



Green Fuel- Implementation Roadmap



Document control

Revision history

Revision No.	Date	Revision
1.0	xx	First Draft

List of Abbreviations

Abbreviation	Full Form
BIS	Bureau of Indian Standards
CO₂	Carbon Dioxide
DG Shipping	Directorate General of Shipping
GFI	Greenhouse Gas Fuel Intensity
GHG	Greenhouse Gas
HFO	Heavy Fuel Oil
ICE	Internal Combustion Engine
IMO	International Maritime Organization
IMU	Indian Maritime University
IPRCL	Indian Port Rail and Ropeway Corporation Limited
ISO	International Organization for Standardization
IWAI	Inland Waterways Authority of India
LNG	Liquefied Natural Gas
LT-LEDS	Long-Term Low Emissions Development Strategy
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MEPC	Marine Environment Protection Committee
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoPNG	Ministry of Petroleum and Natural Gas
MoPSW	Ministry of Ports, Shipping and Waterways
MRV	Monitoring, Reporting and Verification
NDMA	National Disaster Management Authority
NGSP	National Green Shipping Policy
NOx	Nitrogen Oxides
OMCs	Oil Marketing Companies
SDGs	Sustainable Development Goals
WtW	Well-to-Wake

Contents

1	Introduction.....	5
2	Indicative Action Pathway	13
3	Responsibility Mapping.....	18
4	Critical Barriers.....	20
5	Conclusion.....	21

1 Introduction

The decarbonisation of maritime transport is fundamentally dependent on the transition away from conventional fossil-based marine petroleum fuels toward low-carbon, zero-carbon, and near-zero GHG emission alternatives. Shipping currently accounts for approximately 2.8% of global anthropogenic greenhouse gas emissions, with emissions projected to increase in the absence of structural intervention. In response, the International Maritime Organization (IMO) has adopted progressively stringent regulatory measures, culminating in the IMO Net-Zero Framework endorsed at MEPC 83, which introduces mandatory greenhouse gas fuel intensity targets and shifts regulatory assessment from tank-to-wake to well-to-wake emissions. However, formal adoption of the framework’s amendments to MARPOL Annex VI was postponed after the October 2025 extraordinary session and is now expected to be reconsidered at MEPC ES2 in late 2026, creating uncertainty over whether and when the measure will enter into force. These developments establish fuel transition as a central compliance and competitiveness issue for national shipping systems.

Within this global context, India’s maritime sector faces a dual challenge. On one hand, Indian shipping and port operations remain heavily dependent on conventional petroleum fuels such as HFO, LFO, and MGO. On the other, India is positioning itself as a major producer of e-hydrogen and hydrogen-derived fuels under national missions and industrial decarbonisation strategies. The National Green Shipping Policy (NGSP) recognizes that fuel transition is not a single-technology shift but a phased transformation involving multiple fuels, blending pathways, vessel categories, and infrastructure readiness levels. Accordingly, the Green Fuels pillar is designed to enable compliance with international regulations while aligning with India’s domestic energy transition objectives.

1.1 India’s Approach to Green Fuels for Maritime Decarbonisation

Evidence from global and Indian vessel statistics indicates that no single alternative fuel can serve all vessel types and operating profiles in the near to medium term. Internationally, LNG, methanol, biofuels, and LPG dominate the current alternative-fuel vessel fleet, while hydrogen and ammonia remain at early adoption stages, largely limited to pilot projects and order books. For India, coastal vessels below 5,000 GT and ocean-going vessels above 5,000 GT exhibit markedly different fuel consumption patterns, age profiles, and retrofit feasibility. This necessitates differentiated fuel pathways, including drop-in biofuels and low-percentage blending in the near term, and hydrogen-derived fuels such as green methanol and green ammonia in the medium to long term.

Fuel-wise Demand Projections for Indian Shipping:

Fuel Type ¹	2030 Demand (million tonnes)	2050 Demand (million tonnes)	Policy Interpretation
Green Hydrogen ²	~0.026	~0.30	Limited early use, scaling post-2035
Green Ammonia ³	~0.025	~4.4	Becomes dominant zero-carbon fuel by 2050
e-Methanol	~0.037	~0.272	Medium-term transition fuel
LNG	~0.66	~0.30	Transitional fuel only; must be green or bio-LNG by 2050
HFO / LFO and MDO / MGO	~1.43	~0.64	Progressive phase-down

¹ In this table, the term “green” refers exclusively to fuels produced using renewable electricity-based pathways (i.e. e-fuels) with near-zero well-to-wake greenhouse gas emissions.

² Green hydrogen refers to hydrogen produced via electrolysis using renewable electricity.

³ Green ammonia refers to ammonia synthesized from green hydrogen and nitrogen, without fossil feedstocks.

For India, vessel segmentation further reinforces the need for differentiated fuel pathways. Coastal vessels below 5,000 GT constitute a large share of the national fleet and are typically older, diesel-dependent, and characterized by short-sea operating profiles with frequent port calls. These vessels exhibit limited space and payload flexibility, constraining the immediate adoption of low-energy-density fuels such as hydrogen or ammonia. In contrast, Indian ocean-going vessels above 5,000 GT account for a disproportionate share of total maritime energy consumption and emissions, making them central to long-term decarbonisation outcomes, but also requiring fuels that can support long-range operations and high power demand.

Coastal vessels (< 5,000 GT)	Ocean-going vessels (> 5,000 GT)
<ul style="list-style-type: none"> • Large in number • Predominantly diesel-based • Short voyage cycles and frequent port calls • Limited onboard space for low-energy-density fuels • Best suited for drop-in fuels and blending pathways in the near term 	<ul style="list-style-type: none"> • Smaller in number but dominant in total fuel consumption • Long-haul operational profiles • Central to achieving deep emissions reduction • Require hydrogen-derived fuels for long-term compliance

Quantitative assessments for India indicate that near-term compliance with greenhouse gas fuel intensity requirements can be achieved most effectively through drop-in biofuels and low-percentage blending of methanol and biodiesel with conventional fuels. Scenario analysis shows that blending pathways can deliver progressive GFI reductions by 2030 and 2035 without immediate large-scale fleet replacement, particularly for coastal and short-sea segments. However, achieving deeper emission reductions consistent with IMO net-zero trajectories beyond 2040 requires a transition toward hydrogen-derived fuels⁴. Under India’s future fuel scenarios, green methanol demand is projected to increase from approximately 0.037 million tonnes in 2030 to 0.272 million tonnes by 2050, while green ammonia demand is projected to rise from about 0.025 million tonnes in 2030 to approximately 4.4 million tonnes by 2050, underscoring the scale and timing of the required shift.

