Overcoming these challenges would require careful consideration and proactive mitigation strategies. This section discusses select social and environmental issues associated with the Great Nicobar development and highlights approaches that have been effective in addressing such issues in other regions.

BIODIVERSITY AND ECOSYSTEM CONSERVATION

Great Nicobar is home to critical habitats for numerous endangered species, including the Nicobar megapode, leatherback turtles, corals, migratory birds, and Nicobar crab-eating macaques, and all face disruption from port development activities (Aggarwal, 2022). In Brisbane, Australia, the large-scale shellfish reef restoration project in Moreton Bay deployed over 3,000 artificial oyster reefs constructed from recycled shells to significantly improve marine biodiversity and water quality (Dennis & Parks, 2024), demonstrating how infrastructure development can be coupled with active ecosystem enhancement. The Great Nicobar project could implement similar compensatory habitat creation alongside long-term monitoring programs to assess changes in marine ecosystem health.

FOREST CONSERVATION AND DEFORESTATION MANAGEMENT

Developing Great Nicobar will require clearing nearly 131 km² of rainforest in a UNESCO Biosphere Reserve area that supports endemic species (Arthur & Shankar Raman, 2025). The Maasvlakte 2 project in Rotterdam, the Netherlands, established a 25,000-hectare marine protection zone and constructed a 35-hectare dune area along the Delfland coast to compensate for habitat loss and enhance biodiversity in port development contexts (Port of Rotterdam, n.d.). The Great Nicobar project could similarly establish protected forest reserves and implement advanced reforestation techniques using native species to create net positive biodiversity outcomes.

INDIGENOUS COMMUNITY ENGAGEMENT AND RIGHTS PROTECTION

The potential displacement and disruption of the Shompen and Nicobarese peoples raises concerns about indigenous rights. These communities possess traditional ecological knowledge that has sustained island ecosystems for generations (Arthur & Shankar Raman, 2025). When the Vancouver Port Authority involved over 35 indigenous groups through formal consultation processes, information sessions, and community liaison committees, it demonstrated how indigenous voices can be integrated into planning and decision-making processes (Port of Vancouver, 2023). The Great Nicobar project can establish consultation frameworks to develop similar strategies and help ensure that traditional resource-use patterns are meaningfully integrated into project design through binding agreements, for instance to designate specific areas for continued traditional use, establish buffer zones around culturally significant sites, and incorporate traditional ecological knowledge into environmental monitoring protocols.

SEISMIC AND GEOLOGICAL RISK MANAGEMENT

The project's location in Earthquake Zone V entails significant geological hazards, including a high tsunami risk, that raise concerns about long-term infrastructure resilience and environmental protection capabilities (Aggarwal, 2022). Japan's

response to the 2011 Tohoku tsunami, which included comprehensive infrastructure improvements and the establishment of enhanced offshore tsunami sensor networks, significantly improved early warning capabilities and disaster response coordination (Maly & Suppasri, 2020; Somerville, 2021). The Great Nicobar project can incorporate similar advanced monitoring systems and tsunami-resistant infrastructure design standards with comprehensive emergency response protocols.

FRESHWATER RESOURCE MANAGEMENT

Great Nicobar's limited freshwater resources could face increased demand from port operations and population growth that could threaten both human communities and freshwater-dependent ecosystems (Ramakrishna, 2022). Singapore's comprehensive water management approach, which incorporated rainwater harvesting, wastewater recycling, and desalination, demonstrated how to achieve water security while limiting environmental impacts and dramatically reducing reliance on imported water (PwC, 2018; Schauenberg, 2024). The Great Nicobar project can implement similar diversified water management strategies, including advanced rainwater harvesting systems and closed-loop water recycling for port operations.

CLIMATE RESILIENCE AND COASTAL PROTECTION

The project's vulnerability to sea level rise, extreme weather events, and coastal erosion requires proactive adaptation measures that protect both infrastructure investments and natural ecosystems, as climate change impacts in the region are likely to intensify over the project's operational lifetime (Aggarwal, 2022). The Port of Antwerp's climate resilience initiatives, including elevated infrastructure design and protective barriers as part of Belgium's Coastal Safety Master Plan, demonstrate comprehensive frameworks for addressing these challenges through participation in collaborative research initiatives like the CLARION Project (Port of Antwerp Burges, 2024; Singh, 2025). The Great Nicobar project can incorporate similar climate adaptation measures.