The Green Fuels pillar of the NGSP therefore adopts a systems-based approach, integrating fuel production, storage, bunkering, vessel technology, standards, and financing. Its intent is not to prescribe a single fuel choice, but to establish an enabling framework that supports fuel optionality, phased adoption, and risk-managed investment across stakeholders. This approach reflects the reality that fuel availability, cost trajectories, safety considerations, and international regulatory alignment will evolve over time, requiring policy flexibility grounded in evidence and pilot-led learning.

Key Considerations under the Green Fuel Pillar:

- A. The Green Fuels pillar is guided by the need to enable India’s maritime sector to **progressively comply with evolving international greenhouse gas regulations**, particularly those emerging under the IMO framework, while maintaining operational continuity, economic viability, and global competitiveness of Indian shipping.
- B. The policy recognises that fuel transition in shipping is inherently a **systems challenge**, extending beyond vessel technology to include fuel production pathways, storage and bunkering infrastructure, **safety and standards development**, financing mechanisms, and institutional capacity across ports and maritime administrations.
- C. Given uncertainties around future fuel availability, cost trajectories, and international regulatory evolution, the Green Fuels pillar deliberately **avoids prescribing a single fuel or technology pathway**, and instead promotes fuel optionality and technology neutrality, allowing multiple green and low-carbon fuel solutions to evolve in parallel.

⁴ In this document, “green hydrogen” refers to hydrogen produced via electrolysis using renewable electricity, consistent with internationally recognised renewable fuel of non-biological origin (RFNBO) concepts and near-zero well-to-wake greenhouse gas emissions thresholds. Hydrogen produced from fossil feedstocks, including pathways involving carbon capture and storage, is not considered “green” for the purposes of the NGSP Green Fuels pillar.

- D. The framework supports a **phased and risk-managed adoption of green fuels**, recognising that different fuels will reach commercial maturity at different times and that premature lock-in to any single option could expose shipowners and ports to stranded assets or compliance risks.
- E. **Early adoption is expected to be driven by solutions that minimise disruption to existing vessels and port operations**, while longer-term decarbonisation will require deeper integration of new fuels, technologies, and safety systems as experience, standards, and supply chains mature.
- F. The policy places strong emphasis on **port-led enablement, recognising ports as critical nodes for fuel storage, bunkering, safety management**, and interface with hinterland energy systems, and envisages ports playing an active role in facilitating green fuel availability and adoption.
- G. Successful implementation of the Green Fuels pillar depends on **alignment between maritime decarbonisation objectives and national energy transition initiatives**, including renewable energy deployment and alternative fuel production, to ensure that fuel transition in shipping is supported by reliable and scalable supply.
- H. The pillar underscores the importance of **pilot projects, demonstration initiatives, and stakeholder consultations** to generate operational evidence, refine safety and technical standards, and reduce uncertainty before large-scale deployment of new fuels and technologies.

Further, India is actively implementing several Maritime initiatives aimed towards sustainable ports and vessels, uptake of green fuels and development of inland waterways:



India's Paris Agreement commitments include achieving net-zero emissions by 2070, with the **Long-Term Low-Emission Development Strategy (LT-LEDS)** emphasizing sustainable development and climate resilience. Decarbonizing the maritime sector is key to national efforts to limit global temperature rise to 1.5°C. Aligning maritime decarbonization efforts with the **Sustainable Development Goals (SDGs)** underscores India's dedication to sustainable growth. Specifically, these efforts support:



7 AFFORDABLE AND CLEAN ENERGY
Transitioning to renewable energy sources for maritime operations promotes access to clean energy.



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
Investing in green maritime infrastructure and innovative technologies promotes sustainable industrialization and fosters innovation.



12 RESPONSIBLE CONSUMPTION AND PRODUCTION
Implementing sustainable practices in shipbuilding and operations encourages responsible resource use.



13 CLIMATE ACTION
By reducing greenhouse gas emissions, the maritime sector contributes directly to combating climate change.



11 SUSTAINABLE CITIES AND COMMUNITIES
Reducing emissions from ships improves air quality in port cities, enhancing urban sustainability.



14 LIFE BELOW WATER
Lower emissions and cleaner fuels help reduce ocean acidification and pollution, safeguarding marine ecosystems.

1.2 Fuels for India's Green Shipping Transition

1.2.1 Fossil-Liquefied Natural Gas (LNG)

Fossil-based LNG is recognised in the NGSP and associated consultative material as a **transitional marine fuel**, offering limited greenhouse gas intensity benefits relative to conventional marine fuels but not constituting a net-zero solution in the long term. The policy framing reflects international regulatory developments under the IMO, particularly the shift toward well-to-wake greenhouse gas accounting, under which the climate benefits of fossil LNG are constrained by **upstream methane emissions and lifecycle impacts**. As a result, LNG is positioned within NGSP as an **intermediate compliance pathway**, whose long-term acceptability depends on a transition toward bio-LNG or synthetic LNG rather than continued reliance on fossil LNG.

From a lifecycle perspective, fossil LNG can exhibit lower greenhouse gas fuel intensity than heavy fuel oil under specific conditions, particularly when used in high-pressure dual-fuel engines with minimal methane slip and low upstream leakage. Well-to-wake assessments typically place fossil LNG between approximately **65 and 100 gCO₂eq/MJ, compared to 90–94 gCO₂eq/MJ for HFO**, with outcomes highly sensitive to engine technology and methane slip rates.

While this differential enables near-term compliance gains, it remains insufficient to meet post-2040 and net-zero trajectories without carbon-neutral sourcing or offset mechanisms. This technical limitation underpins NGSP's **explicit avoidance of LNG as an end-state fuel**.