CONCLUSION

This analysis evaluated Great Nicobar's potential as an alternative fuel distribution hub. Approximately 900 container ships bunker around 11.1 Mt of fuel annually in Singapore. We estimate that if these vessels were to switch to Great Nicobar, assuming a complete replacement of residual fuel demand by a single fuel type, the potential alternative fuel market would be 25 Mt of ammonia or 23 Mt of methanol.

While this analysis evaluates Great Nicobar's location as well-suited to be a fuel distribution hub, we find that it will take substantial policy intervention for it to be a green fueling hub. Considering distinct alternative fuel scenarios, this would require approximately 0.19–0.25 Mt of green hydrogen and 3.5–4.5 GW of renewable capacity. As meeting 100% of the alternative fuel demand (requiring an estimated 70–89 GW) would consume roughly half of India's planned 125 GW renewable capacity for hydrogen production under the NGHM, simultaneously serving shipping and other sectors requiring green hydrogen could pose a challenge, particularly when we consider demand for hard to decarbonize sectors with lower barriers such as fertilizer production and steelmaking. Given the high cost of green hydrogen production and logistical barriers, the goal of producing volumes in line with IMO's target may be challenging by 2030. Competition with other alternative fuels as well as offtake uncertainty may necessitate strong policy intervention to foster demand and reduce costs.

Careful planning will be key to mitigating the social and environmental risks associated with the Great Nicobar development, which include possible biodiversity loss affecting endangered species like the Nicobar megapode and leatherback turtles, deforestation

of 130 km² of rainforest, and potential disruption to indigenous Shompen and Nicobarese communities. International best practices from similar port developments illustrate how these may be mitigated through comprehensive environmental offsetting, robust indigenous consultation frameworks, advanced monitoring systems, innovative water and waste management, and climate-resilient infrastructure design. The success of Great Nicobar as a bunkering hub will ultimately depend on integrating these environmental stewardship principles with the alternative fuel and renewable energy capacity planning outlined above.

REFERENCES

- Aggarwal, M. (2022). The container terminal that could sink the Great Nicobar Island. *Monga Bay* <https://india.mongabay.com/2022/07/the-container-terminal-that-could-sink-the-great-nicobar-island/>
- Agora Industry. (2024). *12 insights on hydrogen – Brazil edition*. <https://www.agora-industry.org/publications/12-insights-on-hydrogen-brazil-edition>
- Arthur, R., & Shankar Raman, T. R. (2025). An obit for Patai Takaru. *Frontline*. <https://frontline.thehindu.com/environment/great-nicobar-island-andaman-ecological-development-coral-reefs-marine-ecosystems-climate-change/article69158539.ece>
- Brynnolf, S., Taljegard, M., Grahn, M., & Hansson, J. (2018). Electrofuels for the transport sector: A review of production costs. *Renewable and Sustainable Energy Reviews*, 81(2), 1887–1905. <https://doi.org/10.1016/j.rser.2017.05.288>
- Carvalho, F., Osipova, L., & Zhou, Y. (2023). *Life-cycle greenhouse gas emissions of hydrogen as a marine fuel and cost of producing green hydrogen in Brazil*. International Council on Clean Transportation. <https://theicct.org/wp-content/uploads/2023/03/maritime-brazil-hydrogen-costs-mar23.pdf>
- Clarkson Research. (2025). *Tracking “green” technology uptake—April 2025* [Dataset]. <http://www.clarksons.net/portal>
- Comer, B. (2019). *Transitioning away from heavy fuel oil in Arctic shipping*. International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2021/06/Transitioning_from_hfo_Arctic_20190218.pdf
- Dennis, J., & Parks, M. (2024). Ozfish drop more than 3,000 man-made oyster reefs at Port of Brisbane in bid to restore shellfish population. *ABC News*. <https://www.abc.net.au/news/2024-12-20/queensland-oyster-restoration-moreton-bay-port-of-brisbane/104733290>
- DNV. (2025). *IMO MEPC 83: GHG requirements approved, taking effect from 2028*. <https://www.dnv.com/news/imo-mepc-83-ghg-requirements-approved-taking-effect-from-2028/>
- Duong, P. A., Ryu, B. R., Song, M. K., Nguyen, H. V., Nam, D., & Kang, H. (2023). Safety assessment of the ammonia bunkering process in the maritime sector: A review. *Energies*, 16(10), 4019. <https://doi.org/10.3390/en16104019>
- ET Online. (2023). *India identifies three ports in Kandla, Paradip, and Tuticorin to develop as export hubs for hydrogen, ammonia, and methanol*. <https://economictimes.indiatimes.com/industry/renewables/india-identifies-three-ports-in-kandla-paradip-and-tuticorin-to-develop-as-export-hubs-for-hydrogen-ammonia-and-methanol/articleshow/104106875.cms?from=mdr>
- European Hydrogen Observatory. (n.d.). *Cost of hydrogen production* [Dataset]. Retrieved 31 July 2025 from <https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/production-trade-and-cost/cost-hydrogen-production>
- Fan, G., Zhang, H., Sun, B., & Pan, F. (2025). Economic and environmental competitiveness of multiple hydrogen production pathways in China. *Nature Communications*, 16(4284). <https://doi.org/10.1038/s41467-025-59412-y>
- Global Centre for Maritime Decarbonisation. (2024). *Successful ship-to-ship ammonia transfers pave the way for ammonia bunkering in the Pilbara region* [Press release]. <https://gcformd.org/successful-ship-to-ship-ammonia-transfers-pave-the-way-for-ammonia-bunkering-in-the-pilbara-region/>
- Gore, K., Rigot-Müller, P., & Coughlan, J. (2022). Cost assessment of alternative fuels for maritime transportation in Ireland. *Transportation Research Part D: Transport and Environment*, 110, 103416. <https://doi.org/10.1016/j.trd.2022.103416>
- Hierhammer, M. (2023). *Factsheet: The price of green hydrogen and derivatives*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://energypartnership.cn/fileadmin/china/media_elements/publications/2024/EnTrans/H2_Cost_competitiveness_Green_H2_and_Derivatives_EN.pdf
- Hunt, K. M. R., & Bloomfield, H. C. (2024). Quantifying renewable energy potential and realized capacity in India: Opportunities and challenges. *Meteorological Applications*, 31(3). <https://doi.org/10.1002/met.2196>
- International Maritime Organization. (2023). *IMO’s work to cut GHG emissions from ships* [Press release]. <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx>
- International Maritime Organization. (2025). *IMO approves net-zero regulations for global shipping* [Press release]. <https://www.imo.org/en/MediaCentre/PressBriefings/pages/IMO-approves-netzero-regulations.aspx>
- International Transport Forum. (2023). *The potential of e-fuels to decarbonise ships and aircraft*. <https://www.itf-oecd.org/sites/default/files/docs/potential-efuels-decarbonise-ships-aircraft-v2.pdf>
- Kelly, C., & Zhou, Y. (2022). *Hydrogen fuel for transport in India*. International Council on Clean Transportation. <https://theicct.org/publication/india-fuel-hydrogen-cost-jan22/>