Fuel	Approx. GFI (gCO ₂ eq/MJ)
HFO	~90-94
LNG	~65-100
Bio-methanol	~9-17
Green ammonia	~3-12

National future fuel assessments referenced in the NGSP documentation further reinforce LNG's transitional status. For Indian shipping, LNG demand is projected to decline over time, reflecting tightening international regulations and the increasing role of hydrogen-derived fuels. While LNG retains relevance in the near term due to existing engine technology, operational familiarity, and partial infrastructure availability, the policy framework anticipates that continued use of LNG beyond the medium term will require a shift toward bio-LNG or synthetic LNG to remain compliant with international decarbonisation pathways.

Key Policy Signals on LNG from NGSP:

- Fossil-LNG is acknowledged as a **lower-carbon alternative to conventional marine fuels**, but not a zero-carbon fuel.
- Its role is explicitly framed as **transitional, supporting early emissions reduction** while alternative fuels mature.
- LNG's long-term compatibility with IMO net-zero targets is conditional on **green or bio-based sourcing**.
- Methane slip and **upstream emissions** limit LNG's effectiveness under well-to-wake GHG accounting.
- Policy emphasis **shifts progressively away from fossil LNG** toward methanol, hydrogen, and ammonia pathways.
- Ports and shipowners are cautioned against **long-term lock-in risks** associated with LNG-specific infrastructure and assets.

1.2.2 Biofuels

Biofuels are recognised in the NGSP as **critical near-term and transitional solutions** for reducing greenhouse gas emissions from shipping, particularly during the early phases of fuel transition. Their policy relevance stems from their **compatibility with existing vessel engines** and fuel handling systems, enabling

emissions reduction **without requiring immediate fleet replacement** or large-scale retrofitting. Within the NGSP framework, biofuels are positioned as an enabling pathway that supports early compliance with evolving IMO greenhouse gas fuel intensity requirements while longer-term zero-carbon fuels mature.

From a lifecycle emissions perspective, biofuels demonstrate **substantially lower well-to-wake greenhouse gas intensity** compared to conventional marine fuels. Assessments referenced in the consultative process indicate that **biodiesel and bio-methanol achieve GFI values in the range of approximately 10-30 gCO₂eq/MJ**, depending on feedstock and production pathway, compared to **~90-95 gCO₂eq/MJ for heavy fuel oil**. This differential allows biofuels to deliver meaningful emissions reductions within existing technical constraints, reinforcing their role as an early-stage compliance option under GFI-based regulatory regimes.

For India, biofuels are particularly relevant in the near to medium term due to **domestic feedstock availability, alignment with waste-to-energy and circular economy objectives, and comparatively lower infrastructure complexity**. While biofuels alone are not sufficient to achieve net-zero emissions by mid-century, the policy framework recognises their role in **reducing cumulative emissions, building operational experience, and mitigating transition risks** during the early phases of decarbonisation.

Below table summarises the compatibility and infrastructure requirements for biofuels:

Parameter	Biofuels
Engine compatibility	Compatible with existing ICEs (subject to OEM limits)
Vessel modification	Not required for low-percentage blends
Fuel storage	Existing liquid fuel tanks usable
Bunkering systems	Existing liquid bunkering infrastructure
Safety classification	Comparable to conventional liquid fuels
Port readiness requirement	Low incremental change

Key Policy Signals on Bio-fuels from NGSP:

- Biofuels such as biodiesel and renewable diesel as well as e-FT diesel are treated under the NGSP as **transition fuels** and are not considered long-term zero-carbon fuels.
- Reported well-to-wake greenhouse gas fuel intensity values for biofuels range from **approximately 9 to 17 gCO₂/MJ**, depending on the feedstock and production method.
- In the NGSP assessments, biofuels are mainly considered for **blended or drop-in use**, rather than as sole propulsion fuels.
- The NGSP recognises that **long-term decarbonisation will require a move to e-hydrogen**, with biofuels playing a supporting role during the transition period.
- The use of biofuels requires **clear sustainability criteria and lifecycle emissions accounting** to ensure that greenhouse gas reductions are credible.

1.2.3 Green Ammonia

Ammonia is identified in the NGSP as a long-term zero-carbon fuel option for maritime transport, particularly in the context of achieving deep decarbonisation consistent with international net-zero trajectories. The policy framework treats ammonia as a fuel that will require **significant lead time for technology maturation, safety standardisation, and infrastructure development**, and therefore positions it primarily in the medium to long term. Only ammonia produced using **renewable electricity and green hydrogen pathways** is considered compatible with long-term decarbonisation objectives. Fossil-derived ammonia does not provide meaningful lifecycle greenhouse gas reductions and is therefore not aligned with net-zero pathways.

From an energy and fuel characteristics perspective, ammonia exhibits a substantially lower energy density than conventional marine fuels. On a mass basis, the lower calorific value of ammonia is approximately **18.6–18.9 MJ/kg**, compared to **~41–44 MJ/kg for HFO and MGO**, implying a requirement of roughly **2.2–2.3 times more fuel by mass** to deliver equivalent energy. More critically for ship design, liquid ammonia has a volumetric energy density of only **~12–13 MJ/L**, versus **~35–40 MJ/L for HFO/MGO**, resulting in a need for approximately **three times the onboard fuel storage volume**. This significant volumetric penalty has direct implications for vessel layout, tank integration, and cargo capacity, reinforcing ammonia's positioning in the NGSP as a medium- to long-term fuel option requiring purpose-built vessels and dedicated infrastructure.

This has direct implications for ship design, cargo capacity, and retrofitting feasibility, making ammonia more suitable for **newbuild vessels** rather than retrofits in most cases. The document also notes that ammonia combustion presents challenges related to **ignition, flame speed, and NO_x formation**, which are currently being addressed through engine development, dual-fuel concepts, and after-treatment systems.

Currently, ammonia is considered at a **lower technology readiness level compared to LNG and methanol**, with commercial-scale marine engines still under development and early demonstration. As a result, ammonia is treated as a **medium- to long-term fuel option**, with near-term activity expected to focus on **pilots, test vessels, and controlled deployment** rather than widespread adoption. The document emphasises that regulatory frameworks, classification rules, and international safety standards for ammonia as a marine fuel are still evolving.

Combustion of ammonia can result in **nitrous oxide (N₂O)** emissions, a potent greenhouse gas with a high **global warming potential**, which may materially affect lifecycle greenhouse gas intensity. This risk applies irrespective of whether ammonia is fossil-derived or produced via renewable hydrogen pathways. **Effective mitigation** of N₂O emissions through engine design, combustion control, and exhaust after-treatment remains unproven at commercial marine scale, reinforcing the need for **extensive testing and validation** before ammonia can be considered fully aligned with net-zero objectives.

Key Policy Signals on Ammonia from NGSP:

- The **energy density of ammonia is significantly lower than conventional marine fuels**, resulting in substantially higher onboard fuel storage volume requirements to achieve equivalent range, with direct implications for ship layout and payload capacity.
- Marine engine technology capable of operating on ammonia is **still under development**, with current designs addressing challenges related to **high ignition temperature, low flame speed, and combustion stability**.
- Combustion of ammonia leads to **elevated nitrogen oxide (NO_x) emissions**, necessitating the use of advanced combustion control strategies and exhaust after-treatment systems to comply with emission limits.
- Retrofitting existing vessels for ammonia use is assessed as **technically complex and economically challenging**, due to fuel storage requirements, material compatibility, and safety system integration, making ammonia more suitable for **newbuild vessels**.
- Ammonia is **toxic and corrosive**, requiring dedicated containment systems, continuous leak detection, ventilation, emergency shutdown mechanisms, and enhanced crew training to manage operational and safety risks.
- While ammonia is widely handled in industrial applications, **marine fuel use introduces additional risks** related to confined spaces, vessel motion, and port interface operations, requiring marine-specific safety standards and procedures.
- **Bunkering and port infrastructure for ammonia as a marine fuel are currently limited**, with requirements for specialised storage tanks, transfer systems, safety exclusion zones, and emergency response arrangements.

- Regulatory frameworks, classification rules, and international standards for ammonia as a marine fuel are **still evolving**, indicating the need for pilot projects and phased deployment prior to large-scale adoption.

1.2.4 Green Methanol

Methanol is considered under the NGSP as a **transition fuel that can be deployed at scale earlier than hydrogen and ammonia**, while still contributing to greenhouse gas reduction when sourced from e-pathways. Its relevance lies in the availability of commercial marine engine technology, simpler storage and handling requirements, and compatibility with existing liquid fuel logistics. The policy does not treat methanol as a final zero-carbon fuel, but as an intermediate option that supports phased decarbonisation and reduces transition risk.

The GHG performance of methanol is **directly determined by its production pathway**. Fossil-based methanol does not provide material well-to-wake greenhouse gas reductions and is therefore not aligned with long-term decarbonisation objectives under the NGSP. In contrast, **bio-methanol and green methanol** demonstrate substantially lower lifecycle emissions, with reported greenhouse gas fuel intensity values in the range of **approximately 5-25 gCO₂eq/MJ**, depending on feedstock and production route, compared to **91-95 gCO₂eq/MJ for heavy fuel oil**. Accordingly, only bio-based and renewable methanol pathways are considered relevant for emissions reduction under GFI-based regulatory frameworks.

From an operational and infrastructure perspective, methanol is handled as a liquid fuel at ambient temperature and pressure, eliminating the need for cryogenic storage or high-pressure systems. This enables the use of storage tanks and bunkering arrangements broadly similar to those employed for conventional liquid marine fuels, subject to additional safety provisions related to toxicity and flammability. From an energy standpoint, the lower calorific value of methanol is approximately **19.9–20 MJ/kg**, compared to **~41–44 MJ/kg for HFO and MGO**, meaning methanol contains **around 50–55% less energy per unit mass**. This lower mass-based energy content, combined with methanol's lower density, results in a volumetric energy density of only **~15–16 MJ/L**, versus **~35–40 MJ/L for HFO/MGO**. Consequently, vessels operating on methanol require substantially higher onboard fuel volumes to achieve equivalent range, leading to increased tank space requirements and potential impacts on vessel layout, payload capacity, and retrofit feasibility.

1.2.5 Green Hydrogen as a Marine Fuel

Hydrogen is considered in the NGSP and the associated alternative fuels studies as a **zero-carbon fuel option**, either for direct use onboard vessels or as a **primary energy carrier for hydrogen-derived fuels**. It produces no carbon dioxide at the point of use. Its relevance to maritime decarbonisation is therefore linked to its ability to achieve **very low well-to-wake greenhouse gas emissions**, provided that hydrogen is produced from electrolysis of water using renewable electricity (or nuclear based electricity). Renewable hydrogen and RFNBO (Renewable Fuels of Non-Biological Origin) compliant e-methanol and e-ammonia represent the long-term net-zero pathway. Bio-based methanol and ammonia may play a limited transitional role where sustainable biomass is available, but face scalability constraints.

Hydrogen can be stored onboard vessels either as **compressed gas** or as **liquid hydrogen**. Compressed hydrogen is typically stored at pressures of **350–700 bar**, while liquid hydrogen requires storage at **–253°C**. Both storage options impose significant design and operational constraints compared to conventional marine fuels. Hydrogen has a **high gravimetric energy density (approximately 120–142 MJ/kg)**, but a **very low volumetric energy density**, resulting in large fuel storage volumes and reduced vessel range for a given tank size. To deliver the same energy as conventional fuel oil, **compressed hydrogen at 700 bar requires approximately five to six times the storage volume**, while **liquid hydrogen requires approximately four to five times the storage volume**. These volume penalties directly affect vessel layout, cargo capacity, and retrofit feasibility, making hydrogen more suitable for **newbuild vessels or short-range applications**.

Hydrogen propulsion can be achieved using **internal combustion engines adapted for hydrogen** or **fuel cell systems**. Marine hydrogen internal combustion engines remain under development, while fuel cell systems have reached early commercial deployment for **inland waterways and short-sea vessels**. The studies note that hydrogen combustion and handling introduce additional safety considerations due to its **wide**

flammability range (approximately 4–75 %by volume in air) and **low ignition energy**, requiring stringent containment, ventilation, and detection systems.

Port and bunkering infrastructure for hydrogen is assessed as **limited at present**. Dedicated storage, transfer systems, safety exclusion zones, and emergency response arrangements are required. As a result, hydrogen deployment is expected to follow a **pilot-led and phased approach**, aligned with the development of standards, crew training, and port readiness.

Additionally, India is stepping up its green energy transition with the development of a Hydrogen Hub under the National Green Hydrogen Mission, which aims to produce and export around 5 million tonnes of green hydrogen over the next five to six years. The initiative is a key part of India’s long-term strategy to achieve net-zero carbon emissions by 2070.⁵ On January 28th, 2026 Deendayal Port Authority, Kandla, has signed an agreement with energies company, for the design, supply, installation, testing and commissioning of 5 MW Green Hydrogen Plant at Deendayal Port, Kandla.⁶

Key NGSP Signals on Hydrogen

- Hydrogen is recognised as a **clean fuel aligned with long-term decarbonisation goals**
- The policy treats hydrogen as part of a **phased transition**, with early focus on pilots, demonstrations, and standards development.
- Hydrogen deployment is explicitly linked to **national green hydrogen production and renewable energy availability**.
- The NGSP avoids prescribing **direct hydrogen propulsion** for ships in the short term.
- Port and bunkering infrastructure for hydrogen are to be developed **progressively**, alongside safety and regulatory frameworks.

1.2.6 Battery Electric Energy

Battery electric propulsion is considered under the NGSP as a **near-term decarbonisation solution for specific vessel segments**, particularly those operating on **short, fixed routes with predictable duty cycles**. The policy recognises that battery electric systems eliminate direct fuel combustion onboard and therefore produce **zero emissions at the point of use**, while overall emissions performance depends on the carbon intensity of grid electricity used for charging.

The NGSP positions battery electric energy as **segment-specific rather than fleet-wide**, due to limitations related to energy density, vessel range, charging time, and grid interface requirements. As a result, battery electric propulsion is primarily associated with **inland waterways vessels, ferries, harbour craft, tugs, and short-sea coastal operations**, where daily return-to-base operations enable controlled charging.

Battery systems are addressed within the broader framework of **electrification of maritime operations**, alongside shore power and port-side electrification. The policy links battery adoption to port readiness, grid capacity, and renewable electricity integration, rather than treating it as a standalone fuel pathway.

1.3 Possible Solutions and Key Opportunities

The table below outlines key solutions and opportunities for green fuels.

⁵ India to develop Hydrogen Hub at Kandla under National Green Hydrogen Mission, DD News: <https://ddnews.gov.in/en/india-to-develop-hydrogen-hub-at-kandla-under-national-green-hydrogen-mission/>

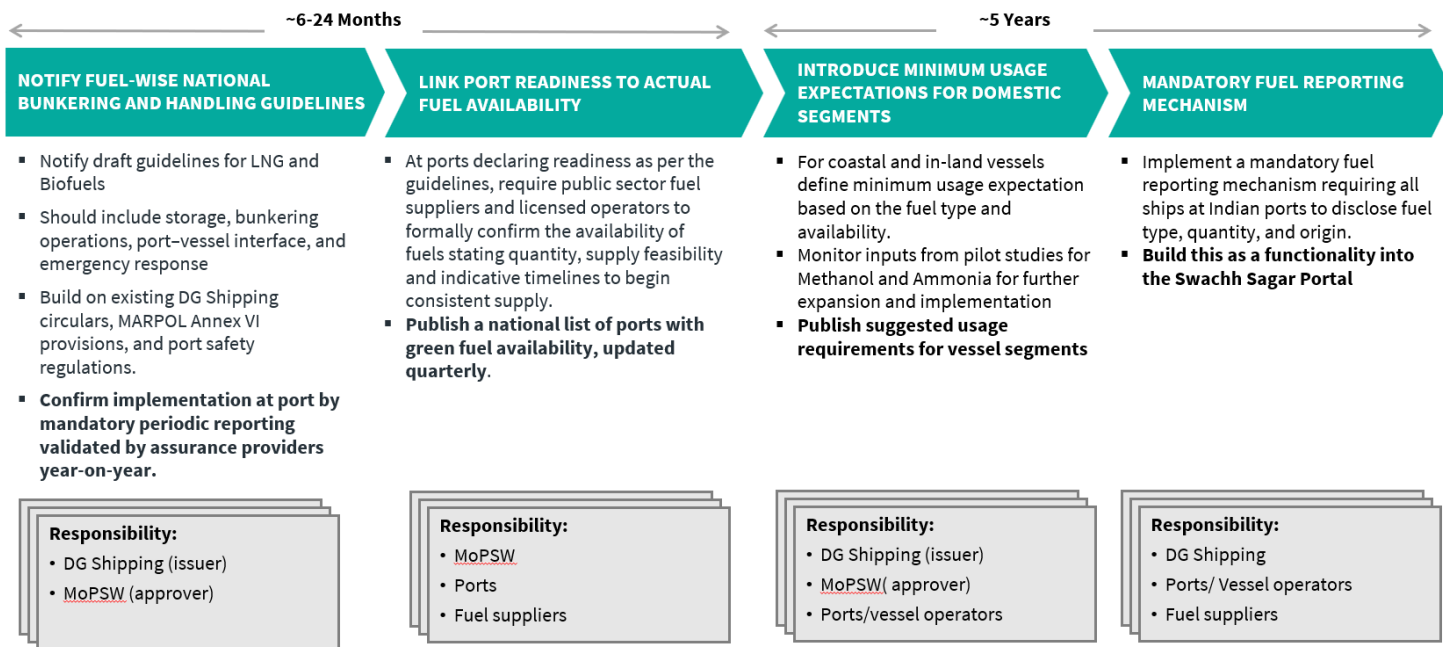
⁶ Deendayal Port Authority Signs Agreement for 5 Mega Watt Green Hydrogen Plant at Kandla, Fuel Cell Works: <https://fuelcellsworks.com/2026/01/30/clean-energy/deendayal-port-authority-signs-agreement-for-5-mega-watt-green-hydrogen-plant-at-kandla>

Solutions	Key Opportunities
LNG	High bunkering infrastructure costs; demand aggregation for long-term investment; price volatility and methane slip challenges.
	Variable Gap Funding (VGF) and PPP models to bridge financial gaps.
	Long-term contracts to mitigate price volatility.
	Methane slip reduction through abatement technologies and sourcing from low-carbon LNG suppliers.
Biofuels (Blending)	Immediate and scalable solution; high GHG reduction potential; GOI's National Biofuel Policy supports adoption.
	High feedstock costs due to limited domestic availability and dependence on imports.
Bio-CNG/Bio-LNG	Abundant feedstock (municipal and agri-waste); high technology readiness level (TRL); easy adoption.
	Aggregation and liquefaction challenges for biomass feedstock.
	GOI policies supporting compressed bio-gas need an extension to bio-LNG production.
e-methanol/e-ammonia	High TRL with minimal modification needed for storage and handling.
	Lack of developed bunkering infrastructure and global standards.
	Demand aggregation is needed to scale production and investment.
	VGF and PPP models to support infrastructure development.
	Classification societies to establish global bunker standards.
Battery electric energy	Abundant renewable energy potential, but technology pathway uncertainty.
	Gradual fuel blending ramp-up to align with supply constraints.

2 Indicative Action Pathway

The NGSP sets out a phased and outcome-oriented implementation pathway for green fuels, aligned with India's maritime decarbonisation goals and evolving international regulatory requirements. Rather than prescribing specific fuel choices, the NGSP defines time-bound targets, enabling actions, and institutional responsibilities to support progressive adoption of low- and zero-carbon fuels across vessel segments and port infrastructure.

Below is a representation of the actions summarized as high level outcomes:



2.1 Short-term Action Plan (0-6 Months)

The short-term action plan has been developed as an initial implementation step for the Green Fuels pillar of the NGSP. The actions focus on establishing foundational enablers required for implementation rather than defining fuel-specific transition pathways.

During the first six months, emphasis is placed on cross-cutting safety, regulatory, institutional, and readiness aspects that apply across multiple fuel options. This approach maintains the technology-neutral intent of the policy and allows future fuel choices to be determined based on readiness, safety, and availability across domestic and international maritime operations.

A. In the short term start with categorise maritime fuels into:

- Transitional fuels
- Near-term zero-GHG emission fuels
- Long-term zero-emission options

Green fuel technologies differ significantly in maturity, safety requirements, and infrastructure needs. Treating all fuels equally at the outset increases regulatory ambiguity and delays decision-making.

Suggestion: Issue a non-binding national position note clarifying that India will pursue a multi-fuel pathway, avoiding premature lock-in.

B. Focus on the identified priority segments to start with implementation in the short term. Under the NGSP these segments are:



C. Assess port-level and vessel-interface readiness, including emergency response capability, firefighting systems, spill containment, crew preparedness, and exclusion zones, to determine whether current arrangements can support alternative fuels safely.

Suggestion: Publish findings to make informed decisions about port readiness.

- D. Identify safety and regulatory gaps for storage, handling, bunkering, and emergency response of priority green fuels, and assign ownership for corrective action. Focus only on bunkering norms, storage requirements, regulatory gaps and emergency responses.

Suggestion: Carrying out a safety assessment aligned with the IMO IGF Code, ISO 20519 (LNG bunkering), ISO 31000 (risk management), and relevant MARPOL Annex VI provisions to identify regulatory gaps is especially important in the short term.

- E. Map roles and responsibilities across ministries, DG Shipping, port authorities, and other agencies. Define coordination and decision-making interfaces for green fuel-related actions.

2.2 Medium-term Action Plan (Up to 2 Years)⁷

The medium-term action plan focuses on moving from foundational readiness to structured implementation under the Green Fuels pillar of the NGSP. The actions during this period are aimed at translating policy intent into operational readiness through pilots, standardization and safety preparedness.

2.2.1 Biofuels and bio-derived drop-in fuels

- A. Identify biofuel blends that can be utilised in marine engines with minimal or no modification, particularly for coastal and inland waterway vessels.
- B. Assess lifecycle emissions performance and sustainability risks of the identified fuels, including feedstock availability and competition with other sectors.
- C. Finalize eligible blends, fuel quality and MRV data requirements for coastal vessels (incl. logbook and intensity metrics where applicable).
- D. Start supplier onboarding and offtake structuring for the coastal hubs named in NGSP (so blends are practically available where vessels refuel).

2.2.2 LNG as a transition enabler

LNG is recognised as a transition fuel and not an end-state fuel under the Green Fuels pillar of the NGSP. In this context, LNG bunkering facilities should be developed to support near-term vessel transition and operational readiness. Accordingly, the following action plan is proposed.

- A. For identified multi-fuel coastal hubs (Chennai, Kandla, Kochi, Paradip), prepare basic terminal-level readiness documents covering how fuels will be stored, how bunkering will be carried out, how emergencies will be handled, and how ships and port facilities will safely interface.
- B. Develop common LNG bunkering procedures that can be applied uniformly across ports, so bunkering infrastructure and operations are consistent and scalable.

2.2.3 Green methanol

- A. Identify vessel categories and operating profiles where methanol retrofits or newbuilds are technically feasible in the near term.
- B. Assess and record methanol readiness at selected ports using the Fuel Readiness Index framework.

⁷ In this section, references to “green fuels” and specific fuels such as green methanol, hydrogen, or ammonia are used in a generic sense. The term does not imply a single production pathway and may include bio-based fuels, bio-derived fuels, and renewable electricity-based fuels. Lifecycle greenhouse gas performance and alignment with long-term net-zero objectives depend on the underlying production route.

- C. Put in place minimum handling, storage, and training requirements for methanol at the port and bunkering operator level.

2.2.4 Green Hydrogen and Green Ammonia

- A. Undertake controlled pilots for hydrogen in clearly defined and low-risk applications such as harbour craft and inland vessels, supported by small-scale storage and bunkering arrangements for demonstration purposes.
- B. Carry out preparatory actions for green ammonia by completing detailed safety studies, hazard assessments, and emergency response planning, and by identifying suitable port clusters based on land availability, safety buffers, and industrial integration potential. Document the progress for future refinement.
- C. Develop fuel-specific safety protocols for hydrogen and ammonia covering storage, transfer, bunkering operations, and emergency response roles at ports.
- D. Conduct simulation and tabletop exercises at selected ports to test emergency response procedures, coordination mechanisms, and decision-making during fuel-related incidents.
- E. Document lessons from pilots and exercises to inform subsequent updates to safety guidelines, training requirements, and regulatory procedures.

2.3 Long-term Action Plan (Upto 5 Years)⁸

The long-term action plan focuses on scaling up and mainstreaming green fuel adoption in Indian shipping based on learnings from earlier phases. Actions during this period aim to transition from pilots and readiness activities to wider deployment, supported by mature safety frameworks, operational standards, market mechanisms, and institutional capacity. The emphasis is on enabling sustained adoption across priority segments while maintaining alignment with evolving international regulations and market developments.

2.3.1 Biofuels (drop-ins)

- A. Clearly list which biofuels or drop-in fuels can be used in coastal shipping and inland waterways. Specify the maximum blend levels that vessels are allowed to use safely. Approve fuels basis lifecycle emissions results, selecting fuels with the lowest emissions.
Suggestion: Aim to publish a clear list of approved fuels and blend limits so ports, shipowners, and suppliers know exactly what is permitted and compliant.
- B. Assess whether domestic producers can reliably supply the required quantity of biofuels. Avoid imposing blending obligations if fuel availability is uncertain or insufficient. Blending should only be required once fuel is actually available in the market, so shipowners are not forced to comply with rules that cannot be met.
- C. Enable routine availability at selected ports by shifting from ad-hoc sourcing to structured supply arrangements with bunkering operators and fuel suppliers.
- D. Allow biofuel use to be reported in existing fuel and emissions reporting formats for coastal and IWT vessels. Use the same reporting and documentation system for biofuels that is used for other fuels, instead of treating biofuels as an informal or ad-hoc practice.

⁸ In this section, references to “green fuels” and specific fuels such as green methanol, hydrogen, or ammonia are used in a generic sense. The term does not imply a single production pathway and may include bio-based fuels, bio-derived fuels, and renewable electricity-based fuels. Lifecycle greenhouse gas performance and alignment with long-term net-zero objectives depend on the underlying production route.

- E. Establish a feedstock and sustainability risk monitoring mechanism so scale-up does not create supply instability or sustainability concerns.

2.3.2 LNG (as a transition fuel)

- A. Create a clear transition horizon for LNG by positioning it as a supporting fuel during the transition period while prioritising scale-up of lower-carbon and zero-emission fuels at the same hubs.
- B. Operate LNG bunkering as a routine service at identified multi-fuel ports, with LNG treated as one of several fuels available rather than a dedicated pathway.
- C. Embed LNG operations into standard port regulations and inspections, so safety oversight, reporting, and compliance are part of normal port functioning rather than special approvals.
- D. Limit further expansion of LNG-specific infrastructure beyond designated hubs and require all new LNG assets to be compatible with future low- and zero-carbon fuel conversion.

2.3.3 Green Methanol

- A. Identify additional ports where methanol bunkering can be introduced beyond initial hubs. Allow expansion only after safety, training, port procedures, and emergency readiness are in place.
- B. Define a methanol compliance and verification approach based on lifecycle emissions accounting so “certified green methanol” has consistent meaning in implementation.
- C. Move from pilot-led operations to regular bunkering service by contracting bunkering operators and establishing standard port operating procedures.
- D. Make methanol available at ready ports so more vessels, including international ones, can use it.

2.3.4 Green Hydrogen

- A. Scale up hydrogen use only after pilot results are reviewed, focusing on low-risk vessels such as inland ferries and harbour craft (e.g., IWAI ferries, port service vessels).

- B. Adopt hydrogen-specific safety and approval standards, aligned with the IMO IGF Code and relevant ISO hydrogen safety standards, for storage, bunkering, and operations.
- C. Establish hydrogen availability at designated locations through small-scale, port-linked storage and bunkering solutions that are designed for controlled expansion.

2.3.5 Green Ammonia

- A. Notify a shortlist of ports eligible for ammonia pilots based on completion of hazard studies, emergency response plans, and regulatory clearances.
- B. Approve and construct dedicated ammonia bunkering facilities at selected ports, including defined storage systems, safety buffer zones, detection systems, and controlled transfer arrangements.
- C. Issue a standard approval and operating framework for ammonia bunkering, covering port approvals, bunkering permissions, operating limits, and compliance checks.
- D. Operationalise ammonia use on selected routes or corridors by linking approved ports, fuel supply arrangements, and participating vessels.

To summarize, the building blocks for the Green Fuel pillar implementation are as indicated in the diagram below:



3 Responsibility Mapping

The implementation of the Green Fuels pillar under the NGSP requires coordinated action across a diverse set of stakeholders. Given the cross-sectoral nature of alternative maritime fuels, clear allocation of roles and responsibilities is critical to avoid overlaps, regulatory gaps, and implementation delays. This responsibility mapping framework identifies key stakeholders involved in green fuel implementation and clarifies their respective roles across the policy, planning, approval, deployment, and operational stages. The framework is intended to support effective coordination, accountability, and phased execution of green fuel initiatives under the NGSP.

Category	Stakeholder	Primary Role
Policy & Governance	Ministry of Ports, Shipping and Waterways (MoPSW)	Overall policy owner of NGSP, coordination of Green Fuels pillar, oversight of ports and shipping
	Directorate General of Shipping (DG Shipping)	Maritime safety regulation, vessel certification, fuel-related operational approvals
	Ministry of Petroleum and Natural Gas (MoPNG)	Fuel standards, LNG and liquid fuel supply ecosystem, coordination with fuel suppliers
	Ministry of New and Renewable Energy (MNRE)	Green hydrogen and green ammonia policy alignment, renewable fuel pathways
	Ministry of Environment, Forest and Climate Change (MoEFCC)	Environmental safeguards, lifecycle emissions alignment, climate reporting
Ports & Infrastructure	Major Port Authorities	Port-level planning, bunkering approvals, safety and emergency preparedness
	Indian Port Rail and Ropeway Corporation (IPRCL)	Port connectivity and supporting infrastructure relevant to fuel logistics
Energy & Fuel Supply	Oil Marketing Companies (OMCs)	Fuel supply, bunkering operations, blending and distribution
	Green Hydrogen Producers	Production and supply of green hydrogen and derivatives
	Biofuel Producers	Supply of sustainable biofuels and drop-in fuels
Shipping & Operations	Indian Shipowners' Association	Fleet transition, fuel adoption decisions, operational feedback
	Inland Waterways Authority of India (IWAI)	Implementation for inland vessels and ferries
	Port Service Vessel Operators	Early adoption for tugs, harbour craft, and service vessels
Safety, Standards & Certification	Bureau of Indian Standards (BIS)	Fuel quality, safety, and equipment standards
	Classification Societies	Vessel design approval, fuel system certification
	Emergency Services and Disaster Management Authorities	Emergency response preparedness at ports
Finance & Market Enablement	Shipping Ministry Financing Bodies	Funding mechanisms, viability gap support
	Multilateral Development Banks	Concessional finance, technical assistance

Knowledge & Capacity Building	Indian Maritime University (IMU)	Training and curriculum development
	Research Institutions and Think Tanks	Technical studies, pilots assessment, policy support

This diagram shows how responsibilities for implementing green fuels under the NGSP are shared across different stakeholders. It explains who sets the direction, who regulates and ensures safety, who implements actions at ports, who supplies fuels, and who uses them in operations. The diagram highlights the need for coordination across these roles to enable safe and effective adoption of green fuels in the maritime sector.



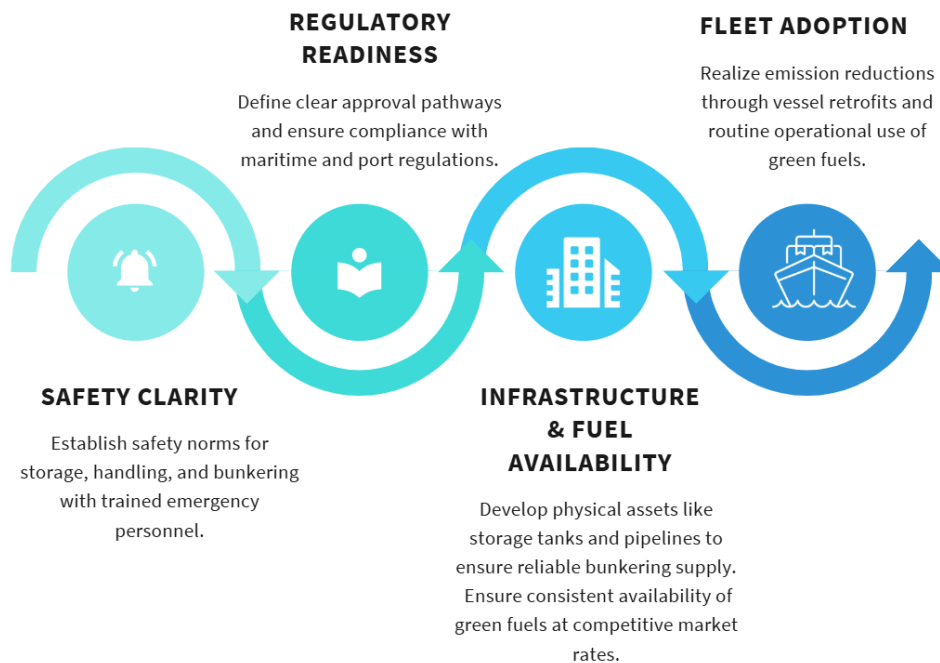
4 Critical Barriers

The implementation of green fuels in the maritime sector faces several structural and operational challenges that influence the pace and scale of adoption. These barriers need to be addressed in a phased and coordinated manner to enable effective execution of the National Green Shipping Policy. Regulatory and approval frameworks for green fuels are still evolving and not yet fully integrated into routine maritime and port operations. This creates uncertainty in timelines, responsibilities, and sequencing for ports, fuel suppliers, and shipowners planning long-term investments.

1. Port readiness across India is uneven and constrained by physical and operational limitations. Many ports face challenges related to land availability, integration with existing terminals, and accommodating new fuel infrastructure alongside ongoing commercial operations.
2. Domestic shipyards currently have limited experience in retrofitting existing vessels or constructing newbuilds designed for alternative fuels, creating uncertainties around technical feasibility, timelines, and costs for fleet transition.
3. Availability of green fuels at ports remains uncertain due to immature supply chains. Domestic production, transport logistics, and bunkering arrangements for biofuels, methanol, hydrogen, and ammonia are developing at different speeds, limiting confidence in sustained fuel access.

4. Cost competitiveness of green fuels is a significant barrier for Indian shipping segments. The price differential with conventional fuels is high, particularly affecting coastal and inland shipping where margins are limited and price sensitivity is high.
5. Institutional coordination across multiple ministries, regulators, and port authorities remains complex. Effective implementation requires consistent alignment between shipping, energy, environment, and port governance systems, which is still being strengthened in practice.
6. Limited domestic operational experience with green fuels slows decision-making and scale-up. Most alternative fuel pathways lack sufficient India-specific data on performance, cost, and operational impact, leading stakeholders to adopt a cautious approach.

To enable a smooth implementation pathway and systematically address the identified barriers, the following priority matrix is proposed:



5 Conclusion

The Green Fuels pillar of the National Green Shipping Policy establishes a structured and phased pathway for decarbonising India’s maritime sector while maintaining operational continuity and economic viability. By adopting a technology-neutral and systems-based approach, the framework recognises the differing maturity levels, infrastructure requirements, and operational constraints associated with alternative marine fuels.

The phased action plans outlined in this document translate policy intent into implementable steps across short-, medium-, and long-term horizons, supported by clear responsibility mapping and an understanding of critical barriers. Successful implementation will depend on coordinated action across ministries, regulators, ports, fuel suppliers, and shipowners, alongside continued alignment with international regulatory developments and national energy transition initiatives. Taken together, the Green Fuels pillar provides a practical foundation for enabling India’s shipping sector to progressively comply with global decarbonisation requirements while positioning the country for long-term competitiveness in a low-carbon maritime economy.