- Maly, E., & Suppasri, A. (2020). The Sendai Framework for disaster risk reduction at five: Lessons from the 2011 Great East Japan Earthquake and Tsunami. *International Journal of Disaster Risk Science*, 11, 167–178. <https://doi.org/10.1007/s13753-020-00268-9>
- Manoj, P. (2023). Adani Ports, Concor, JSW Infra among ten entities file EoI for container transshipment hub in Great Nicobar Island. *ET Infra*. <https://infra.economictimes.indiatimes.com/news/ports-shipping/adani-ports-concor-jsw-infra-among-ten-entities-file-eoi-for-container-transshipment-hub-in-great-nicobar-island/98493152>
- Mao, S., Basma, H., Ragon, P.-L., Zhou, Y., & Jiménez, F. (2021). *Total cost of ownership for heavy trucks in China: Battery electric, fuel cell, and diesel trucks*. International Council on Clean Transportation. <https://theicct.org/publication/total-cost-of-ownership-for-heavy-trucks-in-china-battery-electric-fuel-cell-and-diesel-trucks/>
- Mao, X., Rutherford, D., Osipova, L., & Georgeff, E. (2022). *Exporting emissions: Marine fuel sales at the Port of Singapore*. The International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2022/07/Singapore-exporting_FINAL.pdf
- Maritime & Port Authority of Singapore. (n.d.). *Bunkering statistics*. [Dataset] Retrieved 31 July 2025, from <https://www.mpa.gov.sg/port-marine-ops/marine-services/bunkering/bunkering-statistics>
- Maritime & Port Authority of Singapore. (2024a). *Bunker tanker list—November 2024*. https://www.mpa.gov.sg/docs/mpalibraries/mpa-documents-files/oms/bunkering/bunkering-services-providers/bunker-tanker-list---nov-2024.pdf?sfvrsn=3e94800e_0
- Maritime & Port Authority of Singapore. (2024b, May 24). *Singapore carries out ship-to-ship bunkering of close to 1,340 metric tonnes of blended methanol* [Press release]. <https://www.mpa.gov.sg/media-centre/details/singapore-carries-out-ship-to-ship-bunkering-of-close-to-1-340-metric-tonnes-of-blended-methanol>
- Maritime Technologies Forum. (2024). *Guidelines for the development of liquified hydrogen bunkering systems and procedures*. <https://www.maritimetechnologiesforum.com/documents/2024-mtf-LH2-bunkering-guidelines.pdf>
- Methanex. (2024). *Methanex continues to demonstrate leadership with first ship-to-ship methanol bunkering operation in Trinidad & Tobago, Caribbean* [Press release]. <https://www.methanex.com/news/update/methanex-continues-to-demonstrate-leadership-with-first-ship-to-ship-methanol-bunkering-operation-in-trinidad-tobago-caribbean/>
- Methanol Institute. (2023). *Marine methanol future-proof shipping fuel*. https://www.methanol.org/wp-content/uploads/2023/05/Marine_Methanol_Report_Methanol_Institute_May_2023.pdf
- Ministry of New and Renewable Energy. (2023). *National Green Hydrogen Mission*. <https://mnre.gov.in/en/notice/the-national-green-hydrogen-mission-13-1-2023-648-kb-pdf/>
- Ministry of Ports, Shipping and Waterways. (2023). *Maritime Amritkaal—Vision 2047*. <https://shipmin.gov.in/content/amrit-kaal-2047>
- Ministry of Ports, Shipping and Waterways. (2024). *India shipping statistics 2023* [Dataset]. <https://shipmin.gov.in/sites/default/files/ISS%202023.pdf>
- Moritz, M., Schönfisch, M., & Schulte, S. (2023). Estimating global production and supply costs for green hydrogen and hydrogen-based green energy commodities. *International Journal of Hydrogen Energy*, 48(25), 9139–9154. <https://doi.org/10.1016/j.ijhydene.2022.12.046>
- Navarrete, A., & Zhou, Y. (2024, May 20). *The price of green hydrogen: How and why we estimate future production costs*. International Council on Clean Transportation Staff Blog. <https://theicct.org/the-price-of-green-hydrogen-estimate-future-production-costs-may24/>
- Navarrete, A., Baldino, C., & Pavlenko, N. (2025). *Industry perspectives on advanced sustainable aviation fuel: What barriers remain for these technologies to scale?* International Council on Clean Transportation. <https://theicct.org/publication/saf-what-barriers-remain-for-these-technologies-to-scale-jul25/>
- Olmer, N., Comer, B., Roy, B., Mao, X., & Rutherford, D. (2017). *Greenhouse gas emissions from global shipping, 2013–2015: Detailed methodology*. International Council on Clean Transportation. <https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015>
- Pavlenko, N., Comer, B., Zhou, Y., & Clark, N. (2020). *The climate implications of using LNG as a marine fuel*. International Council on Clean Transportation. https://theicct.org/sites/default/files/publications/Climate_implications_LNG_marinefuel_01282020.pdf
- Port of Antwerp Burges. (2024, May 14). *CLARION Project takes the lead in strengthening European ports' resilience* [Press release]. <https://port-of-antwerp.prezly.com/clarion-project-takes-the-lead-in-strengthening-european-ports-resilience>
- Port of Rotterdam. (n.d.). *Rotterdam Mainport Development Project*. Retrieved 31 July 2025, from <https://www.portofrotterdam.com/en/building-port/ongoing-projects/rotterdam-mainport-development-project>
- Port of Vancouver. (2023). *Indigenous relationships*. https://portvancouver.metro.net/indicators/thriving_communities/aboriginal_relationships
- Press Information Bureau. (2023). *EoI to be invited for the International Transshipment Port at Great Nicobar Island* [Press release]. <https://pib.gov.in/PressReleasePage.aspx?PRID=1894045>

- PwC. (2018). *Singapore water management framework* [Presentation]. https://www.gfdrr.org/sites/default/files/D3_CaseStudy14_PwC_WB_Water_Sector_in_Singapore_20160709_original.1531383095.pdf
- Raj, K., Lakhina, P., & Stranger, C. (2022). *Harnessing green hydrogen opportunities for deep decarbonisation in India*. Niti Aayog and RMI. https://niti.gov.in/sites/default/files/2023-02/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf
- Ramakrishna, I. (2022). Massive infrastructure project threatens Great Nicobar Island. *Frontline*. <https://frontline.thehindu.com/environment/massive-infrastructure-project-proposed-by-central-government-threatens-great-nicobar-island/article65991977.ece>
- Resolution MEPC.364(79), 2022 guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships (2022). <https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.364%2879%29.pdf>
- Resolution MEPC.391(81) (adopted on 22 March 2024), 2024 guidelines on life cycle GHG intensity of marine fuels (2024 LCA guidelines) (2024). [https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.391\(81\).pdf](https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.391(81).pdf)
- Schauenberg, T. (2024). How Singapore got a grip on water scarcity. *Deutsche Welle*. <https://www.dw.com/en/how-singapore-got-a-grip-on-water-scarcity/a-70362786>
- Singh, S. (2025). *Climate change: Port of Antwerp to improve storm defences in response to extreme weather*. Central Dredging Association. <https://dredging.org/news/98/climate-change-port-of-antwerp-to-improve-storm-defences-in-response-to-extreme-weather>
- Somerville, P. (2021). Ten years after the 2011 Tohoku, Japan earthquake and tsunami. *Risk Frontiers*. <https://riskfrontiers.com/insights/ten-years-after-the-2011-tohoku-japan-earthquake-and-tsunami/>
- S&P Global. (2023). *Data & analytics*. <https://www.spglobal.com/en/products/data-analytics>
- Spire. (n.d.). *Spire: Global data and analytics* [Dataset]. Retrieved 15 November 2024, from <https://spire.com/>
- The Economic Times. (2024). *Transshipment port: Govt says 11 players have expressed interest in the project in Great Nicobar Island*. <https://economictimes.indiatimes.com/news/economy/infrastructure/govt-says-11-players-have-expressed-interest-in-transshipment-port-project-in-great-nicobar-island/articleshow/106516724.cms?from=mdr>
- Vives, A. M. V., Wang, R., Roy, S., & Smallbone, A. (2023). Techno-economic analysis of large-scale green hydrogen production and storage. *Applied Energy*, 346, 121333. <https://doi.org/10.1016/j.apenergy.2023.121333>
- Warwick, N. J., Archibald, A. T., Griffiths, P. T., Keeble, J., O'Connor, F. M., Pyle, J. A., & Shine, K. P. (2023). Atmospheric composition and climate impacts of a future hydrogen economy. *Atmospheric Chemistry and Physics*, 23(20), 13451–13467. <https://doi.org/10.5194/acp-23-13451-2023>
- Yin, I. (2022). China's first hydrogen plan focused on lowering costs, building capabilities. *S&P Global*. <https://www.spglobal.com/commodity-insights/en/news-research/latest-news/energy-transition/032922-chinas-first-hydrogen-plan-focused-on-lowering-costs-building-capabilities>
- Zhou, Y., & Searle, S. (2022). *Cost of renewable hydrogen produced onsite at hydrogen refueling stations in Europe*. International Council on Clean Transportation. <https://theicct.org/publication/fuels-eu-onsite-hydro-cost-feb22/>



SCAN TO
DOWNLOAD



Statesman House, 4th Floor,
Barakhamba Road, New Delhi - 110001

www.theicct.org

communications@theicct.org

[@theicct.org](https://twitter.com/theicct.org)

icct
THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION