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Ministry of Ports,
Shipping & Waterways

Government of India

NATIONAL MARITIME DECARBONISATION POLICY

FRAMEWORK

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MARITIME INDIA @NET ZERO

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NATIONAL MARITIME DECARBONISATION POLICY-FRAMEWORK

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A Primer for Administrators and Inter-Ministry Peers

PURPOSE OF THIS DOCUMENT

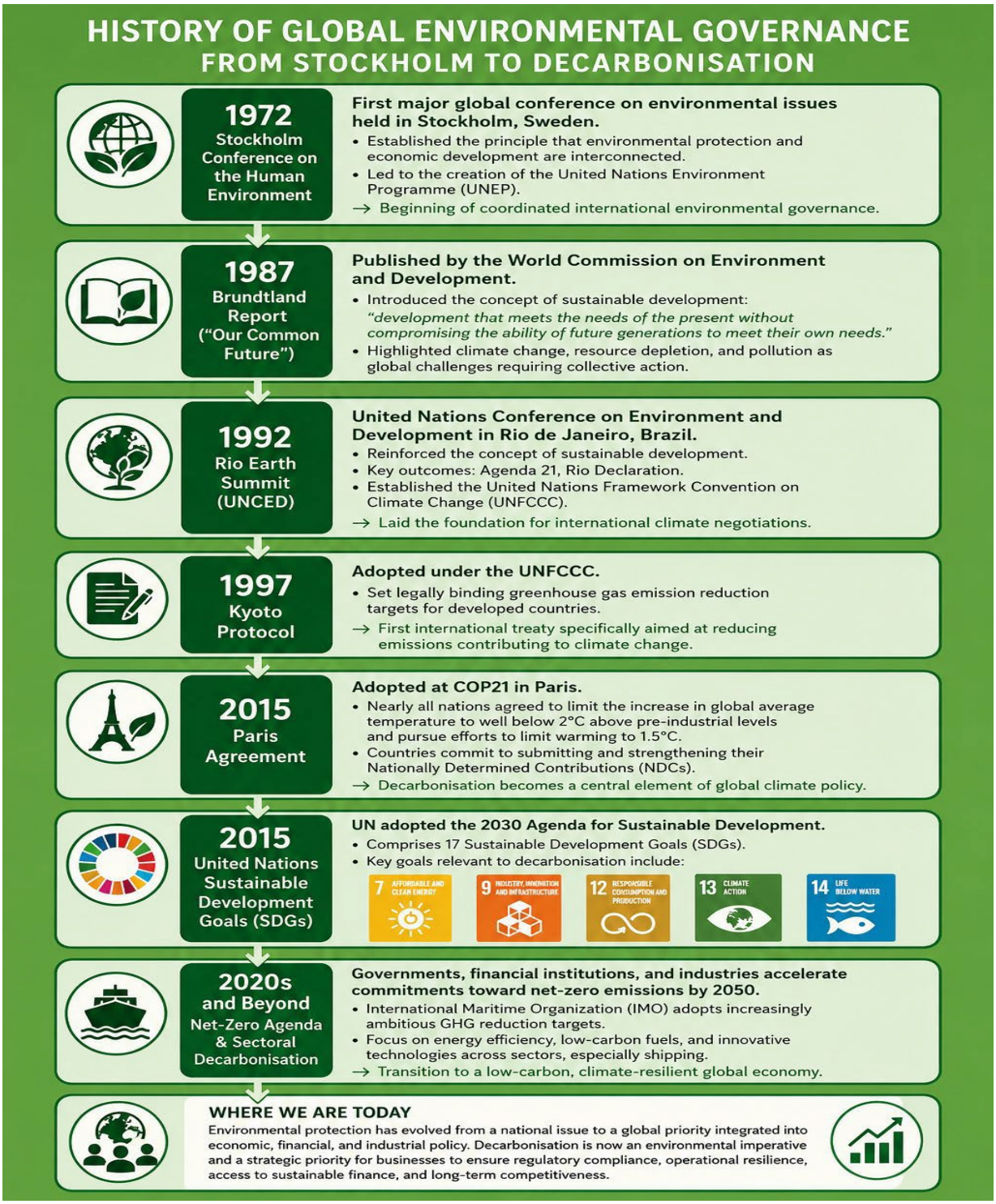
This primer provides the foundational context for India's Maritime Decarbonisation Policy by establishing the global, national, and sectoral developments that shape the decarbonisation agenda. It is intended to build a common understanding among generalist administrators and inter-ministry stakeholders of the regulatory, institutional, and strategic context within which maritime decarbonisation must be positioned.

The document is structured in four sections. **Section 1** charts the evolution of global environmental governance, from the Stockholm Conference of 1972 through major international frameworks including IMO conventions, UNFCCC instruments, the UN Global Compact, the Sustainable Development Goals, and ILO frameworks, establishing the ideational and legal foundations of climate action and decarbonisation. **Section 2** examines India's domestic environmental governance trajectory, covering the legislative foundations, climate commitments, green growth initiatives, and emerging carbon market architecture that collectively shape India's national decarbonisation pathway. **Section 3** provides a comprehensive overview of the international maritime regulatory architecture, including key conventions, technical and operational measures, alternative fuel pathways, and evolving market-based mechanisms, alongside India's adoption, adaptation, and ongoing green shipping initiatives. **Section 4** builds on this foundation to present the rationale, strategic direction, and policy interventions required for a dedicated Maritime Decarbonisation Policy for India.

Taken together, the document serves as an introductory guide to the core principles, regulatory architecture, and policy imperatives of maritime decarbonisation, enabling stakeholders to engage meaningfully with the detailed policy pillars and implementation roadmap.

SECTION – 1: GLOBAL ENVIRONMENTAL GOVERNANCE: THE EVOLUTION OF CLIMATE ARCHITECTURE

The international community's engagement with environmental governance has unfolded over five decades, progressing from awareness of ecological fragility through treaty frameworks targeting specific harms to today's comprehensive net-zero commitments. India has been an active participant, and in several instances a leading voice, at every stage of this evolution. This section traces that arc as the essential foundation for India's current decarbonisation position.



1.1 Stockholm Conference (1972): The Birth of Global Environmental Governance

The United Nations Conference on the Human Environment, held in Stockholm in June 1972, is the founding moment of international environmental governance. Convened against a backdrop of growing scientific alarm over industrial pollution, species loss, and transboundary environmental degradation, Stockholm produced two foundational outputs: the Stockholm Declaration, comprising 26 principles articulating the right to a healthy environment and state responsibility for

transboundary harm, and the Stockholm Action Plan, establishing the United Nations Environment Programme (UNEP) as the anchor institution for international environmental governance.

INDIA AT STOCKHOLM: THE CBDR PROTOTYPE

Prime Minister Indira Gandhi's address at Stockholm established India's enduring moral framing: environmental protection and poverty alleviation are inseparable, and the global community bears differentiated responsibility for the crisis it created. Her formulation, that the poor nations did not cause the pollution crisis yet would bear its heaviest burden, anticipated the CBDR-RC principle by two decades. This framing has anchored India's multilateral environmental positioning ever since.

Stockholm catalysed the creation of national environment ministries worldwide, including India's Ministry of Environment established in 1980, and inspired a generation of domestic environmental legislation. It also established the foundational norm of science-based environmental assessment that underpins all subsequent climate frameworks.

1.2 UNCLOS (1982): The Legal Foundation for Ocean Governance

The United Nations Convention on the Law of the Sea (UNCLOS), opened for signature in 1982 and entering into force in 1994, is the overarching legal framework for all human activities in the ocean, including international shipping. Its relevance to maritime decarbonisation is structural rather than operational:

- Jurisdictional architecture: UNCLOS defines the rights and duties of flag states (jurisdiction over vessels), port states (authority to inspect and detain non-compliant vessels), and coastal states (authority over vessels in territorial waters and EEZs). This three-tier jurisdictional structure is the enforcement architecture on which all IMO environmental regulations, including MARPOL and the GFI framework, rely.
- Article 192 — General Obligation: 'States have the obligation to protect and preserve the marine environment.' This provision provides the foundational legal duty from which all more specific maritime environmental regulations derive authority.
- Article 211 — Pollution from Vessels: Requires states to establish international rules for vessel-source pollution through the competent international organisation (IMO): the direct legal basis for MARPOL and all subsequent IMO environmental conventions.
- India's ratification: India ratified UNCLOS in 1995. As a coastal state with one of the world's longest coastlines (11,098.81 km) and an Exclusive Economic Zone of 2.02 million km^2, India has both significant rights and significant responsibilities under UNCLOS in respect of marine environmental protection.

1.3 The Montreal Protocol (1987): Proof of Concept for Multilateral Environmental Agreements

The Montreal Protocol on Substances that Deplete the Ozone Layer (1987) is widely considered the most successful multilateral environmental agreement in history and the direct template for subsequent climate instruments. Its contributions to the decarbonisation framework are several:

- Technology transition at scale: The phase-out of CFCs required global industry to reformulate refrigerants, aerosols, and fire suppressants within commercially defined deadlines: the first

instance of a multilateral treaty mandating industrial fuel and technology transition at global scale. The parallel to the shipping fuel transition under the GFI framework is direct and deliberate.

- Differentiated timelines: Article 5 Parties (including India) were granted extended compliance timelines, establishing the CBDR-RC precedent that climate negotiators formalised at Rio and that India advocates today at MEPC.
- Multilateral Fund: The Protocol created the first permanent international fund for developing country compliance: the direct architectural precedent for climate finance debates at UNFCCC and IMO's own transition support fund discussions.
- Climate co-benefit: CFCs are potent greenhouse gases. The Montreal Protocol's success removed an estimated 135 billion tonnes CO2-equivalent from projected emissions: the largest single climate intervention in history, demonstrating that well-designed environmental instruments can deliver compound benefits.

1.4 The Brundtland Report (1987): Defining Sustainable Development

The World Commission on Environment and Development, chaired by Norwegian Prime Minister Gro Harlem Brundtland, produced its landmark report "Our Common Future" in 1987, the document that first gave international currency to the concept of sustainable development, defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This formulation became the organising principle of every major environmental framework that followed: Rio 1992, the Kyoto Protocol, the SDGs, and the Paris Agreement all trace their philosophical lineage to the Brundtland Commission's insight that environment and development are inseparable imperatives. For maritime decarbonisation, the Brundtland framing is directly operative: a just fuel transition must deliver economic development for seafarer-supplying nations and green fuel-producing economies while meeting the environmental imperative of net-zero by 2050; this is precisely the tension that CBDR-RC principles at MEPC seek to resolve.

1.5 The UNFCCC Architecture: Rio to Paris

The United Nations Framework Convention on Climate Change (UNFCCC), opened at the Rio Earth Summit in June 1992 and in force since March 1994, established the foundational architecture of international climate governance. Its five principles in Article 3, namely CBDR-RC, special circumstances of developing nations, the precautionary principle, the right to sustainable development, and the open international economic system, have governed climate negotiations for three decades and remain directly operative in India's MEPC positions today.

Instrument / Year	Scope & Significance
1992 — UNFCCC	Foundational architecture: CBDR-RC, precautionary principle, right to sustainable development. 197 Parties. International aviation and shipping excluded from national inventories; delegated to ICAO and IMO.

Instrument / Year	Scope & Significance
1997 — Kyoto Protocol	First binding Annex I targets. Clean Development Mechanism (CDM), Joint Implementation, Emissions Trading. Demonstrated ratcheting ambition; CBDR-RC operationalised through differentiated obligations.
2007 — IPCC AR4	Unequivocal scientific consensus on anthropogenic climate change. 1.5°C / 2°C thresholds quantified. Catalysed political momentum toward Copenhagen and Paris.
2015 — Paris Agreement	NDC architecture; well-below 2°C / 1.5°C goal; Article 6 carbon markets; LT-LEDS framework; Loss and Damage. All countries covered. Shipping implicitly within emissions budget.
2021 — Glasgow (COP 26)	Fossil fuel phase-down; Coal Commitment; methane pledge; tripling of climate finance; India's Panchamrit announced; SDR Special Drawing Rights for climate finance.
2023 — Dubai (COP 28)	First Global Stocktake; transition away from fossil fuels; tripling renewable capacity by 2030; doubling energy efficiency. UAE Consensus acknowledged emissions gap.

1.6 The Basel Convention (1989): Hazardous Waste and the Ship Recycling Link

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989, in force 1992) is directly relevant to maritime decarbonisation through its connection to ship recycling. End-of-life vessels contain substantial quantities of hazardous materials, including asbestos, polychlorinated biphenyls (PCBs), heavy metals, tributyltin (TBT) compounds, and residual hydrocarbons, whose disposal is regulated under Basel. The 1995 Ban Amendment which entered into force in 2019, prohibits the export of hazardous wastes from OECD to non-OECD countries for disposal.

The Basel-IMO interface has been a persistent regulatory tension: major ship recycling nations (India, Bangladesh, Pakistan, Turkey) receive vessels from OECD-flag owners containing hazardous materials that arguably constitute Basel-regulated waste exports. The Hong Kong Convention (discussed in Section 2) was designed specifically to resolve this tension by establishing a self-contained ship recycling framework that, in the view of IMO member states, satisfies Basel's objectives within the maritime regulatory system.

1.7 The London Protocol (1996): Ocean Dumping and Carbon Sequestration

The London Protocol on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1996), updating the 1972 London Convention, prohibits the dumping of all waste and other matter at sea except for a permitted list of materials. Its relevance to decarbonisation has evolved in an unexpected direction: the 2006 amendment to the London Protocol, which came into force in 2019, specifically addresses the storage of carbon dioxide streams in sub-seabed geological formations, thereby establishing the regulatory framework for marine carbon capture and storage (CCS) as a climate mitigation tool.

For India, with its significant offshore sedimentary basins in the Arabian Sea and Bay of Bengal, the London Protocol's CCS provisions create a potential future framework for offshore geological sequestration: a component of the long-term net-zero toolkit that maritime infrastructure (offshore vessels, subsea pipelines) would need to serve.

1.8 The UN Global Compact (2000): Mainstreaming Corporate Climate Responsibility

Launched by Secretary-General Kofi Annan in 2000, the UN Global Compact is the world's largest corporate sustainability initiative with over 17,000 participating companies across 160+ countries. Its ten principles across human rights, labour, environment, and anti-corruption, particularly the environmental triad of Principles 7, 8, and 9 (precaution, greater environmental responsibility, and clean technology diffusion), create voluntary decarbonisation obligations that predate and complement IMO regulation.

The Sea Cargo Charter (2020) and the Poseidon Principles (2019) are the maritime sector's direct expressions of the Global Compact ethos: voluntary industry commitments that translate sustainability principles into measurable, disclosed commercial practice. India’s engagement with this framework is significant, with over 500 Indian companies, including major shipping and port infrastructure operators, participating as Global Compact signatories. This strengthens a market-driven governance layer that supports decarbonisation investments beyond formal regulatory requirements.

1.9 UN Sustainable Development Goals (2015): The Integrating Framework

The 2030 Agenda's 17 SDGs and 169 targets are the integrating framework within which maritime decarbonisation must be understood. The most relevant SDGs are SDG 7 (Clean Energy), SDG 9 (Infrastructure and Innovation), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 17 (Partnerships). India's SDG India Index, administered by NITI Aayog, tracks all States and UTs annually across 290 indicators.

INDIA'S SDG ACHIEVEMENTS: SELECTED SCORECARD (2024–25)

SDG 7: Renewable capacity exceeded 200 GW; 100% rural electrification under Saubhagya; LPG to 100+ million households under PMUY. SDG 9: National Infrastructure Pipeline (INR 111 lakh crore); PM GatiShakti; Sagarmala port-led development; Green Hydrogen Mission targeting 5 MMT/year by 2030. SDG 13: Updated NDC (2022), 45% intensity target; Net-Zero 2070 LT-LEDS. SDG 14: Blue Economy Policy 2021; Deep Ocean Mission (INR 4,077 crore); Coastal Aquaculture Authority

expansion. India co-founded the International Solar Alliance and the Coalition for Disaster Resilient Infrastructure, positioning itself as a multilateral climate institution builder.

1.10 The ILO and the Just Transition Imperative

The International Labour Organisation's Guidelines for a Just Transition (2015) establish that the shift to a low-carbon economy must maximise social and economic opportunities while minimising disruption to workers and communities. The four pillars, namely social dialogue, social protection, active labour market policies, and rights at work, apply directly to the maritime workforce as conventional propulsion systems are phased out over the coming decades.

India’s stake in the maritime sector is substantial, with nearly 3.23 lakh Indian nationals employed at sea globally, making seafaring India’s second-largest services export category after the IT sector. The fuel transition requires new competencies in LNG, methanol, ammonia, and hydrogen handling. India's maritime training institutions, including Indian Maritime University and its affiliated institutes, must develop and deliver STCW-aligned curricula for alternative fuels, creating a training export opportunity that reinforces India's position as the world's premier seafarer-supplying nation. The ILO Maritime Labour Convention (MLC 2006), the 'fourth pillar' of international maritime law, governs the welfare and transition provisions applicable to seafarers facing displacement from automation and fuel system changes.

1.11 Climate Finance: Article 6, Green Climate Fund, and CBAM

Article 6 — Paris Agreement Carbon Markets

Article 6 of the Paris Agreement establishes frameworks for internationally transferred mitigation outcomes (ITMOs), that is, carbon credits traded between countries, and a centralised crediting mechanism (Article 6.4). For maritime decarbonisation, Article 6 is relevant in two respects: the IMO GFI's 'remedial units' (credits earned by zero-emission fuel users) are designed to be Article 6-compatible, allowing Indian green fuel producers to generate internationally tradeable carbon credits from maritime clean fuel supply; and India's Carbon Credit Trading Scheme (CCTS) is being designed with Article 6 linkage capability.

The Green Climate Fund

The Green Climate Fund (GCF), established under the UNFCCC in 2010 and capitalised at USD 12.8 billion for its first replenishment cycle, is the primary multilateral vehicle for climate finance flows to developing countries. India has accessed GCF resources for renewable energy and adaptation projects. The GCF's maritime portfolio is nascent but growing; port resilience, coastal adaptation, and green bunkering infrastructure are eligible categories. India's maritime decarbonisation investment case can be structured to access GCF grant and concessional loan instruments.

EU Carbon Border Adjustment Mechanism (CBAM)

The EU Carbon Border Adjustment Mechanism (CBAM), fully operational from 2026, imposes a carbon price on imports of carbon-intensive goods (steel, cement, aluminium, fertilisers, electricity,

hydrogen) from non-EU countries that lack equivalent carbon pricing. CBAM's direct maritime relevance is twofold: first, vessels carrying CBAM-covered Indian exports to the EU will face increased scrutiny of their voyage emissions in the context of the EU ETS for shipping (in force 2024); second, CBAM creates urgency for India's domestic CCTS development: a credible domestic carbon price could qualify India's exports for CBAM relief. The shipping of CBAM-affected goods generates Scope 3 emissions for Indian exporters, creating market pressure for green shipping services on India-EU trade lanes.

EU ETS and FuelEU Maritime

The European Union's Emissions Trading Scheme (EU ETS) was extended to maritime transport from 1 January 2024, covering CO_2 emissions from large ships (5,000 GT+) on voyages to, from, and within EU ports. From 2024, 40% of reportable emissions are covered; this rises to 70% in 2025 and 100% from 2026. FuelEU Maritime, in force since 1 January 2025, establishes binding lifecycle GHG intensity limits for marine fuels used by ships calling at EU ports, serving as a regional precursor to the IMO GFI and creating immediate compliance pressure for Indian-flag vessels and foreign-flag vessels carrying Indian trade. Together, the EU ETS and FuelEU Maritime represent the most advanced regional carbon pricing and fuel-regulation framework for shipping and have accelerated the commercial case for alternative fuel investment ahead of the IMO’s expected 2028 implementation timeline.

SECTION – 2: INDIA'S DOMESTIC ENVIRONMENTAL GOVERNANCE EVOLUTION

India's domestic environmental governance trajectory has been shaped by its active international engagement, its own ecological imperatives as a country of enormous biodiversity and climate vulnerability, and the imperatives of balancing environmental protection with development for 1.4 billion citizens. This section traces that domestic evolution: from the legislative foundations of the 1970s through to today's comprehensive climate and green economy commitments.

2.1 The Legislative Foundation: Water, Air, and Environment

Water (Prevention and Control of Pollution) Act, 1974

India's first comprehensive pollution control statute established the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) as primary regulatory authorities. Its institutional architecture, including consent procedures, effluent standards, and penalties, provided the template for all subsequent environmental regulation. For the maritime sector, the Water Act's provisions on industrial effluents and coastal water quality remain directly relevant to port operations, vessel discharge management, and the regulation of ballast water and sewage treatment systems.

Air (Prevention and Control of Pollution) Act, 1981

Extending the Water Act's architecture to atmospheric emissions, the Air Act gave CPCB authority to set National Ambient Air Quality Standards (NAAQS) and regulate emission sources. The Act's emission monitoring framework is the domestic regulatory context within which port air quality management, including SOx, NOx, and particulate matter from vessels at berth, is governed. The Act also provides the precedent for India's approach to shipping emission standards as a public health as well as a climate issue.

Environment (Protection) Act, 1986

Enacted in the aftermath of the Bhopal gas tragedy, the EPA is India's principal umbrella environmental legislation. It provides the Central Government with broad enabling powers: setting emission and discharge standards, restricting industrial operations, prohibiting hazardous substance handling, and mandating environmental impact assessments. The EPA's enabling architecture has been used to promulgate the Coastal Regulation Zone (CRZ) notifications governing port development and coastal infrastructure, and provides the legal basis for any future domestic maritime emission standards that may complement India's IMO obligations.

LEGISLATIVE SEQUENCING: INDIA'S ENVIRONMENTAL LAW ARCHITECTURE

Water Act (1974) → Air Act (1981) → EPA (1986): India's environmental legislative sequence demonstrates the institutional logic of building from specific sectoral statutes to an umbrella enabling framework. The emerging maritime decarbonisation architecture follows the same logic: specific instruments (MARPOL implementation, EEXI/CII compliance) leading toward the comprehensive Maritime Decarbonisation Policy. The EPA's breadth also means that domestic

maritime emission standards, green port requirements, and alternative fuel regulations can all be grounded in existing primary legislation.

2.2 National Action Plan on Climate Change (NAPCC)

India's National Action Plan on Climate Change (NAPCC), launched in 2008 under Prime Minister Manmohan Singh, established eight National Missions as the architecture of India's domestic climate response. Each mission is relevant to the maritime decarbonisation context:

Instrument / Year	Scope & Significance
National Solar Mission (JNNSM)	Target: 100 GW solar by 2022 (achieved ~73 GW; revised to 500 GW by 2030). The solar electricity cost reduction driven by JNNSM is the foundation of India's green hydrogen competitiveness for maritime fuels.
National Mission for Enhanced Energy Efficiency	PAT Scheme: Perform, Achieve and Trade. Covers energy-intensive industries through tradeable energy efficiency certificates. Precursor to the CCTS framework. Port trusts included as designated consumers.
National Mission on Sustainable Habitat	Green building codes; urban transport; waste management. Drives electrification of port equipment and terminal operations as part of broader urban sustainability.
National Water Mission	Water use efficiency; conservation. Port and ship operations water management; ballast water treatment infrastructure planning.
National Mission for Sustaining the Himalayan Ecosystem	Glaciology; climate monitoring. Provides scientific baseline for sea level rise projections affecting Indian port infrastructure planning.
National Mission for a Green India	Afforestation; carbon sink enhancement. Carbon sink accounting contributes to India's NDC targets, contextualising the relative contribution of maritime emission reductions.
National Mission for Sustainable Agriculture	Climate-resilient agriculture; soil carbon. Bioenergy feedstock development (including for bio-methanol and bio-LNG for ships) sits within this mission's broader biomass framework.

Instrument / Year	Scope & Significance
National Mission on Strategic Knowledge for Climate Change	Research; capacity building; international cooperation on climate science. IMO technical submissions, IPCC participation, and GFI methodology development are supported through this mission's knowledge infrastructure.

2.3 Mission Amrit Kaal Vishwa Guru (MAKV): India's 2047 Aspiration

Mission Amrit Kaal Vishwa Guru represents India's centenary ambition: to emerge by 2047 as a Viksit Bharat (Developed India) that is simultaneously a global leader in sustainable development, clean technology, and multilateral governance. MAKV's energy export ambition, positioning India as a net exporter of clean energy including green hydrogen and ammonia, makes the maritime sector a strategic vehicle: green fuel produced in India must be shipped to global markets, and India's ports must become world-class green bunkering hubs to serve the global fleet on East-West and India-Africa trade routes.

2.4 Panchamrit and the Net-Zero 2070 Pathway

India's Panchamrit commitments, announced at COP 26 (2021) and formalised in the Updated NDC (August 2022), define the near-term and long-term climate trajectory:

500 GW Non-fossil electricity by 2030	**50%** cumulative electric power installed capacity from non-fossil fuel sources by 2030	**45%** Emissions intensity reduction vs 2005
1 Bn TCO_2e Cumulative carbon reduction by 2030	**2070** Net-Zero Target Year	

Each Panchamrit element has direct maritime implications. The 500 GW renewable target creates the electricity base for green hydrogen electrolysis, the feedstock for green ammonia marine fuel. The 50% renewables share accelerates shore power decarbonisation at Indian ports. The 45% intensity reduction shapes the CCTS architecture that will progressively cover maritime emissions. The Net-Zero 2070 horizon means ships ordered in 2025–2030, with 20–25 year design lives, will be operating at the critical 2045–2055 juncture of the net-zero trajectory, making today's fleet procurement decisions consequential for 2070 compliance.

2.5 National Green Hydrogen Mission (2023)

The National Green Hydrogen Mission, approved by the Cabinet in January 2023 with an initial outlay of INR 19,744 crore, is perhaps the most consequential domestic policy decision for maritime decarbonisation. Its targets, comprising 5 million tonnes per annum (MMTPA) of green hydrogen production by 2030 and creation of 600,000 jobs, directly address the supply-side constraint on maritime fuel transition. The Mission's components include:

- SIGHT (Strategic Interventions for Green Hydrogen Transition): production-linked incentive for green hydrogen and green ammonia manufacturing, targeting domestic and export markets.
- Green Hydrogen Hubs: dedicated industrial zones for green hydrogen production, with anchor demand from industry, fertiliser production, and, critically, export and maritime bunkering.
- R&D framework: electrolyser technology development, fuel cell technology, and storage systems: the same technology base that underpins shipboard hydrogen propulsion.
- Export pathway: USD 8 billion in export revenues from green hydrogen and derivatives by 2030; maritime bunkering, given India's port geography and the scale of the global fleet, is a primary target market.

The Green Hydrogen Mission is the most direct bridge between India's domestic climate policy and maritime decarbonisation. A Maritime Decarbonisation Policy that creates domestic demand for green hydrogen bunkers, sourced from Indian-flag vessels, from foreign-flag vessels at Indian ports, and from a regulatory framework that incentivises early adopters, is the demand-side complement to the Mission's supply-side investments.

2.6 India’s Carbon Market and ESG Architecture

- Energy Conservation (Amendment) Act 2022: Carbon Credit Trading Scheme (CCTS): India's domestic carbon market. Registry, MRV, and trading platform under development by BEE and power exchanges. Designed for Article 6 compatibility. Ports and shipping not yet in Phase 1 scope but enabled by primary legislation.
- BRSR and Corporate Disclosure: Business Responsibility and Sustainability Reporting (BRSR) mandatory for top 1,000 listed companies from FY 2022–23. Scope 1, 2, and 3 emissions covered. Alignment with IFRS S1/S2 underway through MCA. Listed shipping and port companies face climate risk disclosure obligations.
- CBAM Exposure: India's steel, cement, aluminium, and fertiliser exports to the EU face CBAM from 2026. The embodied carbon of these goods includes shipping-related Scope 3 emissions, creating supply chain pressure on Indian exporters to use lower-carbon shipping services: a market-driven decarbonisation signal independent of IMO regulation.

SECTION – 3: MARITIME: THE COMPLETE REGULATORY ARCHITECTURE AND INDIA'S POSITION

This section provides a comprehensive treatment of the international maritime regulatory framework in the context of greening and decarbonisation, covering the full spectrum from foundational safety conventions through pollution prevention, ship recycling, ballast water, anti-fouling, the complete MARPOL GHG trajectory, alternative fuels, operational and technical measures,

and the emerging market-based mechanisms, followed by India's adoption, adaptation, and domestic initiatives.

3.1 The Foundational Architecture: IMO, SOLAS, and STCW

International Maritime Organisation

The International Maritime Organisation (IMO), established as a UN specialised agency in 1958, is the global standard-setting authority for the safety, security, and environmental performance of international shipping. With 176 Member States, IMO develops conventions adopted into domestic law by flag states and enforced through port state control. India has been an IMO Member since its founding, regularly serves on the IMO Council, and is an active participant in MEPC, MSC, and all subsidiary bodies relevant to decarbonisation.

SOLAS — Safety of Life at Sea

The International Convention for the Safety of Life at Sea (SOLAS, current version 1974) establishes minimum standards for ship construction, equipment, and operation. Its decarbonisation relevance has expanded significantly: the IGF Code (International Code of Safety for Ships using Gases or other Low-flashpoint Fuels, in force 2017) governs the safe use of LNG and other alternative fuels on ships, and is being extended through IMO's Sub-Committee on Carriage of Cargoes (CCC) to cover methanol, ammonia, and hydrogen. SOLAS Chapter II-1's provisions for alternative design and arrangements provide the regulatory pathway for hydrogen fuel cell vessels, wind-assisted propulsion, and other novel propulsion technologies to achieve flag state approval.

STCW — Seafarer Training and Certification

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW, 1978, revised 1995 and Manila 2010) establishes global qualification standards for seafarers. Its 2010 Manila Amendments introduced certification requirements for ships using low-flashpoint fuels (LNG). Current STCW work at IMO's Sub-Committee on Human Element, Training and Watchkeeping (HTW) is developing competency frameworks for methanol, ammonia, and hydrogen, directly relevant to India as the world's largest seafarer-supplying nation. India achieved STCW White List status, recognising its training and certification system meets international standards, and its maritime training institutions are positioned to become regional centres for alternative fuel competency.

3.2 MARPOL: The Environmental Convention Architecture

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the principal environmental convention for shipping. Its six Annexes collectively constitute the comprehensive framework for reducing shipping's environmental footprint across all pollution vectors:

Annex / Subject	Scope & Significance
Annex I — Oil	Prevention of pollution by oil from operational and accidental discharges. Oily water separators, oil record books, special areas. Foundation of maritime pollution prevention.
Annex II — NLS	Noxious liquid substances in bulk. Pre-washing requirements, residue discharge standards. Protects marine environment from chemical cargo contamination.
Annex III — Packaged Harmful Substances	Standards for packaging, marking, labelling, documentation, and stowage of harmful substances in packaged form. Integrated with IMDG Code.
Annex IV — Sewage	Prevention of pollution by sewage from ships. Sewage treatment plants, holding tanks, discharge standards. Protects coastal and port water quality.
Annex V — Garbage	Prevention of pollution by garbage. Prohibition on plastic discharge; special area provisions; garbage management plans. Directly addresses marine plastic pollution.
Annex VI — Air Pollution & GHG	The GHG and climate-relevant Annex. SOx caps (Global 0.5% from 2020; 0.1% in ECAs), NOx Tier I/II/III limits, EEDI, SEEMP, EEXI, CII, and the forthcoming GFI framework. The operative instrument for maritime decarbonisation.

3.3 IMO 2020 Sulphur Cap: The Largest Marine Fuel Change in History

The IMO 2020 global sulphur cap, which reduced the maximum sulphur content in marine fuel oil from 3.5% to 0.5% m/m from 1 January 2020, was the most significant change to marine fuel specifications in the history of shipping. Its environmental impact was immediate and substantial: maritime SOx emissions fell by approximately 77% in the first year, delivering major public health benefits for port cities and coastal populations worldwide. Its relevance to the decarbonisation agenda extends beyond the direct environmental benefit:

- Technology demonstration: IMO 2020 proved that the global fleet could transition to a new fuel specification on a defined schedule: the same institutional confidence that underpins the GFI framework's ambition.
- Infrastructure learning: The build-out of VLSFO (Very Low Sulphur Fuel Oil) blending, storage, and bunkering infrastructure in 2018–2020 demonstrated the global maritime fuel supply chain's adaptability. The green fuel bunkering infrastructure challenge is qualitatively more complex, but the IMO 2020 transition is the reference point for planning timelines and logistics.
- Scrubber pathway: The IMO 2020 transition also saw widespread adoption of exhaust gas cleaning systems (scrubbers) that allow continued use of high-sulphur fuel. The GFI

framework's lifecycle accounting explicitly addresses scrubber carbon penalties, ensuring that compliance cost minimisation through exhaust treatment does not create perverse incentives on the GHG trajectory.

- In Emission Control Areas (ECAs), covering North America, the North Sea, the Baltic, and the Mediterranean, the 0.1% sulphur limit has been in force since 2015, and NOx Tier III standards apply to new ships. India is exploring designation of Indian Ocean ECAs around its major ports, which would further drive clean fuel adoption on coastal and port approaches.

3.4 Black Carbon and Short-Lived Climate Forcers

Black carbon (BC), a fine particulate matter produced by incomplete combustion of fossil fuels, biofuels, and biomass, is a potent short-lived climate forcer with a global warming potential approximately 3,200 times that of CO2 over a 20-year horizon. In the Arctic, black carbon deposition on ice and snow accelerates albedo loss and sea ice melt, making shipping's BC emissions from vessels transiting Arctic routes a specific climate concern that has gained significant attention at MEPC since 2011.

MEPC has been developing recommendations on BC reduction from shipping since MEPC 65 (2013). The current focus is on the development of a definition and measurement methodology for BC from shipping, leading to potential mandatory measures. The transition to alternative fuels, particularly LNG, methanol, and hydrogen, substantially reduces or eliminates BC emissions relative to conventional HFO combustion, providing a direct co-benefit of the fuel transition that strengthens the decarbonisation investment case for vessels trading on Arctic-adjacent routes.

3.5 Ballast Water Management Convention (2004)

The Ballast Water Management Convention (BWMC), adopted in 2004 and entering into force in 2017, requires ships to manage their ballast water and sediments to remove, render harmless, or avoid the uptake or discharge of aquatic organisms and pathogens. Its connection to decarbonisation is operational rather than direct: ballast water treatment systems (BWTS) installed to comply with the BWMC consume shipboard electrical power, adding to the energy demand that must be accounted for in CII calculations. The optimisation of BWTS energy consumption, through UV treatment systems, hybrid approaches, and intelligent operational scheduling, is a component of the holistic ship energy management that underpins CII rating improvement programmes.

India is yet to ratify the Convention. Nevertheless, Indian shipping is progressively aligning with IMO ballast water management standards through regulatory guidance, Statement of Compliance mechanisms, and survey oversight by notified Recognised Organisations (ROs), supporting compliance readiness for vessels operating on international routes.

3.6 The AFS Convention and Biofouling: The Hidden Efficiency Lever

The International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS Convention, 2001, in force 2008) prohibits the use of organotin compounds (tributyltin, TBT) in anti-

fouling paints, which had previously been highly effective but caused widespread marine toxicity. The AFS Convention's significance for decarbonisation extends well beyond its intended scope:

- Hull fouling and fuel consumption: Marine organisms accumulating on a ship's hull can increase hydrodynamic drag by 10–40%, directly increasing fuel consumption and GHG emissions. The development of effective, non-toxic anti-fouling systems, such as silicone-based coatings, nano-coatings, and hull-air lubrication systems, is therefore a direct decarbonisation measure.
- Biofouling management guidelines: MEPC.1/Circ.811 (2011) provides voluntary guidelines for the management of biofouling to minimise the transfer of invasive aquatic species, but the guidelines also explicitly address the energy and emissions benefits of hull cleaning and optimised coating selection. A vessel maintaining a clean hull can reduce fuel consumption by 5–10% relative to a heavily fouled hull, representing one of the highest-return, lowest-cost decarbonisation measures available to fleet operators.
- In-water cleaning: The development of in-water hull cleaning technology, including robotic cleaning systems that can maintain hull condition without dry-docking, is a growing industry with direct relevance to Indian ship repair and port service sectors. IMO is developing guidelines for in-water cleaning that will inform future mandatory measures.

India has ratified the AFS Convention. Indian-flag vessels are prohibited from applying TBT-based anti-fouling systems, and DGS surveys include AFS compliance. The development of anti-fouling technology and robotic hull cleaning services at Indian ship repair yards represents an opportunity in the growing green shipping services market.

3.7 The Hong Kong Convention (HKC, 2009): Safe and Environmentally Sound Ship Recycling

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (HKC), adopted at a Diplomatic Conference in Hong Kong in May 2009 and entering into force on 26 June 2025, is among the most consequential IMO conventions for India. Its entry into force represents a fundamental transformation of the global ship recycling industry, an industry in which India, through the Alang shipbreaking yards in Gujarat, holds a dominant global position.

The Convention's Scope and Requirements

The HKC applies to ships of 500 GT and above flying the flag of a Party, and to ship recycling facilities operating under the jurisdiction of a Party. Its principal requirements are:

- Inventory of Hazardous Materials (IHM): All ships must carry a continuously maintained Inventory of Hazardous Materials documenting the presence and location of asbestos, heavy metals, PCBs, ozone-depleting substances, and other listed hazardous materials. The IHM has three parts: Part I (present on the ship), Part II (operational wastes), Part III (stores). New ships must have an IHM from the keel-laying stage; existing ships must develop IHMs for flag state approval.
- Ship Recycling Plan (SRP): When a ship is to be recycled, the owner must develop a Ship Recycling Plan tailored to the specific ship and the specific recycling facility. The SRP must address the safe and environmentally sound management of all materials identified in the IHM.
- Authorised Ship Recycling Facility: Ships may only be recycled at facilities authorised under the Convention's requirements, which include impermeable floors for work areas, hazardous

waste management systems, worker health and safety standards, and environmental management systems. Facilities must be listed on the IMO's authorised facility list.
- Statements of Compliance and Completion: Ships receive a Ready for Recycling Certificate prior to demolition; recycling facilities issue a Statement of Completion upon completion of recycling, creating a documentary chain that enables verification of compliance.

ALANG AND THE HKC: INDIA'S COMPETITIVE TRANSFORMATION

Alang-Sosiya in Gujarat handles approximately 30–35% of global ship recycling tonnage, making it one of the world's largest ship recycling centres by volume. India's ratification of the HKC and the development of HKC-compliant facilities at Alang, supported by the Ship Breaking Code, the Recycling of Ships Act, 2019, and recent SBFAS provisions including the Shipbreaking Credit Note mechanism, position India to capture a significant share of the global scrapping market. Ships from countries with stringent environmental regulations, including the EU, Norway, and Japan, are expected to increasingly prefer HKC-compliant facilities. The HKC's entry into force in June 2025 transforms compliance from a competitive advantage to a market prerequisite.

HKC and the Decarbonisation Nexus

The HKC's connection to maritime decarbonisation is direct and multi-dimensional:

- Fleet renewal catalyst: HKC compliance imposes additional costs on ship owners, including IHM preparation and surveys for existing vessels, making the recycling of older, less efficient ships more commercially viable than continued operation. This incentivises fleet renewal with modern, energy-efficient, and alternative-fuel-ready vessels, directly advancing the CII compliance and GFI transition agenda.
- Circular economy for marine materials: The HKC's hazardous material management framework ensures that steel and other materials recovered from end-of-life ships are processed through environmentally sound channels. For India's steel industry, a major CBAM-affected sector, having access to large volumes of ship steel recycled under certified environmentally sound conditions is a supply chain sustainability credential of growing commercial value.
- Green recycling premium: As ESG requirements tighten for ship owners under BRSR, Poseidon Principles, and investor sustainability criteria, the ability to certify that a vessel's end-of-life recycling was conducted at an HKC-authorised facility becomes a reportable sustainability metric. This creates a commercial premium for HKC-compliant recycling that the Alang industry is well-positioned to capture.
- India's regulatory implementation: The Recycling of Ships Act, 2019 (India) gives domestic legislative effect to the HKC, establishing the framework for facility authorisation, IHM documentation, and enforcement. The Alang Ship Recycling Yard has multiple facilities that have achieved Statement of Compliance under the new Act, and the process of obtaining full HKC authorisation is well advanced.

3.8 The EEDI/EEXI/CII Regulatory Progression

MARPOL Annex VI's GHG regulatory framework has evolved through three paradigm shifts:

Paradigm 1 — Technical Efficiency: EEDI (2013 onwards)

The Energy Efficiency Design Index (EEDI), in force since 2013, established the first mandatory global CO2 standard for new ships. Phase 0 through Phase 3 tighten the required value by up to 30% relative to the 2008 fleet baseline. Phase 3 for most ship types took effect from 2025, requiring new builds to incorporate significant efficiency technology: optimised hull forms, waste heat recovery systems, air lubrication, improved propeller design, and in some cases alternative propulsion. The EEDI's methodology, measuring attained CO2 per unit of transport work versus a required value, provided the conceptual framework adapted for subsequent instruments.

Paradigm 2 — Operational Performance: EEXI and CII (2023 onwards)

The Energy Efficiency Existing Ship Index (EEXI), adopted at MEPC 76 and in force since January 2023, extended the design-index concept to the existing fleet. Most ships comply through engine power limitation (EPL), a technical measure that limits maximum continuous rating, effectively mandating a degree of slow steaming. The Carbon Intensity Indicator (CII), also in force since January 2023, assigns an annual A–E rating to cargo ships of 5,000 GT+ based on actual operational CO2 intensity (grams CO2 per deadweight tonne-nautical mile for most ship types). Required values tighten annually through 2030. Ships rated D for three consecutive years or E in any single year must submit corrective action plans within their SEEMP Part III.

Paradigm 3 — Fuel Transition: GFI and IMO Net-Zero Framework (2028 onwards)

MEPC 80 (July 2023) adopted the Revised IMO GHG Strategy, establishing net-zero greenhouse gas emissions from international shipping by or around 2050 as the headline goal. At MEPC 83 (April 2025), IMO Member States reached agreement in principle on the IMO Net-Zero Framework, including the Goal-based Fuel Intensity (GFI) standard, which proposes lifecycle (well-to-wake) GHG intensity thresholds for marine fuels, alongside an economic measure to disincentivise high-emission fuels and incentivise zero- and near-zero emission alternatives through tradable compliance units. Formal adoption through MARPOL Annex VI amendments remains pending, with entry into force expected around 2028.

MRV Infrastructure: IMO DCS and EU MRV

The GFI framework rests on a mature data infrastructure. The IMO Data Collection System (DCS), in force under MARPOL Annex VI since 2019, requires ships of 5,000 GT and above to collect and report fuel oil consumption data to their flag state, which in turn aggregates and submits the data to the IMO Ship Fuel Oil Consumption Database. This provides the ship-level fuel consumption and operational data necessary for emissions accounting and compliance assessment under the GFI framework. In parallel, the EU Monitoring, Reporting and Verification (MRV) Regulation, in force since 2018 for vessels calling at EU ports, established a more granular voyage-level reporting requirement that has driven shipping companies to invest in digital emissions tracking systems ahead of the broader IMO DCS timeline. Together, IMO DCS and EU MRV have built the data governance infrastructure on which the GFI economic instrument and the CII rating system depend: without

verified fuel consumption and voyage data at ship level, neither the remedial unit mechanism nor the A–E rating system is enforceable. India's Directorate General of Shipping administers IMO DCS compliance for Indian-flag vessels; building domestic MRV capacity that aligns with both IMO and EU requirements is a prerequisite for Indian shipping companies operating on international and EU-trading routes.

3.9 Alternative Fuels: The Full Technology Spectrum

The transition to zero- and near-zero emission fuels is the core of Paradigm 3. The full technology spectrum ranges from near-term transitional fuels that reduce emissions incrementally, to medium-term fuels that can achieve significant GHG reductions, to long-term fuels capable of achieving net-zero on a well-to-wake basis:

Instrument / Year	Scope & Significance
LNG — Liquefied Natural Gas	Reduces CO2 by 20–25% vs HFO on a TtW basis; methane slip risks can negate WtW benefits if not managed. Near-term bridge fuel; over 900 LNG-capable vessels in service globally. India: Petronet LNG at Kochi and Dahej could serve coastal LNG bunkering.
LPG — Liquefied Petroleum Gas	Lower carbon than HFO; available through existing LPG infrastructure. Limited to smaller ship classes (VLGCs); growing adoption in gas carriers. India: existing LPG import and distribution infrastructure provides near-term bunkering pathway.
Methanol	15-30% CO2 reduction (grey methanol) to near-zero (green methanol from biomass or electrolytic hydrogen + CO2). Low flashpoint requires IGF Code compliance. Maersk, Stena operating methanol dual-fuel vessels commercially. India: green methanol production potential from biomass and stranded renewables.
Ammonia	Zero CO2 at combustion (nitrogen oxide management required). Green ammonia (electrolytic hydrogen + Haber-Bosch) achieves near-zero WtW. Toxicity and handling challenges require new safety standards. MAN ES and WinGD developing ammonia engines. India's fertiliser industry provides existing ammonia infrastructure base.
Green Hydrogen	Zero emissions at combustion; near-zero WtW if produced from renewables. Storage challenges (cryogenic or high pressure) limit to short-sea and ferry applications near term. Long-term deep-sea option via fuel cells or combustion engines. India's Green Hydrogen Mission targets 5 MMT/year; maritime bunkering is a primary offtake market.

Instrument / Year	Scope & Significance
Bio-LNG / Bio-methane	Biomethane produced from organic waste, agricultural residue, or dedicated energy crops. Near-zero to negative WtW depending on feedstock. Compatible with LNG infrastructure. India: significant agricultural waste feedstock potential; National Bioenergy Programme.
Bio-methanol	Produced from biomass; similar WtW profile to bio-LNG. Compatible with methanol engine infrastructure. India: sugar industry molasses stream; lignocellulosic biomass. Can be blended immediately with grey methanol.
FAME / HVO (Biofuels)	Fatty Acid Methyl Esters (biodiesel) and Hydrogenated Vegetable Oil as drop-in fuel blends (B20, B30) for existing engines. Immediate emission reduction potential; GFI lifecycle accounting applies. India: National Biofuel Policy 2022 targets 5% blending in shipping fuel by 2030.
Nuclear Propulsion	Zero operational emissions. Currently limited to naval and icebreaker applications; commercial regulatory framework under development at IAEA/IMO. Long-term option for large vessels on specific trade routes. India: civil nuclear programme provides technological context.
Fuel Cells	Direct conversion of hydrogen or ammonia to electricity; high efficiency; zero emissions at point of use. Currently deployed on ferries and small vessels; scaling to large ships in development. Waterstoff-powered ferries operating in Norway; hydrogen fuel cell tanker concepts in development.
Wind-Assisted Propulsion (WAPS)	Rotor sails (Flettner rotors), rigid wing sails, kite sails, and suction sails reduce main engine load. Fuel savings of 5–30% depending on trade route and wind conditions. MEPC developing technical guidelines. Pyxis Ocean (sails); Vale ore carriers (flapping wing); growing commercial deployment.
Solar / Battery Hybrid	Photovoltaic panels supplementing shipboard power; battery energy storage for peak shaving and cold ironing connection. Suited to short-sea, ferries, and port operations vessels. India: coastal ferry electrification programme; battery-electric tugs in deployment.

3.10 Technical and Operational Efficiency Measures

The fuel transition to alternative energies is a paradigm-3 ambition. The immediate decarbonisation opportunity, delivering emission reductions in the 2025–2035 window, lies in the full deployment of technical and operational efficiency measures across the existing fleet. These measures are often

overlooked in favour of the more technologically exciting fuel transition narrative, yet they represent the largest near-term emissions reduction opportunity at lowest cost:

Technical Measures

- Hull form optimisation and retrofitting: Bulbous bow optimisation, stern appendages, and hull coating upgrades reduce resistance and fuel consumption by 3–8%.
- Propeller efficiency: Propeller boss cap fins (PBCF), ducts, pre-swirl stators, and contra-rotating propellers improve propulsive efficiency by 3–5%.
- Air lubrication systems (ALS): Micro-bubbles injected under the hull reduce frictional resistance by 5–10%. Silverstream Technologies, DAMEN, and Mitsubishi commercial systems in service.
- Waste heat recovery (WHR): Recovering exhaust heat through steam turbines or organic Rankine cycle systems generates supplementary electricity, reducing auxiliary engine fuel consumption by 3–10%.
- Engine tuning and retrofit: Turbocharger upgrades, fuel injection optimisation, derating, and variable speed auxiliary engines reduce fuel consumption on existing machinery.
- Shaft generators / PTOs: Power take-off from main engine to generate electricity when at sea improves overall energy system efficiency.

Operational Measures

- Speed optimisation and slow steaming: A 10% reduction in vessel speed reduces fuel consumption by approximately 19–27% (cubic relationship). Slow steaming, the single most cost-effective operational measure, is already widespread but has not been systematically mandated. The CII's declining trajectory incentivises continued speed management.
- Just-in-time (JIT) arrival: Vessels notified of berth availability in real time can reduce speed when berth congestion would otherwise require waiting at anchor, eliminating unnecessary fuel burn. IMO has published JIT arrival guidelines and is working toward industry-wide adoption through the Port Collaborative Decision Making (PortCDM) framework.
- Voyage optimisation and weather routing: AI-assisted route planning and real-time weather routing can reduce voyage fuel consumption by 3–8% by optimising speed profiles and avoiding adverse weather.
- Port turnaround efficiency: Reducing time at anchor through berth pre-booking, faster cargo handling, and port community system (PCS) digitisation reduces auxiliary engine running hours and eliminates idle fuel burn.
- Trim and draft optimisation: Adjusting vessel trim to its hydrodynamically optimal condition reduces resistance by up to 2%; managing cargo distribution to optimise draft similarly contributes.
- Cargo planning and load factor optimisation: Maximising cargo per voyage reduces the carbon intensity per tonne of cargo moved, directly improving CII ratings.
- Autopilot and manoeuvring optimisation: Efficient autopilot settings, reduced course deviations, and optimised port approach manoeuvring reduce fuel consumption on coastal and port approaches.

Digital and AI-Enabled Efficiency

The digitalisation of shipping operations, through vessel performance monitoring systems (VPMS), IoT sensor arrays, digital twins, predictive maintenance, and AI voyage optimisation platforms, represents the most scalable near-term efficiency lever. Key developments:

- Digital twins: Real-time computational models of vessel hydrodynamics, machinery, and cargo loading allow operators to continuously optimise speed, trim, and route for minimum fuel consumption. Wärtsilä, Kongsberg, and ABB deploy commercial digital twin platforms.
- Predictive maintenance: AI analysis of engine and machinery sensor data predicts component wear before failure, enabling maintenance that maintains peak efficiency and avoids fuel-wasting degraded performance.
- Autonomous and AI-assisted navigation: Reduces human-error-driven inefficiency in manoeuvring and passage planning; Rolls-Royce/Intel and Kongsberg have demonstrated autonomous vessel operation.
- Port community systems and e-documentation: Reducing port pre-arrival documentation burden and enabling real-time berth data sharing enables JIT arrival; India's PORTNET system and the National Logistics Policy's single-window goals are the domestic implementation.

3.11 Shore Power (Cold Ironing) and Green Ports

Shore power, which connects vessels to onshore electricity supply while at berth rather than running auxiliary diesel engines, is the most immediate and cost-effective decarbonisation measure for port-side operations. A vessel at berth typically runs auxiliary engines consuming 1–4 tonnes of fuel per day; shore power eliminates this entirely when supplied from a decarbonised grid. The environmental co-benefit extends beyond CO2: NOx, SOx, and particulate matter from vessels at berth are a major source of urban air quality degradation in port cities.

India's Harit Sagar (Green Port) Guidelines, issued by the Ministry of Ports, Shipping and Waterways in 2023, establish the framework for India's port decarbonisation programme. Key provisions include:

- Mandatory shore power connectivity at all major ports for cruise ships, ferries, and bulk carriers by specified timelines.
- Renewable energy targets: all major ports to achieve 60% renewable electricity consumption by 2030.
- Green hydrogen and ammonia bunkering infrastructure: identification of pilot ports (JNPT, Kandla, Visakhapatnam, Paradip, Kochi, Chennai) for green fuel bunkering infrastructure development.
- Port equipment electrification: replacement of diesel-powered harbour craft, forklifts, reach stackers, and terminal tractors with electric or hydrogen-powered alternatives.
- Environmental Management Systems: ISO 14001 certification for all major ports.
- Carbon footprint reporting: annual port-level GHG inventory and reduction targets, aligned with the IMO Port Carbon Intensity Indicator (PCII) framework.

The Green Tug Transition Programme, a specific initiative under Harit Sagar, targets replacement of diesel-powered harbour tugs at major Indian ports with LNG, hydrogen, or battery-electric tugs, with a phased timeline beginning with pilot deployments at JNPT and Kochi. The programme is modelled on the successful green tug transitions at the Port of Singapore and Abu Dhabi ports.

Port-Side Regulatory Measures: Port CII, Just-in-Time Arrival, and MARPOL Port Reception Facilities

The decarbonisation regulatory framework does not apply to vessels alone; ports are integral nodes in the emissions architecture. Three port-side instruments are of direct relevance to India's maritime decarbonisation programme:

Port Carbon Intensity Indicator (Port CII): Unlike the Carbon Intensity Indicator (CII) under MARPOL Annex VI, which is a ship-specific metric applicable to vessels of 5,000 GT and above, port decarbonisation in India is guided through carbon accounting and environmental performance monitoring under the Harit Sagar Green Port Guidelines. Harit Sagar requires major ports to prepare greenhouse gas inventories, track carbon emissions per tonne of cargo handled, and monitor progress through defined Environmental Performance Indicators aligned with global sustainability reporting practices such as the Green Reporting Initiative (GRI). Strengthening these carbon accounting and benchmarking mechanisms would create measurable baselines, support targeted green infrastructure investments, and enhance the competitiveness of Indian ports as low-carbon logistics hubs on key trade corridors.

Just-in-Time (JIT) Arrival: JIT arrival is the practice of optimising a vessel's speed and routing so that it arrives at port precisely when a berth is available, eliminating the common practice of sailing at full speed and then waiting at anchor. Studies indicate that JIT arrival can reduce voyage fuel consumption by 5–14% on affected port calls. IMO has developed guidelines for JIT port calls under the MEPC-NCSR joint working group, and several port authorities, including Singapore MPA and Port of Rotterdam, have implemented real-time berth information systems to enable JIT. India's PORTNET system provides the digital infrastructure for JIT deployment at major Indian ports; integrating real-time berth availability data with vessel traffic services (VTS) and formalising JIT protocols under the Maritime Decarbonisation Policy would deliver immediate, low-cost emission reductions across the Indian port network.

MARPOL Port Reception Facilities (PRF): MARPOL Annexes I through VI require ports to provide adequate reception facilities for ship-generated waste, including oily bilge water, sewage, garbage, scrubber washwater, and exhaust gas cleaning residues. Inadequate PRF availability is a longstanding compliance gap at many Indian ports, creating incentives for illegal at-sea discharge. MEPC has adopted the Comprehensive Manual on Port Reception Facilities and an online PRF reporting system (GISIS module). India's Maritime Decarbonisation Policy should mandate PRF adequacy assessments at all major and non-major ports, establish minimum standards aligned with MARPOL Annex VI scrubber residue management, and integrate PRF planning into Harit Sagar's green port certification. Adequate PRFs are both a MARPOL compliance obligation and a prerequisite for India's aspiration to be a responsible, high-standard maritime nation.

3.12 Green Corridors, the Clydebank Declaration, and IMO GreenVoyage2050

Green Shipping Corridors

Green shipping corridors are specific trade routes between two or more ports along which zero-emission shipping solutions are demonstrated and scaled. The concept, pioneered by the Getting to Zero Coalition and formalised through bilateral government agreements, focuses the early deployment of alternative fuel bunkering infrastructure on high-traffic specific routes rather than attempting a simultaneous global transition. Notable established or announced corridors include Shanghai–Rotterdam (hydrogen/ammonia), Vancouver–Yokohama, and the Maersk-operated green methanol corridors.

For India, green corridor development on key trade routes such as Mundra/JNPT to Rotterdam, Kochi to Singapore, and Visakhapatnam to Yokohama, offers a pathway to demonstrate green bunkering capability, attract zero-emission fleet deployment to Indian ports, and build the commercial relationships with foreign shipping companies and cargo owners that accelerate adoption at scale. The Ministry of Ports, Shipping and Waterways has engaged with the Global Maritime Forum and Getting to Zero Coalition on India corridor development.

The Clydebank Declaration (2021)

The Clydebank Declaration, launched at COP 26 with 22 signatory states (growing to 30+ by 2024), commits participating governments to support the establishment of at least six green shipping corridors by the mid-2020s. The Declaration's significance for India is that it represents the leading edge of government-level commitment to specific route decarbonisation: the policy instrument that creates the enabling conditions (port infrastructure, fuel supply guarantees, regulatory sandboxes) within which private investment in zero-emission shipping operates. India's accession to or engagement with the Clydebank Declaration would signal commitment to corridor-level action complementing IMO fleet-level regulation.

IMO GreenVoyage2050

IMO GreenVoyage2050 is a capacity-building project funded by Denmark, Finland, France, Germany, the Netherlands, and Norway, and implemented by the IMO to assist developing countries in implementing short-term GHG reduction measures and preparing for long-term maritime decarbonisation. India is a project partner, with DGS engaged in implementation of the voluntary JIT arrival guidelines, SEEMP Part III compliance support, and development of the national framework for CII reporting. The project provides technical assistance, training, and pilot project development resources that supplement India's own domestic capacity, an example of the international technology transfer and capacity-building provisions India advocates for in MEPC negotiations.

3.13 The Poseidon Principles, Sea Cargo Charter, and Getting to Zero Coalition

Poseidon Principles

The Poseidon Principles (2019), now with 30+ signatory banks representing approximately USD 185 billion of ship finance portfolios, commit lenders to assess and disclose the climate alignment of their shipping portfolios against the IMO GHG Strategy trajectory. Ships persistently above the alignment threshold face financing constraints: higher margins, shorter tenors, or exclusion from

Poseidon lenders' portfolios. For Indian shipping companies accessing international capital, Poseidon creates near-regulatory compliance pressure ahead of IMO's formal instruments.

Sea Cargo Charter

The Sea Cargo Charter (2020), a complementary initiative for cargo owners and charterers, commits signatories to assess and disclose the climate alignment of their chartered shipping. Major commodity traders (Cargill, Louis Dreyfus), mining companies (Rio Tinto, Vale), and energy majors are signatories. The Sea Cargo Charter creates demand-side pressure: Indian cargo owners and exporters whose counterparties are Sea Cargo Charter signatories face scrutiny of the carbon intensity of the vessels they charter, creating a commercial incentive for Indian shippers to deploy or charter lower-carbon vessels.

Getting to Zero Coalition

The Getting to Zero Coalition, a partnership between the Global Maritime Forum, Friends of Ocean Action, and the World Economic Forum, brings together 200+ companies across the maritime value chain, including shipowners, fuel producers, ports, cargo owners, and financiers, committed to having commercially viable zero-emission vessels in operation by 2030. The Coalition's corridor workstream, fuel pathway analysis, and policy advocacy complement and accelerate the IMO regulatory trajectory. India's engagement with Coalition members, particularly on green corridor development and green fuel offtake agreements, creates the commercial anchoring for domestic green fuel investment.

3.14 India’s Adoption of IMO Frameworks and Domestic Institutions

India's adoption of IMO conventions occurs through the Merchant Shipping Act, 1958 (and amendments), with the Directorate General of Shipping (DGS) serving as the flag state administration and statutory survey and certification functions delegated to seven notified Recognised Organisations (ROs):

- MARPOL Annex VI: Implemented through Merchant Shipping (Prevention of Air Pollution from Ships) Rules. Indian-flag vessels carry IAPP Certificates; DGS has issued CII compliance guidance circulars; IRS is an authorised CII verifier.
- STCW: India on STCW Whitelist. IMU and affiliated institutes deliver STCW Basic and Advanced training; extension to alternative fuel competencies in development.
- Ballast Water Management Convention: India is yet to ratify the Convention. Nevertheless, ballast water management practices in Indian shipping are progressively being aligned with IMO standards through regulatory guidance, operational controls, and survey oversight by notified Recognised Organisations (ROs).
- AFS Convention: India ratified; TBT prohibition enforced; hull coating standards incorporated into IRS survey requirements.
- HKC (Recycling of Ships Act 2019): Domestic legislation enacted; Alang facilities advancing toward full HKC authorisation; Ship Breaking Code revised to align with HKC standards.
- London Protocol: India a party; CCS provisions noted in context of offshore sequestration potential.

3.15 Maritime India Vision 2030 and Harit Sagar: The Domestic Platform

Maritime India Vision 2030 (MIV 2030), launched at the Maritime India Summit 2021, provides the strategic framework across 10 themes and 150 initiatives. Its decarbonisation-relevant dimensions include the Sagarmala port-led industrialisation programme (INR 4 lakh crore), ship repair and recycling hub development, inland waterway expansion (National Waterways electrification), coastal shipping promotion, and cruise sector development. MIV 2030 creates the infrastructure platform on which Harit Sagar's decarbonisation requirements are deployed.

The overlap between MIV 2030, Harit Sagar, the Green Hydrogen Mission, MAKV, and Panchamrit creates a powerful strategic alignment: every green maritime investment simultaneously advances the port-led development agenda, the clean energy export ambition, the 2030 climate targets, and the 2047 Viksit Bharat vision. A Maritime Decarbonisation Policy is the instrument that activates and coordinates this alignment across ministries and regulatory bodies.

3.16 India’s GFI Position and CBDR-RC Advocacy

India's position at MEPC on the GFI and IMO Net-Zero Framework is nuanced: neither blanket endorsement nor blanket opposition. India supports GFI Tier 1 compliance trajectories that are technically feasible, equitably structured, and do not disadvantage developing countries through asymmetric fuel access or infrastructure readiness. India advocates for meaningful CBDR-aligned transition support; revenue from the IMO economic instrument directed to green fuel infrastructure in developing countries; lifecycle accounting that recognises India's biofuel and green hydrogen potential; differentiated compliance timelines reflecting fleet age profiles; and infrastructure parity conditioning before penalty imposition.

INDIA'S MEPC POSTURE: CONSTRUCTIVE AMBITION AT MEPC

India's active engagement across MEPC, ISWG-GHG intersessional meetings, and IMO Council reflects a posture of constructive ambition, supporting the net-zero goal while ensuring its operationalisation reflects equity principles. India co-sponsors proposals on capacity-building funds, advocates for well-to-wake accounting that rewards its green hydrogen and biofuel potential, and has contributed substantively to the GFI text. This posture gives India credibility as a constructive multilateral actor, a credibility that reinforces its broader diplomatic positioning in climate negotiations.

SECTION – 4: RATIONALE: WHY DECARBONISE MARITIME?

The regulatory architecture and India's positioning having been established, the case for maritime decarbonisation rests on four strategic anchors that together constitute a rationale far more compelling than the sector's share of national emissions.

ANCHOR 1: ENERGY & STRATEGIC SECURITY

India's renewable cost advantage creates globally competitive green fuel economics. Maritime anchor demand makes green hydrogen and ammonia production commercially viable, converting chronic hydrocarbon import dependency into a clean fuel export surplus with strategic energy security dividends.

The Solar-to-Fuel Cost Chain

India's average solar irradiation of 4.5–6.5 kWh/m^2/day drives utility-scale solar LCOE below USD 0.03/kWh, among the world's lowest. Electrolyser power input constitutes 60–70% of green hydrogen production cost; at Indian renewable prices, green hydrogen approaches commercial parity with grey hydrogen on a 5–10 year horizon. Green ammonia inherits this cost advantage. Both fuels are the leading zero-emission candidates for deep-sea shipping. India's solar advantage is a strategic asset in the future marine fuel market, but only if a domestic demand anchor is created through a maritime decarbonisation programme.

India imports approximately 85% of crude oil requirements at over USD 130 billion annually. Domestic green fuel production for maritime, combined with green bunkering services at Indian ports on the East-West and India-Africa routes, converts import expenditure into domestic industrial value, creates energy price stability, and generates export revenues from the global fleet's transition demand. The Green Hydrogen Mission's 5 MMTPA target by 2030 creates the supply base; a Maritime Decarbonisation Policy creates the demand certainty that makes large-scale electrolyser investment commercially bankable.

ANCHOR 2: MARITIME AS LEAD SECTOR FOR INDIA'S NET-ZERO 2070

Of all sectors on India's net-zero pathway, maritime is the most transition-ready and its global regulatory framework is the most advanced, its technology pathways are the most clearly defined, and its 20–25 year capital replacement cycle is the most amenable to planned intervention. Early action catalyses the broader economy through green fuel scale effects, MRV infrastructure spillovers, and demonstration credibility.

Sectoral Readiness and Catalytic Spillovers

Dual-fuel engines for LNG, methanol, and ammonia are commercially available. Wind-assisted propulsion systems are in commercial service. Air lubrication systems reduce fuel consumption in deployed installations. The fuel transition pathway is the most clearly defined of any hard-to-abate sector, more so than steel, cement, or aviation. The investment decisions made for new builds ordered in 2025–2035 determine the fleet's carbon profile in 2045–2060: the critical juncture of India's net-zero trajectory. Acting now is categorically more cost-effective than retrofitting or retiring assets later.

Maritime's catalytic spillovers are concrete: scale effects from maritime hydrogen demand reduce production costs for industrial users of the same molecules (steel, fertilisers); MRV infrastructure developed for GFI compliance transfers directly to the CCTS; demonstration of viable decarbonisation strengthens India's climate credibility in diplomatic and financial market terms. Maritime sits at the tip of India's transitional sphere: the most mature point from which momentum builds across harder sectors.

ANCHOR 3: MAXIMUM AMPLIFICATION — END-TO-END CARBON ACCOUNTING

Shipping offers one of the most robust foundations for end-to-end carbon accounting among global sectors: every ship is a uniquely identified registered asset, every bunker delivery is commercially metered, and every voyage records origin, destination, cargo, and distance. While full well-to-wake carbon accounting is still evolving under the IMO's emerging fuel lifecycle frameworks, the institutional architecture for fuel consumption monitoring, voyage reporting, and emissions verification is already well established. This infrastructure for maritime carbon compliance constitutes a national asset that can be leveraged across India's CCTS and NDC reporting architecture.

The Template Value

The GFI framework's well-to-wake lifecycle accounting, covering upstream production through to combustion, is the most rigorous supply chain carbon methodology in any regulated global sector. The institutional infrastructure being built for compliance: fuel certification bodies, carbon registries, port-level data systems, verification protocols, constitutes a national capability directly deployable in the CCTS and NDC reporting architecture. India's investment in maritime carbon accounting is not a compliance cost; it is the construction of a cross-economy institutional asset that accelerates the maturity of the broader domestic carbon market.

ANCHOR 4: TRADE COMPETITIVENESS, REPUTATIONAL RISK, AND PUBLIC HEALTH

Beyond strategic energy security and the net-zero pathway, maritime decarbonisation is compelled by three converging pressures: the trade and market access consequences of carbon regulations now taking effect, the reputational imperatives of India's global positioning, and the domestic public health dividends of cleaner port-city air.

Trade Competitiveness and Market Access Risk

The EU ETS extension to shipping (January 2024) and FuelEU Maritime (2025) have converted the decarbonisation agenda from a future compliance consideration into a present commercial cost. Indian-flag vessels on EU-trading routes now carry carbon price exposure; Indian exporters using foreign-flag vessels face Scope 3 shipping emissions embedded in their EU ETS compliance costs. The EU CBAM, fully operational from 2026, creates further linkage: steel, aluminium, cement,

fertiliser, and hydrogen exports to the EU must account for production and logistics emissions, including shipping. While these regulations are still developing in scope and enforcement intensity, the direction of travel is unambiguous: access to the most lucrative global markets will increasingly be conditioned on demonstrable low-carbon supply chains that include low-carbon shipping. India's export competitiveness in the EU, its second-largest trading partner, depends in part on the ability to offer verifiably green shipping services. Acting now to build green bunkering infrastructure, MRV capability, and a credible domestic carbon framework positions India ahead of the compliance curve rather than in reactive catch-up when the standards bite harder.

Reputational Risk and Diplomatic Capital

India has built significant diplomatic capital as a responsible climate actor: the Panchamrit commitments, the International Solar Alliance, CDRI co-founding, and constructive engagement at MEPC have positioned India as a multilateral leader rather than a reluctant follower. This positioning is an asset: in climate negotiations, in attracting green finance, in securing preferential terms on capacity-building programmes, and in the diplomatic influence that shapes the rules at MEPC and UNFCCC. A failure to act domestically on maritime decarbonisation risks eroding that capital: it exposes India to the accusation of advocating CBDR-RC principles at IMO while not deploying its own policy tools in a sector where it has clear sovereign leverage. A Maritime Decarbonisation Policy reinforces India's narrative as a Vishwa Guru in climate governance: a country that leads by example, not merely by advocacy.

Domestic Air Quality and Public Health in Port Cities

Shipping emissions are not only a climate problem; they are a public health emergency in port cities. A vessel burning heavy fuel oil at berth emits SOx, NOx, black carbon, and fine particulate matter (PM2.5) at concentrations that materially degrade urban air quality. Studies of major port cities worldwide link vessel emissions to elevated rates of respiratory disease, cardiovascular illness, and premature mortality in surrounding populations. India's major port cities, namely Mumbai, Chennai, Kolkata, Visakhapatnam, Kochi, and JNPT-Navi Mumbai, are among the most densely populated urban centres on the coast; the populations living downwind of port operations bear a disproportionate health burden. MARPOL Annex VI's SOx ECA provisions have reduced sulphur emissions at sea, but berth-side emissions remain largely unaddressed in India's domestic framework. Shore power deployment, JIT arrival to reduce anchoring time, and stricter berth-side emission standards directly convert maritime decarbonisation investment into measurable public health benefits: reducing hospital admissions, improving quality of life in port communities, and alleviating pressure on India's urban health infrastructure. This co-benefit case makes maritime decarbonisation a health ministry and urban development issue, not only a shipping and climate policy matter.

First-Mover Pricing Power in the Indian Ocean Region

Singapore, Rotterdam, and Fujairah are positioning as green bunkering hubs, but no Indian Ocean port has yet secured an equivalent first-mover advantage. India's geography, astride the busiest East-West and India-Africa shipping corridors, with multiple deep-draught ports and renewable energy at competitive cost, creates a structurally advantaged position for green bunkering hub

development. The first regional hub to achieve scale in green ammonia or methanol bunkering will establish the supply chain relationships, certification infrastructure, and commercial contracts that subsequent entrants must compete against. Critically, as the first mover in the region, India will be positioned to set market prices for green bunker fuels before competition from other Indian Ocean ports develops, capturing a pricing premium and margin that later entrants will not be able to replicate. The window is open: Gulf ports are investing heavily and could close the advantage within this decade. A Maritime Decarbonisation Policy that provides regulatory certainty, infrastructure incentives, and demand anchors for green fuel producers, combined with India's Green Hydrogen Mission supply pipeline, is the instrument that converts geographic advantage into durable market leadership and pricing power.

CONCLUSION: THE CASE FOR A MARITIME DECARBONISATION POLICY

The preceding sections have traced the full arc: from Stockholm 1972 and UNCLOS through the Montreal Protocol's technology transition precedent, the UNFCCC climate architecture, the Basel-HKC ship recycling nexus, the London Protocol's CCS provisions, the UN Global Compact's corporate sustainability framework, the SDGs, and the ILO's just transition imperative; through India's legislative evolution from the Water and Air Acts to the EPA, NAPCC, Green Hydrogen Mission, and Panchamrit; to the complete maritime regulatory architecture comprising SOLAS, STCW, MARPOL's six Annexes including the IMO 2020 global sulphur cap, black carbon, the AFS Convention, HKC, the EEDI/EEXI/CII progression, the full alternative fuels spectrum, technical and operational efficiency measures, Harit Sagar, green corridors, the Clydebank Declaration, the Poseidon Principles, and the emerging IMO Net-Zero Framework.

The conclusion that emerges from this landscape is both inevitable and urgent.

Four Grounds for a Standalone Maritime Decarbonisation Policy

- The regulatory clock is ticking: At MEPC 83, IMO Member States reached agreement in principle on the mid-term GHG reduction measures, including the proposed Goal-based Fuel Intensity (GFI) standard and an associated economic measure under the emerging IMO Net-Zero Framework. Once formally adopted through MARPOL Annex VI amendments, these measures are expected to significantly influence Indian-flag vessels and vessels calling at Indian ports, potentially from around 2028. India therefore cannot afford to defer engagement; the strategic choice is between proactive policy design and reactive compliance under frameworks shaped by others.
- The opportunity window is time-bounded: Singapore, Rotterdam, and Fujairah are already positioning as green bunkering hubs. The EU ETS and FuelEU Maritime are creating commercial urgency for alternative fuel investment. Green corridors are being established. The window within which India can secure a competitive position as the green bunkering hub for the Indian Ocean region is open, but not indefinitely.
- No existing instrument is sufficient: MIV 2030 provides the infrastructure platform but not the decarbonisation regulatory framework. The EPA provides enabling authority but not sector-specific standards. The CCTS covers industrial emitters but not vessels. MARPOL implementation through DGS addresses flag state compliance but not the supply chain, finance, HKC implementation, or skills dimensions. A Maritime Decarbonisation Policy is the integrating instrument that fills these gaps and creates the coherent regulatory signal investors, shipowners, port developers, and fuel producers need.

- The strategic anchors are compelling and time-sensitive: Energy security, lead-sector catalysis, and the carbon accounting template, together with the HKC commercial opportunity at Alang, the Harit Sagar green port transformation, the green corridor potential, and India's 250,000-strong seafarer community's just transition, constitute a national strategic case for maritime decarbonisation that transcends the sector's emissions share.

THE POLICY IMPERATIVE

A Maritime Decarbonisation Policy is the instrument through which India: converts its renewable advantage into a green marine fuel export position; implements HKC compliantly and captures the global ship recycling premium; deploys Harit Sagar's green port framework with regulatory force; accelerates net-zero by leading with the most transition-ready sector; builds carbon accounting infrastructure that strengthens the CCTS; and discharges IMO obligations in ways that reflect CBDR-RC and serve India's development interests. It is not a compliance document; it is a national strategic instrument.

PART II: Executive Summary

India's maritime sector is entering a decisive decade of transformation. As the country expands port capacity, strengthens shipbuilding, modernises inland waterways and positions itself as a global logistics and manufacturing hub, the global maritime landscape is simultaneously being reshaped by net-zero commitments, lifecycle emissions standards, sustainable finance and rapidly evolving regulatory frameworks.

The National Maritime Decarbonisation Policy Framework (NMDPF) responds to this moment by establishing the integrated national architecture within which India's maritime decarbonisation transition will be planned, financed, governed and measured. It aligns industrial growth, infrastructure development, technology innovation, green finance and human capital under a common decarbonisation logic, providing the policy spine that connects India's existing maritime programmes into a coherent long-term strategy.

At the heart of the NMDPF are eight interconnected policy pillars that collectively define India's long-term transition pathway.

Pillar 1 - Green Shipbuilding and Retrofits establishes a comprehensive pathway for transforming India's vessel ecosystem through performance-linked incentives, national green certification standards, retrofit financing, innovation clusters, zero-emission coastal shipping, and digital MRV systems. By combining industrial policy with lifecycle emissions standards and future-fuel readiness, the pillar aims to position India as a competitive global hub for low-carbon shipbuilding while accelerating modernization of the domestic fleet.

Pillar 2 – Green Ports advances the transition of Indian ports into low-carbon, digitally enabled and climate-resilient logistics hubs through large-scale electrification, renewable energy adoption, shore power infrastructure, smart environmental monitoring, sustainable infrastructure standards and green corridor initiatives. The pillar extends beyond port boundaries by incorporating value chain emissions, coastal ecosystem protection and international partnerships, creating an integrated model for sustainable port development.

Pillar 3 – Green Ship Recycling reinforces India's leadership in responsible end-of-life vessel management by strengthening compliance with international conventions, digital governance, worker safety, environmental protection and circular economy principles. Through a national recycling portal, green steel pathways, innovation programmes and modern compliance frameworks, the pillar positions ship recycling as both a strategic industrial sector and a critical contributor to resource efficiency and maritime decarbonisation**.**

Pillar 4 – Green Finance establishes the enabling financial architecture required to scale maritime decarbonisation by introducing a dedicated maritime green finance taxonomy, ESG reporting frameworks, digital MRV systems and innovative financing instruments. By aligning domestic financial mechanisms with international sustainability standards while mobilising blended finance, green bonds, concessional lending and multilateral partnerships, the pillar seeks to unlock long-term investment across ships, ports, alternative fuels and circular economy infrastructure.

Pillar 5 – Green Skills and Capacity Building develops the human capital required for India's maritime transition through a National Green Maritime Skill Mission integrating competency

standards, specialised certification pathways, simulation-based training and international collaboration. By creating a future-ready workforce equipped for alternative fuels, digital systems, sustainable port operations and green technologies, the pillar ensures that maritime decarbonisation becomes an inclusive transition generating high-quality employment and global talent leadership.

Pillar 6 – Alternative Fuels Alternative Fuels accelerates the transition towards low- and zero-emission maritime energy systems through biofuel blending mandates, green hydrogen, ammonia, methanol and electrification pathways, supported by bunkering infrastructure, Green Fuel Development Zones, demand aggregation mechanisms, green shipping corridors and long-term investment in next-generation fuels. By strengthening domestic production capabilities and enabling future fuel ecosystems, the pillar seeks to establish India as a leading producer, supplier and consumer of sustainable maritime fuels.

Pillar 7 – Green Technology Green Technology positions innovation as the primary enabler of maritime decarbonisation by promoting advanced propulsion systems, AI-enabled operations, digital twins, onboard carbon capture, smart ports, renewable energy integration and frontier technologies. Through coordinated research, certification frameworks and technology parks, the pillar seeks to accelerate domestic innovation while strengthening India's long-term technological competitiveness.

Pillar 8 – Pollution Prevention/ Waste Management complements decarbonisation by strengthening waste management, oil spill preparedness, water quality monitoring, noise control and marine ecosystem protection. By embedding circular economy principles and international environmental standards across maritime operations, the pillar ensures that India's maritime growth remains environmentally responsible, resilient and globally aligned.

Supporting these pillars is a comprehensive governance framework that defines institutional responsibilities, implementation mechanisms, monitoring systems, financing linkages, and inter-ministerial coordination processes required for effective execution. The framework adopts a phased approach with measurable outcomes, enabling adaptive implementation while maintaining long-term strategic direction.

Recognising the global nature of maritime decarbonisation, the framework also places significant emphasis on international cooperation. It identifies opportunities for collaboration on green shipping corridors, sustainable finance, technology transfer, research partnerships, harmonised standards, capacity building, and multilateral engagement.

The National Maritime Decarbonisation Policy Framework adopts a whole-of-government and whole-of-sector approach to maritime transition. By integrating infrastructure development, industrial policy, climate action, innovation, finance and social inclusion within a single strategic architecture, it provides a clear roadmap for building a competitive, resilient and low-carbon maritime ecosystem while positioning India as a global leader in sustainable maritime development.

PART III: Policy Framework Pillars

Pillar 1: Green Shipbuilding and Retrofits

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

The global shipbuilding industry is undergoing a major transition driven by tightening decarbonisation regulations, fuel transition requirements, and growing demand for low and zero-emission vessels. Alternative fuel vessels operating on LNG, methanol, ammonia, hydrogen and hybrid-electric propulsion systems are moving from pilot deployment to commercial scale, while demand for retrofits is increasing for energy-efficiency systems, onboard carbon capture, shore power integration and digital fuel optimisation technologies. The IMO's Revised GHG Strategy, FuelEU Maritime regulations, EU ETS requirements and sustainability-linked financing frameworks are accelerating investment in green shipbuilding and retrofitting globally.

China, the Republic of Korea and Japan continue to dominate global shipbuilding output, together accounting for over 90% of global orderbook tonnage. China has integrated green shipbuilding within large-scale industrial manufacturing ecosystems and alternative fuel technology programmes. The Republic of Korea has positioned green shipbuilding as a strategic national industry through investments in ammonia-fuelled vessels, hydrogen propulsion systems and low-carbon ship technologies. Japan has focused on fuel-flexible vessel designs and integrated fuel-transition roadmaps linking shipping, ports and industrial decarbonisation. Singapore and Norway have emerged as leaders in green retrofits, maritime innovation, digital MRV systems and green corridor deployment through targeted public-private investment models.

India's shipbuilding sector remains a strategic pillar of the country's maritime industrial ambitions, with policy support increasingly focused on capacity expansion, technological modernisation, and green vessel development. In this context, the Shipbuilding Financial Assistance Scheme (SBFAS), extended until 31 March 2036 with a corpus of ₹24,736 crore and incorporating support through the Shipbreaking Credit Note Scheme, together with the proposed Shipbuilding Development Scheme (SbDS) with a budgetary outlay of ₹19,989 crore, provides the financial backbone for expanding domestic shipbuilding capacity to 4.5 million Gross Tonnage annually, supporting mega shipbuilding clusters, infrastructure expansion, ship design and technology development, and risk coverage mechanisms. Maritime India Vision 2030 and Amrit Kaal Vision 2047 further identify shipbuilding and maritime manufacturing as strategic sectors for long-term growth and competitiveness.

India has also initiated early-stage green maritime transition measures. The Green Tug Transition Programme (GTTP) has been launched to support cleaner propulsion systems for harbour tugs, while the Inland Waterways Authority of India (IWAI) has initiated deployment of electric vessels and hydrogen-fuel feasibility projects for inland waterways. Shipyards and maritime technology firms are increasingly exploring hybrid-electric systems, methanol-ready vessels, shore power integration and digital fuel optimisation technologies. The Directorate General of Maritime Administration (DGMA), Maritime Development Fund (MDF) and Sagarmala Finance Corporation Limited (SMFCL) together provide the institutional foundation for scaling green shipbuilding and retrofit financing frameworks.

SECTION 2: POLICY MEASURES

1.1 Definition

A Green Ship means a ship that integrates advanced technologies, low- or zero-emission energy systems, and operational best practices to reduce emissions, fuel consumption, and environmental pollution, while complying with applicable national and international regulatory standards and contributing towards India's maritime decarbonisation goals. Green Ships shall be classified as Energy Efficient, Low Emission, or Zero Emission based on verified lifecycle emissions performance and technology integration, and shall include both newbuilds and retrofitted vessels meeting prescribed certification criteria.

1.2 Fleet Modernisation and Green Shipbuilding

1.2.1 The Shipbuilding Financial Assistance Scheme (SBFAS) shall be supplemented with a Green Ship Incentive Layer linked to the National Green Ship Certification Framework, Green Compliance Index (GCI), verified lifecycle emissions reduction, and prescribed domestic value addition requirements.

1.2.2 In the near to medium term, vessels integrating transition technologies including dual-fuel flexibility, methanol-ready or LNG-ready architecture, wind-assisted propulsion, waste heat recovery systems, hybrid-electric propulsion, air lubrication systems, digital fuel optimisation systems, and other notified low-emission technologies shall be eligible for enhanced assistance under Shipbuilding Financial Assistance Scheme (SBFAS) based on verified lifecycle emissions reduction and Green Ship Certification tier classification.

1.2.3 In the long term, priority support shall be provided for vessels achieving certified net-zero lifecycle emissions through full electrification, green hydrogen, ammonia propulsion, fuel-cell systems, or equivalent zero-emission propulsion systems, with support of up to 50% of incremental green technology cost over conventional vessel baselines.

1.2.4 Green shipbuilding incentives shall be disbursed only upon compliance with notified Green Ship Design Standards, Green Ship Certification tier requirements, MRV reporting obligations, and verification of domestic value addition.

1.2.5 The Directorate General of Maritime Administration (DGMA), in coordination with the National Green Maritime Coordination Cell (NGMCC), the central coordination body for implementation of the National Maritime Decarbonisation Policy, shall notify Green Ship Design Standards covering fuel readiness, lifecycle emissions accounting, energy efficiency, onboard digital monitoring, future-fuel-ready design provisions, and retrofit compatibility.

1.3 Green Ship Certification and Procurement

1.3.1 A National Green Ship Certification Framework shall be notified under the Merchant Shipping Act, 2025, with tiered certification standards covering high-efficiency vessels, future-fuel-ready vessels, and zero-emission-ready vessels aligned to IMO GHG Fuel Intensity (GFI) thresholds and alternative fuel compatibility requirements.

1.3.2 Mandatory basic compliance under the Green Ship Certification Framework shall apply to all Indian-flagged ships in alignment with applicable IMO decarbonisation and emissions compliance requirements, while advanced compliance standards shall be progressively mandated for coastal and inland waterway newbuilds in accordance with evolving global green shipping standards.

1.3.3 Green Ship Certification shall be progressively integrated into the vessel registration framework from 2030 onwards and linked to eligibility for Shipbuilding Financial Assistance Scheme (SBFAS) support, Green Compliance Index (GCI)-based incentives, and access to concessional finance.

1.3.4 A Government ship procurement, including vessels for the Indian Coast Guard, port authorities, public sector shipping companies, inland waterways, and research institutions, shall progressively prioritise procurement of green-certified vessels.

1.4 Green Retrofitting and Retrofit Finance

1.4.1 A dedicated subsidy, linked to verified emission reduction outcomes, shall be introduced to support retrofitting of existing vessels with alternative fuel systems, hybrid propulsion, onboard carbon capture, energy-saving devices, hull efficiency technologies, waste heat recovery, digital fuel optimisation, and other notified low-emission technologies, subject to techno-economic feasibility based on vessel age, residual asset life, structural suitability, retrofit complexity, and expected emissions reduction.

1.4.2 Financial risk-sharing mechanisms for green retrofitting shall be operationalised through government-backed loan guarantees, concessional financing, insurance premium subsidies, blended finance mechanisms, public-private partnership frameworks, and green bonds linked to verified emissions performance.

1.4.4 Sagarmala Finance Corporation Limited (SMFCL) and the Maritime Development Fund (MDF) shall establish dedicated green retrofit financing windows aligned with National Green Maritime Coordination Cell (NGMCC)-certified eligibility criteria and MRV verification frameworks.

1.5 Green Innovation and Industrial Ecosystems

1.5. A Green Innovation Fund financed through the Maritime Development Fund (MDF) shall support pilot deployment, localisation, and commercialisation of green propulsion technologies, hybrid-electric systems, methanol-ready vessel systems, onboard carbon capture technologies, battery-electric propulsion systems, digital emissions monitoring systems, and other maritime decarbonisation technologies.

1.5.2 Green Shipbuilding Clusters shall be designated in Andhra Pradesh, Odisha, Gujarat, Maharashtra, and Tamil Nadu as integrated low-carbon maritime manufacturing and innovation hubs supporting green vessel construction, retrofit engineering, marine battery integration, alternative fuel systems, propulsion technologies, and digital maritime systems.

1.6 Zero Emission Coastal and Inland Shipping

1.6.1 Selected coastal and inland waterway routes shall be designated as Zero Emission Zones (ZEZs) based on the corridor selection framework identified under the India Green Corridors Pre-Feasibility Study and Consortium Incubation Workshop (CIW), considering fuel availability, port readiness, infrastructure, vessel suitability, and techno-economic feasibility. Initial implementation shall prioritise the first wave of shortlisted inland and coastal corridors, with progressive transition towards zero- and low-emission vessel operations, particularly for inland passenger ferries, harbour craft, coastal cargo vessels, and other short-sea shipping segments.

1.6.2 The Green Tug Transition Programme (GTTP) shall be expanded to accelerate the transition of conventional tug operations towards zero- and low-emission propulsion systems through targeted financial support, green procurement mandates, supporting charging and bunkering infrastructure at ports, and phased adoption of cleaner tug technologies including electric, hybrid-electric, hydrogen, methanol, and other notified alternative fuel systems.

1.7 Regulation, MRV and Shipyard Decarbonisation

1.7.1 A national Monitoring, Reporting and Verification (MRV) framework shall be operationalised through NLP-Marine for monitoring lifecycle emissions, GHG Fuel Intensity (GFI), fuel transition progress, energy efficiency performance, retrofit outcomes, and environmental performance of notified maritime assets.

1.7.2 Green Compliance Index (GCI)-linked reporting requirements shall be mandatory for notified categories of vessels, shipyards, ports, and retrofit projects.

1.7.3 Green Shipyard Decarbonisation Standards, including a yard-specific Green Compliance Assessment (GCA) framework, shall be notified to monitor and progressively reduce emissions from shipbuilding and ship repair operations through renewable energy adoption, energy-efficient manufacturing, low-carbon fabrication practices, electrification of yard equipment, resource efficiency measures, and lifecycle carbon accounting.

1.8 International Collaboration

1.8.1 Strategic international partnerships shall be strengthened with leading green maritime nations, the IMO, classification societies, maritime technology providers, and multilateral institutions to facilitate technology transfer, technical cooperation, regulatory harmonisation, capacity building, alternative fuel safety standards, digital MRV systems, and access to maritime decarbonisation finance in alignment with global decarbonisation pathways[1].

1.8.2 International collaborations shall support pilot and demonstration projects, joint R&D programmes, knowledge exchange, and domestic capability development in green maritime technologies, including alternative fuels, hybrid and battery-electric propulsion systems, green

[1] India and Singapore are collaborating on a Green and Digital Shipping Corridor to promote low-emission shipping and maritime digitalisation. Under the India–Denmark Green Strategic Partnership, the India Green Shipping Corridors Pre-Feasibility Study was undertaken to identify viable green corridor opportunities for India. Through the IMO GreenVoyage2050 Programme, technical cooperation is being strengthened to support maritime decarbonisation through capacity building, pilot projects, and adoption of low- and zero-emission shipping solutions.

shipbuilding, and other low- and zero-emission maritime solutions, while supporting implementation of IMO decarbonisation measures.

1.9 Governance

1.9.1 This pillar shall be implemented under Working Group 1, led by the Directorate General of Maritime Administration. DGMA shall be responsible for notifying the Green Ship Certification Framework and Green Ship Design Standards under the Merchant Shipping Act 2025, administering GCI-linked compliance and reporting requirements for vessels and shipyards, and overseeing the restructured Shipbuilding Financial Assistance Scheme (SBFAS) performance-linked framework. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

1.9.2 The Ministry of Heavy Industries and DPIIT shall be responsible for designating Green Shipbuilding Clusters and coordinating domestic manufacturing capability development in green maritime technologies. Sagarmala Finance Corporation Limited and the Maritime Development Fund shall be responsible for operationalising dedicated green retrofit and newbuild financing windows aligned with NGMCC-certified eligibility criteria.

1.9.3 The Working Group shall coordinate with the Indian National Shipowners Association, Indian Register of Shipping, and Cochin Shipyard Limited on implementation. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3: TARGETS

Short-Term (0–6 Months)

1. Initiate the process for the development of Green Ship Design Standards and Green Ship Certification Framework, GCI-linked incentives, and green retrofit financing mechanisms through Shipbuilding Financial Assistance Scheme (SBFAS), Sagarmala Finance Corporation Limited (SMFCL), and the Maritime Development Fund (MDF).
2. Initiate development of Zero Emission Zones (ZEZs), including route-level techno-economic feasibility assessments, fuel availability planning, supporting bunkering and charging infrastructure frameworks, and national MRV reporting architecture through NLP-Marine.
3. Identify Green Shipbuilding Clusters and initiate international partnerships for green propulsion technologies, lifecycle assessment methodologies, digital MRV systems, and maritime decarbonisation financing.

Medium-Term (6 Months–2 Years)

4. Notify Green ship design standards, Operationalise the Green Ship Certification Framework, national MRV reporting systems, green retrofit financing windows, and GCI-linked reporting requirements for notified maritime assets.
5. Promote alternative fuel penetration in coastal and inland waterway fleets through phased implementation of Zero Emission Zones (ZEZs), Green Tug Transition Programme (GTTP), technically feasible retrofit initiatives, and supporting alternative fuel infrastructure.
6. Initiate Green Shipbuilding Clusters in identified coastal maritime states and plan/execute pilot projects for green propulsion systems, onboard carbon capture technologies, and low-emission vessel operations.
7. Promote renewable electricity utilisation in notified shipyards and operationalise green shipyard decarbonisation standards.
8. Prioritise green-certified vessels for at least 30% of government ship procurement, wherever technically and operationally feasible.

Long-Term (2–5 Years)

9. Mandate advanced Green Ship Certification compliance for all coastal and inland waterway newbuilds and operationalise role-based Green Compliance Index (GCI) reporting across notified maritime sectors.
10. Strive to achieve 30% clean fuel adoption across the Indian coastal and inland fleet through scale-up of green vessel deployment, technically viable retrofit programmes, fleet modernisation, and alternative fuel infrastructure.
11. Strive to achieve 50% renewable electricity utilisation in notified shipyards and operationalise integrated low-carbon shipbuilding and green maritime manufacturing ecosystems.
12. Position India among the leading global green shipbuilding and green retrofit destinations through integrated green shipbuilding, green fuel infrastructure, digital MRV systems, and maritime decarbonisation financing frameworks.

Pillar 2: Green Ports

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

India's port sector has undergone significant transformation over the past decade, driven by increasing cargo volumes, terminal mechanisation, infrastructure expansion, and growing emphasis on environmental sustainability. With 14 Major Ports and over 200 Non-Major Ports administered by State Maritime Boards, ports play a critical role in supporting India's trade, energy security, industrial development, and logistics connectivity. As port operations continue to expand, environmental considerations associated with energy consumption, equipment operations, vessel activities, dredging, waste generation, and coastal ecosystem impacts have gained increasing prominence.

The sustainability agenda within Indian ports has been guided by a series of national policy and institutional initiatives. Maritime India Vision 2030 introduced sustainability as a key pillar of port modernisation, while the Maritime Amrit Kaal Vision 2047 further reinforced the role of ports in supporting India's long-term decarbonisation and green growth ambitions. At the operational level, the Harit Sagar Guidelines have provided a structured framework for environmental management, resource efficiency, pollution prevention, renewable energy adoption, and ecosystem protection across ports. More recently, the Green Port Performance Index (GPPI) has established a standardised mechanism for assessing and benchmarking environmental performance across Indian ports.

Renewable energy deployment has emerged as one of the most visible sustainability achievements across Indian ports. Several major ports have undertaken significant investments in solar and wind energy infrastructure to reduce dependence on conventional grid electricity and lower operational emissions. Ports such as New Mangalore Port Authority, V.O. Chidambaranar Port Authority, Visakhapatnam Port Authority, Jawaharlal Nehru Port Authority, Paradip Port Authority, Cochin Port Authority, Mumbai Port Authority, and Deendayal Port Authority have implemented renewable energy projects ranging from rooftop solar systems to utility-scale solar and wind installations. In several cases, renewable energy contributes a substantial proportion of internal electricity consumption, demonstrating growing commitment towards clean energy adoption.

Alongside renewable energy deployment, ports have increasingly focused on **electrification** of equipment and infrastructure. Electrification initiatives include the replacement of diesel-powered cargo handling equipment with electric alternatives, deployment of electric rubber-tyred gantry cranes, electric yard equipment, electrified conveyor systems, and adoption of electric vehicles within port premises. Several ports have also initiated early-stage deployment of Shore Power (Onshore Power Supply) infrastructure to enable vessels to connect to grid electricity while at berth, reducing emissions associated with onboard auxiliary engines. The Green Tug Transition Programme (GTTP) has further accelerated efforts to transition harbour craft and tug operations towards cleaner propulsion technologies.

Energy efficiency improvements have become an integral component of port sustainability programmes. Indian ports have undertaken initiatives such as LED lighting retrofits, automated energy management systems, smart metering, energy audits, terminal automation, operational optimisation, and building efficiency upgrades. These measures have contributed to reductions in electricity consumption, operational costs, and emissions intensity while improving overall resource efficiency.

Environmental management practices have also expanded significantly across major and non-major ports. Many ports operate wastewater treatment and recycling facilities, rainwater harvesting systems, dust suppression mechanisms, environmental monitoring programmes, and solid waste management systems. Green belt development, mangrove conservation, afforestation initiatives, biodiversity enhancement programmes, and beneficial reuse of dredged material are increasingly being integrated into port environmental management strategies. Regular monitoring of air quality, harbour water quality, noise levels, and environmental compliance indicators has become common practice across major ports.

Carbon accounting and sustainability reporting practices are gradually emerging within the sector. Several ports have initiated monitoring of fuel consumption, electricity usage, and greenhouse gas emissions as part of environmental management and sustainability reporting activities. While individual ports have made progress in emissions monitoring, a nationally harmonised framework for carbon accounting, emissions reporting, baseline development, and performance benchmarking has yet to be established.

International Benchmarking

Globally, leading ports have increasingly adopted comprehensive decarbonisation strategies that extend beyond environmental compliance and focus on measurable emissions reduction, energy transition, digitalisation, and climate resilience. Ports such as Rotterdam, Antwerp-Bruges, Hamburg, Singapore, Los Angeles, and Long Beach have established integrated sustainability frameworks supported by carbon accounting systems, renewable energy infrastructure, alternative fuel ecosystems, and advanced monitoring platforms.

A common feature across leading international ports is the adoption of emissions accounting frameworks, enabling systematic measurement and management of direct, indirect, and value-chain emissions. Shore Power Supply systems have been progressively deployed at select leading ports like Port of Rotterdam and Los Angeles to reduce vessel emissions at berth, while electrification of cargo handling equipment, port vehicles, and terminal operations has become increasingly widespread. Several ports have also invested in large-scale renewable energy projects, battery energy storage systems, and smart energy management platforms to support low-carbon operations.

International ports are increasingly adopting Green Corridor initiatives, Just-in-Time arrival systems, and digital platforms to optimise vessel-port interactions and reduce operational emissions. Sustainability reporting, digital Monitoring, Reporting and Verification (MRV) systems, and climate resilience planning have become integral components of port management frameworks.

Indian ports have made notable progress in renewable energy deployment, equipment electrification, environmental monitoring, and sustainability initiatives. Building on these efforts, further advancement in emissions management, reporting system, digitisation and clean energy infrastructure can support the continued transition towards sustainable and low carbon port operations.

SECTION 2: POLICY MEASURES

2.1 Definition

A Green Port is a port facility that systematically reduces its greenhouse gas emissions, air pollutant discharges, and environmental impacts across all port-owned and port-controlled operations through the integration of renewable energy systems, electrification of cargo handling equipment and harbour craft, shore power infrastructure, sustainable waste and water management, and real-time environmental monitoring. A Green Port further supports the broader maritime energy transition by providing infrastructure for the production, storage, bunkering, and supply of

alternative maritime fuels to calling vessels, and by enabling vessels to reduce their own emissions during port stays.

2.2 Port Operations and Equipment – Scope 1

2.2.1 The electrification of cargo handling equipment, harbour craft, and port vehicles shall be mandated through a phased implementation programme, with compliance timelines scaled to port size and operational category. Renewable energy integration, smart energy management, waste management, and air quality monitoring shall be required across all major and non-major ports. Environmental performance shall be assessed and publicly reported annually against the Green Port Performance Index (GPPI)

2.2.2 Ports, shipyards, and maritime industrial facilities shall progressively integrate solar, wind, battery storage, and smart grid systems to reduce dependence on fossil fuels. In alignment with the Harit Sagar Green Port Guidelines and Maritime India Vision 2030, all major ports shall endeavour to achieve a renewable energy share exceeding 60% by 2030 and 90% by 2047. All new port construction and major retrofits shall comply with LEED, IGBC, or GRIHA green building standards, with green procurement standards applied to all major equipment and infrastructure tenders.

2.2.3 Hybrid or low-emission technologies for dredgers, harbour craft, and port vehicles shall be mandated through a phased implementation programme. Mandatory real-time IoT-based environmental monitoring shall be instituted at all major ports, covering emissions from port machinery, cargo handling equipment, and harbour craft. Environmental performance data shall feed into the national MRV framework and form the basis for mandatory periodic auditing and public sustainability reporting.

2.3 Port Energy and Infrastructure – Scope 2

2.3.1 The development of Shore Power Supply infrastructure shall be progressively undertaken across major and non-major ports to reduce emissions from vessels at berth. For smaller harbour craft, ferries and patrol vessels, shore power connections shall be prioritised. For larger commercial vessels including container ships, bulk carriers and tankers, Shore Power Supply infrastructure shall be developed in a phased manner subject to standardised technical requirements, grid capacity assessments, renewable electricity integration, and incentive mechanisms for adoption.

2.3.2 Ports shall progressively increase the share of renewable energy in port operations through deployment of solar, wind, and other suitable clean energy technologies, supported by renewable electricity procurement, battery energy storage systems, and smart energy management solutions. Progressive expansion of renewable energy shall be pursued by 2030 with ports achieving 90% renewable energy consumption by 2047 in alignment with the Harit Sagar Green Port Guidelines.

2.3.3 Energy efficiency measures shall be integrated across port terminals, buildings, lighting systems, and operational infrastructure through adoption of energy-efficient technologies, smart grid solutions, and continuous energy performance improvement programmes.

2.4 Vessels, Value Chain and Coastal Environment – Scope 3

2.4.1 A voluntary framework for tracking and disclosing Scope 3 emissions associated with vessel calls, hinterland transportation, and port-linked logistics operations shall be developed to support comprehensive emissions visibility across the maritime value chain. Major ports shall be encouraged to progressively integrate Scope 3 emissions data into their annual sustainability disclosures, in alignment with evolving international reporting standards and the National Green Port Index methodology.

2.4.2 Green Corridor initiatives, Just-in-Time arrival systems, digital port call optimisation measures, and other collaborative vessel-port efficiency programmes shall be promoted to reduce emissions associated with vessel movements, waiting times, and port interface activities.

2.4.3 Ports shall establish and maintain adequate waste reception facilities, pollution prevention infrastructure, and environmental management systems in accordance with applicable national regulations and international conventions to minimise adverse impacts on the marine environment.

2.4.4 Biodiversity conservation, coastal ecosystem protection, mangrove restoration, and nature-based solutions shall be integrated into port planning, development, and operational activities to strengthen environmental sustainability and ecological resilience.

2.4.5 Climate risk assessment, adaptation planning, and resilience measures shall be incorporated into port development and operational frameworks to address risks associated with sea level rise, extreme weather events, coastal erosion, flooding, and other climate-related impacts.

2.5 Technology and Digitalisation

2.5.1 Digital platforms and smart port technologies shall be promoted to support emissions monitoring, environmental compliance, operational efficiency, and sustainability reporting across major and non-major ports.

2.5.2 Carbon accounting tools, digital dashboards, IoT-enabled monitoring systems, and other data-driven solutions shall be deployed to support performance benchmarking, regulatory compliance, and informed decision-making.

2.5.3 The Maritime Single Window (MSW) shall be progressively strengthened to achieve full integration across all major and non-major ports in alignment with IMO FAL convention requirements. The Integrated Berth and Terminal management system (IBTMS) shall be implemented across major ports to support real time berth scheduling, vessel traffic management and port call optimization.

2.6 Research and Innovation

2.6.1 Research, development, and pilot projects for emerging port decarbonisation technologies shall be promoted through collaboration between ports, research institutions, industry, and technology providers, with financial support for technology validation and scale-up across energy efficiency, renewable energy integration, low-emission equipment, digital systems, and climate-resilient port infrastructure.

2.7 International Cooperation and Maritime Diplomacy

2.7.1 India shall actively engage with the IMO, including MEPC processes, and international maritime forums to shape and align with evolving global port sustainability standards. Strategic partnerships with international port authorities, technology providers, and multilateral organisations shall be promoted to facilitate technology transfer, joint research, and adoption of global best practices in green port development and maritime decarbonisation.

2.7.2 India shall further pursue sister port partnerships between major Indian ports and leading international green ports to facilitate knowledge exchange, technology transfer and benchmarking of sustainability practices. India's participation in key international maritime forums and events, including dedicated India Pavilions, shall be strengthened to showcase green port initiatives and attract global partnerships. Engagement with International Labour Organization (ILO) shall be maintained to ensure that the green port transitions is inclusive and supports the protection of port workers' rights and livelihoods.

2.8 Governance

2.8.1 This pillar shall be implemented under Working Group 3, led by the Indian Ports Association in coordination with the Major Port Authorities. The Indian Ports Association shall be responsible for coordinating the adoption of the Green Port Performance Index across all major ports, overseeing compliance with Harit Sagar Green Port Guidelines, and facilitating the Annual Port Sustainability Forum. Major Port Authorities shall be responsible for operationalising electrification timelines, renewable energy targets, OPS infrastructure, and the National Green Port Digital Platform within their respective jurisdictions. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

2.8.2 MoPSW through State Maritime Boards shall be responsible for coordinating GPPI reporting and Green Port Certification requirements for non-major ports above prescribed throughput thresholds. The Ministry of Power and State Distribution Companies shall be responsible for grid capacity augmentation and tariff harmonisation required for shore power implementation. National Centre of Excellence in Green Port and Shipping (NCoEGPS) shall provide technical secretariat support and maintain the national repository of port sustainability performance data.

2.8.3 The Working Group shall comprise the Indian Ports Association, Major Port Authorities, State Maritime Boards, National Centre of Excellence in Green Port and Shipping (NCoEGPS), Inland Waterways Authority of India, Ministry of Power, State Distribution Company (DISCOM), and port operators. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3 TARGETS

Short-Term (0–6 Months)

1. Establish the National Port Sustainability Council under MoPSW with a dedicated Green Ports Working Group; notify phased electrification timelines for cargo handling equipment,

port vehicles, and harbour craft across all major ports, with compliance schedules scaled to port size and operational category.

2. Strengthen the Green Port Performance Index (GPPI) framework by integrating ISO 14001 and ISO 50001 compliance credited inputs, introduce tiered Green Port Certification levels linked to composite GPPI score thresholds, and mandate third-party verification of port-submitted data from the first assessment cycle.
3. Issue renewable energy adoption targets for all major ports and notify green procurement standards for port equipment and infrastructure tenders; formally extend the Green Tug Transition Programme to dredgers, pilot vessels, mooring boats, and other port-controlled harbour craft with phased transition schedules and associated financial incentives.
4. Commence procurement and development of the National Green Port Digital Platform as the single interface for Scope 1 and Scope 2 emissions reporting, GPPI score computation, third-party audit workflows, and port sustainability reporting across major and non-major ports.

Medium-Term (6 Months–2 Years)

5. Strive to achieve a minimum 50% renewable energy share in port operations at all major ports; operationalise battery energy storage systems and smart energy management platforms; and expand renewable energy adoption to non-major ports.
6. Operationalise the National Green Port Digital Platform with mandatory emissions reporting, third-party audit workflows, and integration with the Maritime Single Window; publish port-wise GPPI scores annually.
7. Notify phased Shore Power Supply installation timelines for all 14 major ports and establish the shore power financing framework in coordination with the Ministry of Power and state DISCOMs and promote installation of Shore Power Supply at Non major ports
8. Operationalise Just-in-Time arrival systems at all major ports and notify the Green Maritime Corridor framework with designated priority domestic routes.

Long-Term (2–5 Years)

9. Maximize renewable-powered operations at all major ports through accelerated renewable energy deployment; complete electrification of cargo handling equipment; and achieve universal Shore Power Supply coverage across all major port terminal categories.
10. Extend mandatory GPPI reporting and Green Port Certification to all non-major ports above prescribed throughput thresholds under the Indian Ports Act 2025; mandate Green Port Certification as a condition for eligibility under central green finance and incentive schemes.

Pillar 3: Green Ship Recycling

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

The global ship recycling market, valued at $9.1 billion in 2025, is projected to reach $13 billion by 2030 at a CAGR of 7.4%, driven by an ageing global fleet, tightening emissions regulations accelerating end-of-life decisions, and growing demand for recycled steel.[2] Bulk carriers, container

[2] BCC Research, *Global Ship Recycling Market*, August 2025

ships, and oil tankers constitute the dominant vessel categories entering the recycling pipeline. Asia accounts for the major share of global recycling activity, with the South/West Asian cluster India, Bangladesh, and Pakistan processing the largest volumes by DWT (Dead Weight Tonnage).[3]

India ranks among the top two ship recycling nations globally by deadweight tonnage processed, maintaining a stable throughput of 3–4 million DWT annually through market cycles between 2019 and 2026. Bangladesh is the aggregate volume leader but has demonstrated pronounced cyclicality across market cycles, reflecting vulnerability to steel price fluctuations and demand shocks. Turkey holds large number of HKC (Honk Kong Convention) compliant facilities globally but processes comparatively modest volumes. It competes primarily on proximity to European markets rather than scale. India's recycling performance has been consistent across this period. This reflects structural yard capacity and regulatory stability rather than opportunistic market entry. It is a foundation on which a green premium positioning can be credibly built. [4]

Ship recycling in India is concentrated almost entirely at Alang, Bhavnagar (Gujarat), which has 150 plots, 128 operational, and 115 HKC-compliant yards. Two minor facilities exist in Kerala and West Bengal but remain outside the compliance framework.The list of global HKC-compliant ship recycling facilities is dominated by Turkey and Bangladesh The 115 yards in India have received HKC SOC (Statement of Compliance) from recognised organisations and the authorization process is underway.[4]

India has built a domestic regulatory framework aligned with international standards. The Ship Breaking Code (2013) was the first step. The Recycling of Ships Act (2019) and Ship Recycling Rules (2021) followed. The Ship Recycling Regulation (2026) is the most recent addition, timed to align with the Hong Kong Convention entering into force on 26 June 2025[3] .[3] Financial instruments are also in place. The Ferrous Scrap Development Fund (FSDF) has deployed ₹104.41 crore toward worker welfare and environmental upgradation at Alang. The Ship Recycling Credit Note, under the Shipbuilding Financial Assistance Scheme (SBFA), carries an allocation of ₹4,001 crore. It incentivises compliant recycling by offering ship owners a credit note equivalent to 40% of scrap value, redeemable against new shipbuilding in Indian yards.[5]

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SECTION 2: POLICY MEASURES

3.1 Definition

Green ship recycling in India refers to the process of dismantling end-of-life ships in compliance with the Recycling of Ships Act, 2019, the Hong Kong International Convention, and other international/domestic standards. It prioritizes worker safety, environmental protection, and resource recovery, supported by a framework of certification, hazardous material control, and regulatory oversight.

[3] Clarksons Research, Demolition Location Data, 2019–2026
[4] IMO, List of Authorized Ship Recycling Facilities under the Hong Kong Convention, 2025
[5] Ministry of Ports, Shipping & Waterways — FSDF & SBFA Scheme Documentation, 2026

3.2 Compliance Framework and International Standards

3.2.1 All ship recycling facilities operating in India shall achieve and maintain compliance with the provisions of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (HKC) and the Recycling of Ships Act, 2019 and the Recycling of Ships Regulations, 2026.

3.2.2 Ship recycling facilities shall be categorised under a national compliance framework comprising:
(a) HKC (Hong Kong Convention) -Compliant Facilities;
(b) EUSRR (European Union Ship Recycling Regulation) -Compliant Facilities; and
(c) Transition Facilities undertaking compliance upgradation.

3.2.3 The Directorate General of Maritime Administration (DGMA), in coordination with State Maritime Boards as competent authorities, shall develop yard-specific compliance roadmaps for all transition facilities by 2028.

3.2.4 Technical handholding, capacity-building support and compliance advisory services shall be facilitated through recognised industry associations, training institutions and accredited technical partners to accelerate compliance adoption.

3.2.5 Financial incentives under notified schemes shall be linked to demonstrated progress towards HKC and EUSRR compliance.

3.3 National Ship Recycling Digital Platform

3.3.1 A National Ship Recycling Portal shall be established under the Directorate General of Maritime Administration (DGMA) as the single digital window for implementation of the Hong Kong Convention, the Recycling of Ships Act, 2019 and the Recycling of Ships Regulations, 2026.

3.3.2 The Portal shall enable end-to-end digital governance of ship recycling activities through real-time monitoring, transparent compliance management, auditability and stakeholder integration, and shall connect the DGMA, State Maritime Boards as competent authorities, Recognised Organisations, ship recycling facilities and authorised service providers.

3.3.3 The Portal shall provide digital workflows for ship recycling facility registration and licensing, Ready for Recycling Certificate management, Ship Recycling Plan submission and approval, Inventory of Hazardous Materials (IHM) submission and verification, inspection and audit management, compliance tracking, and incident and non-conformity reporting.

3.3.4 The Portal shall maintain a national registry of ship recycling facilities and associated records, including Hong Kong Convention (HKC) and EU Ship Recycling Regulation (EUSRR) compliance status, ISO certifications, worker training and competency records, safety performance indicators, environmental monitoring data and other regulatory information as may be notified.

3.3.5 The Portal shall serve as the national repository for Inventory of Hazardous Materials (IHM) records and shall enable electronic capture, preparation, submission, verification, storage and retrieval of hazardous material inventories through a class-neutral and interoperable digital architecture.

3.3.6 The Portal shall serve as the national repository for ship recycling data and progressively incorporate modules for greenhouse gas accounting, green steel traceability, circular economy reporting, Ferrous Scrap Development Fund (FSDF) project monitoring, IMO-GISIS integration and dashboard-based monitoring of sectoral sustainability and compliance performance.

3.4 Foundational Standards for Sustainable Ship Recycling

3.4.1 Ship recycling facilities shall progressively adopt a foundational standards framework to strengthen operational quality, environmental management, worker safety and responsible recycling practices, thereby supporting readiness for compliance with the Hong Kong Convention (HKC) and the EU Ship Recycling Regulation (EUSRR). The foundational standards framework shall comprise:

(a) ISO 30000 – Ship Recycling Management Systems;

(b) ISO 9001 – Quality Management Systems;

(c) ISO 14001 – Environmental Management Systems; and

(d) ISO 45001 – Occupational Health and Safety Management Systems.

(e) ISO 50001 – Energy Management Systems

3.4.2 Ship recycling facilities shall establish systems for monitoring and reporting workplace incidents, near misses, emergency preparedness, worker training, medical support facilities, sanitation infrastructure and other worker welfare measures in accordance with applicable standards and regulatory requirements.

3.4.3 Ship recycling facilities shall implement environmental management and compliance systems, including monitoring and control of runoff, wastewater discharge, emissions, hazardous waste handling and other environmental aspects, in accordance with applicable regulatory requirements and recognised industry standards.

3.4.4 Ship recycling facilities shall progressively adopt resource-efficient and environmentally responsible operational practices, including renewable energy utilisation, energy consumption monitoring, alternative cutting technologies and other measures that reduce occupational hazards, emissions and environmental impacts.

3.5 Capacity Building, Research and Innovation

3.5.1 A National Ship Recycling Institution shall be established in Alang as a centre of excellence for training, research, innovation and technical support to strengthen India's ship recycling ecosystem and facilitate the adoption of global best practices.

3.5.2 The Institution shall develop and deliver accredited capacity-building programmes covering worker safety, hazardous material management, environmental compliance, sustainable recycling practices, implementation of the Hong Kong Convention (HKC), and adoption of the foundational standards prescribed under this Policy.

3.5.3 Research, development and pilot deployment of advanced ship recycling technologies shall be promoted to improve worker safety, operational efficiency, material recovery, resource utilisation and environmental performance across ship recycling facilities.

5.3.4 Innovation programmes shall support the development and adoption of emerging technologies including alternative cutting methods, automation, digital inspection and monitoring systems, material traceability solutions, renewable energy integration, energy-efficient equipment and other technologies that enhance the sustainability and competitiveness of the sector.

3.5.5 The National Ship Recycling Institution shall facilitate collaboration between industry, academia, technology providers, classification societies, financial institutions and government agencies to accelerate innovation, knowledge transfer and dissemination of best practices across the ship recycling value chain.

3.3.6 A framework for mapping and integrating the informal secondary materials market associated with ship recycling shall be developed. Given that a significant share of non-steel materials recovered from end-of-life vessels including fittings, equipment, furnishings and consumables currently enters circulation through informal trade channels, a structured traceability and reporting mechanism shall be established to capture the full material recovery footprint of the sector, support circular economy accounting, and progressively bring informal market participants within the regulatory and welfare framework.

3.6 Green Steel, Circular Economy and Sustainable Finance

3.6.1 A Green Steel Pathway for the ship recycling sector shall be established to promote the traceability, certification and utilisation of recycled ship steel within domestic manufacturing, infrastructure and maritime value chains, thereby supporting India's circular economy and decarbonisation objectives.

3.6.2 The Bureau of Indian Standards (BIS), in coordination with relevant ministries and industry stakeholders, shall develop standards and certification mechanisms for recycled ship steel, including guidance on material quality, traceability and suitable end-use applications for structural and non-structural purposes.

3.6.3 The Bureau of Energy Efficiency (BEE), in coordination with the Directorate General of Maritime Administration (DGMA), steel industry stakeholders and relevant government agencies, shall develop methodologies for measuring and certifying the energy efficiency, carbon footprint and resource efficiency of recycled ship steel across the value chain, from vessel recycling through processing and end-use applications.

3.6.4 A national greenhouse gas accounting framework shall be developed for ship recycling facilities and recycled ship steel, based on internationally recognised methodologies, to enable measurement, reporting and verification of emissions, resource efficiency and environmental performance across the recycling value chain.

3.6.5 The Ferrous Scrap Development Fund (FSDF) shall be operationalised to support environmental upgrades, compliance improvements, green steel initiatives, digitalisation, technology adoption, worker welfare and circular economy projects. Financial incentives and

market-based instruments shall be explored and notified to reward facilities demonstrating superior compliance, environmental performance, material recovery and emissions reduction outcomes. The Ship Recycling Credit Note, introduced under the Shipbuilding Financial Assistance Scheme (SBFA), shall continue to be operationalised as a demand-side instrument linking compliant ship recycling with new shipbuilding in Indian yards.

3.7 Governance

3.7.1 This pillar shall be implemented under Working Group 5, led by the Directorate General of Maritime Administration in coordination with the Ministry of Environment, Forest and Climate Change. DGMA shall be responsible for administering the Recycling of Ships Act 2019 and the Recycling of Ships Regulations 2026, maintaining the Document of Authorisation to conduct Ship Recycling (DASR) which are issued by State Maritime Boards, operationalising the National Ship Recycling Portal, and overseeing yard-level compliance with HKC and EUSRR standards. MoEFCC shall be responsible for environmental clearance processes, in coordination with the State Pollution Control Board on discharge standards applicable to ship recycling facilities, and alignment of the national GHG accounting framework for ship recycling with India's NDC reporting obligations. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

3.7.2 The State Maritime Boards shall be responsible for state-level coordination of yard compliance roadmaps, worker welfare programmes, and environmental monitoring at Alang and other recycling clusters within the country. They will also issue the Document of Authorisation to conduct Ship Recycling. The Bureau of Indian Standards shall be responsible for notifying recycled ship steel standards and certification mechanisms. The Bureau of Energy Efficiency shall be responsible for developing carbon footprint certification methodology for recycled ship steel across the value chain. The Ferrous Scrap Development Fund shall be administered jointly by DGMA and the Ministry of Steel to finance environmental upgrades, compliance improvements, green steel initiatives, digitalisation, technology adoption, worker welfare and circular economy projects. 3.7.3 The Working Group shall comprise DGMA, MoEFCC, the State Maritime Boards, the Ship Recycling Industry Association, the Ministry of Steel, Indian Register of Shipping, HKC compliance bodies, and academic and technical institutions. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3: TARGETS

Short-Term (0–6 Months)

1. Classify all licensed ship recycling facilities under HKC-compliant, EUSRR-compliant and Transition categories and publish yard-specific compliance roadmaps for Transition Facilities.
2. Commence the procurement and development of the National Ship Recycling Portal and establish national registry of ship recycling facilities with HKC/EUSRR compliance status and initiate development of digital Inventory of Hazardous Materials (IHM) management systems.

3. Initiate technical guidance and capacity building support for ISO standards compliance (ISO 30000, ISO 9001, ISO 14001, ISO 45001, ISO 50001) as mandated under the First Schedule of the Ship Recycling Regulations 2026.
4. Activate framework for FSDF utilization for worker welfare and environmental upgradation, worker safety certification programmes and welfare-linked insurance schemes at Ship recycling facilities.
5. Initiate HKC compliance support programme for all Transition Facilities, including technical assistance, gap assessments and targeted capacity building to accelerate upgrade to full HKC-compliant status.

Medium-Term (6 Months–2 Years)

6. Operationalise the National Ship Recycling Portal as single digital window integrating DGMA, state maritime boards as competent authorities and Recognised Organisations, with modules for IHM verification, compliance tracking, environmental monitoring, safety performance and FSDF project monitoring.
7. Establish the National Ship Recycling Institution at Alang with accredited training modules for worker safety and all four ISO standards fully operational.
8. Notify BIS standards for recycled ship steel and BEE carbon footprint certification methodology and develop national GHG accounting framework based on ISO 14067 and GHG Protocol.
9. Initiate bilateral end-of-life ship supply agreements with key vessel-owning nations.
10. Achieve 100% HKC compliance across all operational ship recycling facilities by the end of the medium-term horizon, completing the upgrade of all Transition Facilities in accordance with yard-specific compliance roadmaps with formal IMO HKC authorisation for all yards.
11. Initiate EUSRR compliance readiness programme for facilities seeking European-flagged vessel recycling contracts, including gap assessments against EU Ship Recycling Regulation requirements and implementation roadmaps for eligible yards.

Long-Term (2–5 Years)

12. Attain EUSRR compliance as the established standard for facilities engaged in European-flagged vessel recycling.
13. Integrate carbon intensity metrics and lifecycle MRV across all licensed yards through the Portal, operationalise BIS-certified green steel supply chain, and scale FSDF R&D support for advanced yard technologies.
14. Publish yard-wise sustainability performance via reports through the Portal and establish India as the globally preferred green ship recycling destination.

Pillar 4: Green Finance

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

Green finance is increasingly a structural driver of maritime decarbonisation globally, moving beyond voluntary commitment toward a fundamental reshaping of how shipping assets are financed. The Poseidon Principles, a framework committing signatory financial institutions to align

their ship finance portfolios with the IMO's long-term decarbonisation goals, currently counts 29 signatory banks representing approximately $185 billion in investments, over half of the total global ship finance portfolio. Borrowers under green and sustainability-linked loans are required to commit capital to projects meeting defined environmental criteria, with regular reporting and strict compliance monitoring. The direction is unambiguous: access to international ship finance is progressively contingent on demonstrable environmental performance, and institutions that cannot meet green finance criteria will face increasing difficulty accessing competitive capital.

India's maritime sector has received a significant capital commitment through a Cabinet-approved allocation of ₹69,725 crore across four flagship schemes, as summarised below:

Scheme	Allocation	Key Components
Shipbuilding Financial Assistance Scheme (SFAS)	**INR 24,736 crore**	Cost differential support; Shipbreaking Credit Note; National Shipbuilding Mission
Maritime Development Fund (MDF)	**INR 25,000 crore**	Maritime Investment Fund (INR 20,000 cr) + Interest Incentivisation Fund (INR 5,000 cr)
Shipbuilding Development Scheme (SbDS)	**INR 19,989 crore**	Greenfield clusters; brownfield expansion to 4.5M GT; India Ship Technology Centre
Legal, Policy and Process Reforms	**Structural enabler**	Demand aggregation; infrastructure status for ships; flagging reforms; GST rationalisation
Total Cabinet Allocation	**INR 69,725 crore**	

However, none of these allocations are currently green-labelled, green-conditioned, or subject to environmental performance criteria. India's broader green finance landscape, while growing, remains concentrated in renewable energy, existing green bond issuances by SBI, Bank of Baroda and Union Bank have not extended to maritime applications, and no maritime-specific green finance taxonomy currently exists. The sovereign green bond framework, while under development, does not yet include the shipping sector. Discussions with the Asian Infrastructure Investment Bank (AIIB) on maritime green finance are ongoing.

SECTION 2: POLICY MEASURES

4.1 Definition

A structured and verifiable financial mechanism, including green bonds, loans, public-private partnerships, and ESG investments, dedicated to the funding of environmentally sustainable maritime projects. This includes green ship construction, repair and retrofitting, port electrification, clean fuel infrastructure, energy-efficient terminal equipment, and circular economy-driven ship recycling including green steel production.

4.2 Maritime Green Finance Taxonomy

4.2.1 A maritime-specific green finance taxonomy shall be developed, building upon India's draft Climate Finance Taxonomy Framework, to provide a standardised classification of green, transitional and brown maritime investments across shipbuilding, ship recycling, ports, inland waterways and alternate fuels infrastructure.

4.2.2 The taxonomy shall define eligible green activities, environmental criteria and performance thresholds for each sub-sector, and shall serve as the foundational reference for green bond issuances, sustainability-linked loans, ESG reporting and second-party assurance.

4.2.3 The taxonomy shall be aligned with the International Capital Market Association (ICMA) Green Bond Principles, International Finance Corporation (IFC) Performance Standards, EU Taxonomy, proposed GFI Tier 1/2 criteria and the IMO Net-Zero Framework and shall be periodically reviewed to reflect evolving international standards.

4.3 ESG Reporting & Digital Infrastructure

4.3.1 A maritime sector ESG reporting framework shall be established, with standardised templates for each sub-sector defining KPIs for carbon emissions, energy efficiency, worker safety and environmental compliance, mapped to the taxonomy under clause 4.2.

4.3.2 Digital MRV platforms and ESG reporting tools shall be developed and integrated with existing port management systems and the National Ship Recycling Portal, enabling real-time performance tracking and transparent disclosure.

4.3.3 The ESG reporting framework shall align with mandatory disclosure requirements under the Companies Act and SEBI listing obligations, benchmarked against GRI, TCFD and IMO data collection systems.

4.3.4 ESG reporting performance shall be linked to eligibility and preferential access to green financial instruments, incentive schemes and compliance cost reductions.

4.4 Green Finance Mobilisation

4.4.1 The Maritime Development Fund (MDF), comprising the Maritime Investment Fund (INR 20,000 crore) and Interest Incentivisation Fund (INR 5,000 crore), shall be examined for introduction of green conditionality criteria to direct a defined proportion of its corpus toward taxonomy-aligned maritime projects.

4.4.2 Sagarmala Finance Corporation Limited (SMFCL) shall assess the feasibility of establishing a dedicated green financing vertical with bespoke financial products and instruments for projects meeting the Maritime Green Finance Taxonomy criteria

4.4.3 The Shipbuilding Financial Assistance Scheme and Shipbuilding Development Scheme shall progressively incorporate green eligibility criteria prioritising alternate fuel-ready vessels, energy-efficient shipbuilding and low-carbon shipyard infrastructure.

4.4.4 Viability Gap Funding, blended finance, de-risking instruments and venture capital support for maritime innovation shall be mapped under the taxonomy, with preferential interest rates under the Interest Incentivisation Fund for taxonomy-aligned projects and PPP modalities for green maritime infrastructure.

4.5 Green Finance Instruments

4.5.1 The following instruments shall be developed and notified in consultation with RBI, SEBI and Ministry of Finance:

(a) Green Maritime Bonds — structured in accordance with India's Draft Sovereign Green Bond Framework and ICMA Green Bond Principles, with mandatory use-of-proceeds reporting and second-party assurance ;

(b) Concessional Import and Export Finance — for clean maritime technologies, alternate fuel systems and green-certified vessels;

(c) Maritime Climate Credits — tradeable instruments recognising verified emissions reductions, aligned with emerging IMO market-based measures.

4.5.2 Shore power infrastructure financing shall be structured through Power Finance Corporation in partnership with the Indian Ports Association for major ports and SMFCL for non-major ports.

4.6 International Cooperation & Green Finance Diplomacy

4.6.1 India shall engage with the Green Climate Fund, Global Environment Facility and Asian Infrastructure Investment Bank (AIIB) to mobilise concessional and co-financing arrangements for green maritime infrastructure and alternate fuels development.

4.6.2 Bilateral green finance partnerships shall be pursued with the EU, Japan and Norway, leveraging their green maritime finance frameworks and technology transfer mechanisms.

4.6.3 Research and innovation partnerships with international institutions, classification societies and technology providers shall be developed to build India-specific green finance methodologies and carbon accounting tools, consistent with India's Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC) positions.

4.7 Carbon Markets & Market-Based Mechanisms

4.7.1 The development of maritime carbon market mechanisms shall be explored as a long-term incentive instrument, including the feasibility of carbon credit advance purchase agreements, in consultation with MoEFCC and TERI and with reference to Article 6 of the Paris Agreement.

4.7.2 India's engagement with IMO market-based measures shall be guided by its Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC) principles and Greenhouse Gas Fuel Intensity (GFI) Tier 1/2 positions. Carbon market mechanisms shall be treated as supplementary instruments and shall not substitute for direct public investment or green conditionality embedded in existing schemes.

4.8 Governance

4.8.1 This pillar shall be implemented under Working Group 6, led by Sagarmala Finance Corporation Limited in coordination with the Ministry of Finance. SMFCL shall be responsible for operationalising the dedicated green maritime finance vertical, administering the Maritime Development Fund green conditionality criteria, and facilitating access to taxonomy-aligned financing instruments for ports, shipyards, shipping companies, and fuel infrastructure developers. The Ministry of Finance, through the Department of Economic Affairs, shall be responsible for maritime sector inclusion under India's sovereign green bond framework, coordination with RBI and SEBI on green maritime bond and sustainability-linked loan standards, and alignment of maritime green finance instruments with India's broader Climate Finance Taxonomy Framework. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

4.8. Priority sector lending guidelines for green maritime projects shall be developed in consultation with RBI. Green bond issuance standards and ESG disclosure requirements for listed maritime entities shall be developed in consultation with SEBI. The maritime carbon market framework shall be developed in coordination with MoEFCC, consistent with India's domestic carbon market architecture and Article 6 engagement at the UNFCCC. Financing pathways for green hydrogen and ammonia as maritime fuels shall be developed in alignment with MNRE, with reference to bunkering demand signals through IMDA.

4.8.3 The Working Group shall comprise Sagarmala Finance Corporation Limited (SMFCL), Ministry of Finance, RBI, SEBI, Asian Development Bank, World Bank, Green Climate Fund, New Development Bank, European Investment Bank, International Renewable Energy Agency (IRENA), green bond issuers, and maritime lenders. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3: TARGETS

Short-Term (0–6 Months)

1. Constitute a technical working group comprising RBI, SEBI, Ministry of Finance, Department of Economic Affairs and MoPSW and initiate development of the maritime-specific green finance taxonomy building on India's draft Climate Finance Taxonomy Framework.
2. Aim to commission feasibility assessments for green conditionality criteria under the Maritime Development Fund (MDF) and a dedicated green vertical within Sagarmala Finance Corporation Limited (SMFCL).
3. Initiate the development of the maritime sector ESG reporting framework aligned with Companies Act and SEBI disclosure requirements.
4. Commence background discussions with AIIB, Green Climate Fund, EU, Japan and Norway on co-financing arrangements.
5. Engage with the Department of Economic Affairs to include maritime infrastructure as an eligible category under India's Sovereign Green Bond Framework
6. Commission a feasibility study for India's first green maritime bond issuance by a major port authority, with reference to the Sovereign Green Bond Framework. The study will serve as proof of concept for the Maritime Green Finance Taxonomy and for institutional green bond issuances in the maritime domain.

Medium-Term (6 Months–2 Years)

7. Notify the maritime green finance taxonomy and operationalise the ESG reporting framework with digital MRV platforms integrated into port management systems and the National Ship Recycling Portal.
8. Develop and freeze the maritime sector ESG reporting framework including standardised templates, KPI definitions and baseline capture methodology
9. Notify green conditionality criteria for the MDF and issue SMFCL green vertical scheme guidelines (if approved), enabling the first tranche of taxonomy-aligned green maritime project financing.
10. Facilitate India's first green maritime bond issuance under the notified taxonomy and operationalise concessional finance structures for clean maritime technologies.
11. Promote bilateral green finance partnerships with EU, Japan and Norway and secure co-financing commitments from AIIB (Asian Infrastructure Investment Bank) and Green Climate Fund for priority green maritime infrastructure projects.

Long-Term (2–5 Years)

12. India's green maritime finance architecture shall be fully operational across all sub-sectors, with taxonomy-aligned capital flows, mandatory ESG reporting, and green-conditioned public schemes applied across the full ₹69,725 crore maritime scheme architecture. Maritime sector inclusion under India's sovereign green bond framework shall be achieved, and a maritime carbon market framework aligned with IMO market-based measures and Article 6 of the Paris Agreement shall be operationalised, positioning Indian maritime entities to access global sustainability-linked finance on competitive terms.

Pillar 5: Green Skill

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

The global maritime sector is entering a major workforce transition as decarbonisation shifts from voluntary adoption to operational compliance. The transition towards ammonia, methanol, hydrogen, LNG, biofuels, battery-electric vessels, shore power, digital MRV systems and smart port technologies is creating new green maritime occupations across shipping, ports, shipbuilding, ship repair, inland waterways and associated maritime services. The Maritime Just Transition Task Force estimates that nearly 450,000 seafarers may require additional training by 2030, increasing to around 800,000 by the mid-2030s[6], to support operation of zero and near-zero emission vessels. Workforce transition is therefore becoming a core requirement for maritime decarbonisation.

Leading maritime nations have already integrated green skill development into their maritime transition strategies. Singapore has established the Maritime Energy Training Facility for alternative fuel and maritime decarbonisation training supported by digital certification systems. Norway has linked workforce development with green ferries and green corridor pilots, while Denmark has integrated maritime training within bilateral green shipping cooperation frameworks. Japan and the Republic of Korea have aligned green skill development with shipbuilding and alternative fuel technology roadmaps. At the international level, IMO and the Maritime Just Transition Task Force have launched fuel-specific training frameworks for ammonia, methanol and hydrogen-fuelled vessels. These models demonstrate that green maritime transition requires role-specific competency standards, simulation-based training infrastructure and institutionalised certification systems.

India has a strong foundation to position itself as a global green maritime talent hub. India is among the world's largest suppliers of seafarers, with nearly 3.23 lakh[7] active Indian seafarers employed globally. The country has an established maritime education ecosystem through the Directorate General of Shipping, Indian Maritime University, DGMA-approved maritime training institutes, port training systems and shipyard training capacity. MoPSW has also initiated regional maritime skill development through the Maritime Skill Development Centre in Guwahati and the Centre of Excellence for Inland Water Transport in Dibrugarh.

However, India's maritime skilling framework remains primarily aligned to conventional vessel operations and STCW compliance. Maritime decarbonisation now requires competency streams in alternative fuel operations, hydrogen and ammonia safety systems, methanol and LNG operations, battery-electric propulsion, green bunkering, emissions monitoring, digital MRV systems, sustainable port operations and green retrofitting. These capabilities remain fragmented and are not yet organised under a unified national green maritime competency framework aligned with the ongoing comprehensive revision of the STCW Convention and emerging IMO guidance.

SECTION 2: POLICY MEASURES

[6] Maritime Just Transition Task Force - https://www.ics-shipping.org/press-release/training-seafarers-for-a-decarbonized-future/

[7] Ministry of Ports, Shipping and Waterways - https://x.com/shipmin_india/status/2065759779705045341

5.1 Definition

Green Skills refers to the technical, operational, digital, environmental, and safety competencies required to support sustainable, low-carbon, and environmentally compliant maritime operations across shipping, ports, inland waterways, shipbuilding, ship repair, recycling, logistics, and associated maritime activities. These include competencies relating to alternative fuels, emissions reduction technologies, MRV systems, energy efficiency, digital maritime systems, sustainable port operations, green retrofitting, pollution prevention, and environmental compliance.

5.2 Green Maritime Skill Mission

5.2.1 A Green Maritime Skill Mission (GMSM) shall be launched as an inter-ministerial initiative led by the Ministry of Ports, Shipping and Waterways (MoPSW) in coordination with the Ministry of Skill Development and Entrepreneurship (MSDE), the Directorate General of Maritime Administration (DGMA), the Indian Maritime University (IMU), the Inland Waterways Authority of India (IWAI), and the Skill Council for Green Jobs (SCGJ). The Mission shall establish India as a global hub for green maritime talent by 2030 through a unified framework for green maritime job roles, competency standards, training programmes, and certification pathways.

5.3 Curriculum Development and Certification

5.3.1 Green shipping competencies shall be mandatorily integrated into all DGMA-approved pre-sea and post-sea maritime training curricula. Training programmes shall cover alternative and low-carbon fuels, energy efficiency and emissions reduction, digital maritime technologies, shore power systems, sustainable port operations, green shipbuilding, retrofit technologies, and environmental compliance requirements.

5.3.2 Training standards and certification frameworks shall be aligned with relevant IMO instruments, including the Generic Interim Guidelines on Training for Seafarers on Ships Using Alternative Fuels and New Technologies (STCW.7/Circ.25), the Maritime Just Transition Task Force (MJTTF) Baseline Training Frameworks, the ongoing comprehensive revision of the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention, and other internationally recognised standards.

5.3.3 Role-specific certification pathways shall be developed for seafarers, bunkering personnel, port operators, shipyard personnel, retrofit specialists, emergency responders, environmental compliance officers, and maritime digital systems operators.

5.4 Green Maritime Training Centres

5.4.1 A national network of Green Maritime Training and Simulation Centres shall be established at designated maritime universities, DGMA-approved institutes, ports, and shipyard facilities, operationalising a three-tier architecture comprising awareness programmes, vocational and technical skilling, and advanced specialised certification. Simulation-based training facilities for alternative fuel systems, voyage optimisation, MRV systems, and emergency response shall be deployed at designated national maritime training hubs. Training quality and faculty standards across the network shall be maintained under a national accreditation framework notified by DGMA.

5.4.2 Specialised training infrastructure and programmes shall be developed for alternative fuel handling and bunkering, hydrogen and ammonia safety, LNG and low-flashpoint fuel operations, marine battery and energy storage systems, smart port technologies, and emissions monitoring, covering seafarers, port operators, and personnel across inland waterways, coastal shipping, and green corridor operations.

5.4.3 The Indian Ocean Centre of Excellence for Sustainable Maritime Transport (IOCE-SMarT) shall be operationalised as a regional centre of excellence for green maritime capacity building, applied research, technology demonstration, and international knowledge exchange. IOCE-SMarT shall support curriculum development, faculty training, simulation-based learning, industry partnerships, and technical cooperation with global institutions, including the IMO's Maritime Technology Cooperation Centres (MTCC) network, to strengthen green maritime capabilities across India and the wider Indian Ocean region.

5.5 Green Talent Fund

5.5.1 A Green Talent Fund shall be established under the Maritime Development Fund to finance scholarships, fellowships, apprenticeships, specialised training programmes, and research initiatives in green shipping and maritime decarbonisation, covering advanced study in green propulsion systems, alternative fuel technologies, sustainable maritime infrastructure, and digital maritime systems. Companies investing in certified green workforce development programmes shall be eligible for salary co-funding support and applicable fiscal incentives.

5.5.2 The Green Talent Fund shall be supported through allocations under the Maritime Development Fund, IMU-led research and curriculum development initiatives, national skill development programmes, and industry co-funding mechanisms.

5.6 Workforce Transition and International Collaboration

5.6.1 Reskilling and upskilling programmes shall be developed for maritime professionals transitioning to alternative fuel operations, green retrofit projects, MRV systems, digital maritime technologies, battery-electric and hybrid propulsion, shore power systems, and sustainable port operations. Recognition of Prior Learning mechanisms and accelerated certification pathways shall be developed to facilitate transition into emerging green maritime occupations.

5.6.2 Strategic international collaborations for technology transfer, joint research, capacity building, and specialised certification shall be formalised through bilateral maritime cooperation agreements with leading maritime nations. Partnerships with the IMO, classification societies, and global maritime academies shall be institutionalised to support specialised green shipping certifications, faculty exchange programmes, and international recognition of Indian maritime qualifications.

5.7 Governance

5.7.1 This pillar shall be implemented under Working Group 7, led by the Indian Maritime University in coordination with the Ministry of Skill Development and Entrepreneurship (MSDE). IMU shall be responsible for developing and maintaining the National Green Maritime Skills Framework, integrating green competency modules into DGMA-approved pre-sea and post-sea curricula, overseeing the national network of Green Maritime Training and Simulation Centres, and

administering the IMU- National Centre of Excellence in Green Port and Shipping (NCoEGPS) Research Consortium. MSDE shall be responsible for aligning green maritime occupational standards with the National Skills Qualifications Framework, coordinating the Skill Council for Green Jobs, and integrating maritime green skills pathways into national skilling programmes and Recognition of Prior Learning mechanisms. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

5.7.2 DGMA shall be responsible for notifying the national accreditation framework for Green Maritime Training Centres, approving role-specific certification pathways for seafarers, bunkering personnel, and port operators, and ensuring alignment of training standards with applicable IMO instruments and the STCW Convention as revised. The Maritime Development Fund shall be responsible for operationalising the Green Talent Fund, including scholarship, fellowship, and apprenticeship disbursement mechanisms and industry co-funding arrangements.

5.7.3 The Working Group shall comprise the Indian Maritime University, Ministry of Skill Development and Entrepreneurship (MSDE), DGMA-approved maritime academies, the Skill Council for Green Jobs, IWAI training centres, port training centres, and classification societies. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3: TARGETS

Short-Term (0–6 Months)

1. Initiate development of the Green Maritime Skill Mission (GMSM) and the National Green Maritime Skills Framework.
2. Initiate integration of green fuel handling, MRV systems, digital maritime technologies, and sustainable port operations modules into DGMA-approved maritime training curricula and initiate development of national certification pathways for alternative fuel handling, green retrofit operations, emissions monitoring systems, and digital maritime systems.
3. Identify designated Green Maritime Training and Simulation Centres at maritime universities, ports, shipyards, and IWAI training hubs and establish the Green Talent Fund framework under the Maritime Development Fund with support from IMU-led research initiatives and national skill development programmes.
4. Designate the Indian Maritime University, Mumbai as the first Green Maritime Training and Simulation Centre pilot, delivering training and simulation-based assessment across green fuel handling, MRV reporting systems, and alternative fuel safety as an initial proof of concept.

Medium-Term (6 Months–2 Years)

5. Operationalise specialised certification programmes for ammonia, methanol, hydrogen, LNG, battery-electric propulsion, shore power operations, and green bunkering across all DGMA-approved pre-sea and post-sea training programmes.
6. Operationalise the national network of Green Maritime Training and Simulation Centres, including dedicated programmes for inland waterways, coastal shipping, green corridor operations, and battery-electric vessel systems.
7. Operationalise the Green Talent Fund for scholarships, apprenticeships, workforce transition initiatives, and Recognition of Prior Learning mechanisms for maritime professionals transitioning to green maritime operations.
8. Formalise international cooperation partnerships with IMO, classification societies, and leading maritime nations for specialised certification, faculty exchange, and trainer development.

Long-Term (2–5 Years)

9. Achieve nationally recognised and internationally aligned green maritime competency and certification systems across shipping, ports, inland waterways, shipbuilding, ship repair, and recycling sectors.
10. Operationalise Centres of Excellence for green shipping technologies, alternative fuels, and sustainable maritime operations, positioned as regional hubs for green maritime training and research.
11. Institutionalise long-term international partnerships for joint certification, maritime research, and green maritime technology capability development.

Pillar 6: Alternate Fuels

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

India's maritime sector is in the early stages of an alternate fuel transition. Policy frameworks under the National Green Hydrogen Mission, Harit Sagar Green Port Guidelines, and Maritime India Vision 2030 are translating into port infrastructure investment and pilot activity.

Biofuels

Biofuels present the most immediately deployable pathway for Indian shipping. They can be blended with existing marine gas oil and marine diesel oil supply chains without dedicated port infrastructure or vessel modification. Key developments:

I. Biofuel blends are being supplied through conventional fuel chains at major Indian ports, with no dedicated infrastructure required at the blending stage.
II. India has established a sustainability certification requirement for marine biofuels through MS Notice No. 14 of 2023, which mandates that no biofuels shall be supplied to ships in blended or unblended form without certification under a recognised international sustainability scheme, including the International Sustainability and Carbon Certification (ISCC) or the Roundtable on Sustainable Biomaterials (RSB) or equivalent. A Proof of Sustainability document must accompany the Bunker Delivery Note for all biofuel supply transactions. A comprehensive national certification framework aligned with international

regulatory requirements including FuelEU Maritime and the IMO GHG Fuel Intensity standard remains to be notified to support verified compliance reporting at scale.

III. The Harit Sagar Green Port Guidelines and India's fuel transition roadmap position biofuels as the first commercially deployable marine bunkering option for domestic coastal vessels.

Globally, second-generation biofuels including hydrotreated vegetable oil are seeing accelerating uptake, driven by FuelEU Maritime's 2% renewable fuel blending mandate in force from 2025.

Methanol

Methanol is the most commercially advanced alternate fuel pathway in India. Key developments:

I. India's first shore-to-ship methanol bunkering trial was completed at Deendayal Port (Kandla) on 2 April 2026, in collaboration with Stolt Tankers, JM Baxi, Aegis Vopak, and Indian Oil Corporation, with on-site verification by DNV. The port was rated Level 6 on the IAPH Port Readiness Level scale for methanol bunkering. Kandla already has compatible infrastructure from its existing grey methanol cargo handling operations.

II. Deendayal Port is targeting availability of approximately 500 KTPA of RFNBO-compliant e-methanol by 2028-29 to support deep-sea dual-fuel vessels on the Asia-Europe trade corridor.

III. V.O. Chidambaranar Port (Tuticorin) has received Rs. 35 crore in MNRE funding for methanol bunkering and refuelling infrastructure, with a 2x750 m^3 storage facility under development targeting commercial operations by FY 2026-27.

IV. Mumbai Port has issued an Expression of Interest for methanol bunkering infrastructure.

V. Cochin Shipyard Limited signed a contract with CMA CGM in February 2026 for the construction of six 1,700 TEU LNG dual-fuel feeder container vessels, marking India's entry into alternative fuel vessel construction for a major international operator.

VI. India has notified a national green methanol production standard.

Globally, methanol dual-fuel vessel orders grew 164% year-on-year in 2023. Maersk's operational methanol containership fleet has established methanol as the first commercially deployed green alternative fuel at scale in deep-sea shipping.

LNG

India has well-developed domestic LNG supply infrastructure through a network of regasification terminals and gas pipelines. Marine-specific bunkering infrastructure is at an earlier stage:

I. The Harit Sagar Green Port Guidelines mandate at least one LNG bunkering station at each major port by 2030.

II. Adani Ports and Special Economic Zone Limited and Bharat Petroleum Corporation Limited (BPCL) signed an MoU in October 2025 to develop India's first ship-to-ship LNG bunkering facility at Vizhinjam Port in Kerala, positioned on the East-West global shipping corridor. The facility has not yet moved to construction as of mid-2026.

III. JNPA signed an MoU with the Port of Marseille Fos in February 2026 to promote LNG, hydrogen, and green shipping collaboration between India and Europe.

Globally, LNG remains the only alternative marine fuel at commercial scale, accounting for approximately 6.1% of total reported marine fuel consumption in 2023.

Green Ammonia

Green ammonia has strong production-side momentum in India, with maritime bunkering on a post-2030 horizon:

I. The Government of India approved a dedicated green hydrogen and ammonia handling jetty at Paradip Port in February 2026 at Rs. 797.17 crore, with 4 MTPA annual handling capacity, to be implemented on a build-operate-transfer basis. Construction is yet to commence.
II. Deendayal Port has a 3.5 MMTPA green ammonia-compatible jetty and has allocated 3,400 acres to developers, with a production target of 7 MMTPA by 2030.
III. V.O. Chidambaranar Port has allocated 501 acres for green hydrogen and ammonia development, with a 2 MMTPA production target by 2030.
IV. Reliance Industries has announced a USD 3 billion green ammonia supply agreement with South Korea's Samsung C&T under a 15-year contract.
V. A green ammonia export corridor between VOC Port, Rotterdam, and Singapore has the potential to support approximately 11 MTPA of aggregated import demand by 2030.

Port-level standards, bunkering workforce training, and regulatory frameworks for marine ammonia handling are under development with reference to emerging international standards.

Globally, ammonia-fuelled two-stroke engines entered commercial service in 2026, with the technology expected to become commercially significant for deep-sea shipping by 2035 to 2040.

Green Hydrogen

Green hydrogen for maritime propulsion is positioned on a 2035 horizon, consistent with Harit Sagar targets:

I. Deendayal Port has commissioned a 1 MW electrolyser-based green hydrogen plant, with a Rs. 2,775 crore power infrastructure proposal approved for CTU connectivity and a 300 MLD desalination plant study underway to support hydrogen production at scale.
II. V.O. Chidambaranar Port completed a 10 Nm^3 per hour green hydrogen demonstration plant in March 2025 at a cost of Rs. 3.8 crore, with 501 acres allocated for wider green hydrogen development.
III. Paradip Port has a dedicated hydrogen terminal in the pipeline through PPP with an estimated investment of Rs. 700 crore, with completion targeted by 2027. Land allocation by the state government is under discussion.
IV. WAI's hydrogen-powered ferry prototype is the most advanced domestic maritime hydrogen application currently in evidence.

Globally, hydrogen fuel cell vessel orders are accelerating. The technology is establishing a commercial position in short-sea and ferry operations, with deep-sea application expected post-2040.

Battery-Electric and Hybrid

Battery-electric propulsion is advancing in India's harbour craft and inland waterway segments:

I. The Green Tug Transition Programme targets deployment of at least 30% green tugs at all major ports by 2030, with full transition by 2036. As of July 2025, Deendayal Port Authority has completed both the tender float and contract award. VOCPA, JNPA, PPA, NMPA, and VPA have issued Notices Inviting Tender. KPL is planning green tug procurement after its current diesel tug contract expires in August 2027.
II. 100 green tugs are in the procurement pipeline across all major ports at an investment of approximately Rs. 12,000 crore.
III. Hybrid propulsion is being deployed on select inland waterway vessels and ferries under the Harit Nauka Guidelines framework.
IV. As of 2023-24, renewable energy accounted for 15.48% of total electricity consumption across Indian major ports. Mumbai Port Authority and Deendayal Port Authority have already achieved the 60% renewable energy target, with DPA at 69.41% and Mumbai Port at 87.22%. Nine major ports are on track to meet the 60% target by 2030.

Globally, battery-electric propulsion is suited to short-range, low-power applications at current technology levels. Autonomous and AI-enabled electric vessel operations are progressing from pilot to commercial deployment in Norway, Japan, and Singapore.

SECTION 2- POLICY MEASURES

6.1. Definition

Alternative maritime fuels are any energy source, fuel, or propulsion system used in maritime operations that measurably reduces greenhouse gas emissions or air pollutant emissions compared to conventional fossil marine fuels, assessed on a well-to-wake lifecycle basis. This includes biofuels, methanol, liquefied natural gas, green hydrogen, green ammonia, synthetic e-fuels, and electricity, as well as emerging advanced energy systems including nuclear propulsion, where they demonstrate verifiable environmental benefit.

6.2 Fuels Ready for Immediate Deployment

6.2.1 Mandatory blending of sustainable biofuels shall be introduced for domestic coastal vessels using marine gas oil or marine diesel oil, commencing in 2027 and increasing progressively in line with demonstrated domestic supply availability. The blending mandate applies to domestic coastal operations and is distinct from the IMO GHG Fuel Intensity (GFI) framework adopted at MEPC 83, which governs international voyages of vessels above 5,000 GT. India shall align its domestic maritime fuel standards with the GFI framework, with implementing regulations notified by 2028. Where certified sustainable biofuel is demonstrably unavailable at a bunkering location, the competent authority may grant temporary compliance relief for the affected route or port, subject to annual review and withdrawal once adequate supply is established.

6.2.2 All biofuels supplied to ships in blended or unblended form shall be certified under a recognised international sustainability scheme, including the International Sustainability and Carbon Certification (ISCC) or the Roundtable on Sustainable Biomaterials (RSB) or equivalent, in accordance with MS Notice No. 14 of 2023. A Proof of Sustainability document shall accompany the

Bunker Delivery Note for all biofuel supply transactions. Where certified sustainable biofuel is demonstrably unavailable at a bunkering location, the competent authority may grant temporary compliance relief for the affected route or port, subject to annual review and withdrawal once adequate supply is established. Non-compliance with blending mandates shall attract penalties as prescribed by the competent authority.

6.2.3 Financial incentives shall be introduced to accelerate domestic production of low and zero-GHG maritime fuels, for establishment of green hydrogen, green ammonia, green methanol, and sustainable biofuel production plants, Production-Linked Incentives for incremental production, and a 10-year corporate tax holiday for new qualifying fuel producers. Subsidies shall be structured on a well-to-wake GHG intensity basis, with higher incentive levels for fuels achieving greater emissions reductions, ensuring that the framework remains open to all qualifying alternative fuel pathways. A dedicated green maritime fuel financing window shall be established under the Maritime Development Fund to provide concessional loans and credit enhancement for early-stage fuel production projects, with sustainability-linked loan frameworks promoted through RBI priority sector lending guidelines.

6.2.4 The electrification of small domestic vessels, including inland ferries, river craft, and short-sea coastal vessels, shall be promoted through financial incentives for vessel construction and retrofitting, and through the development of shore-based electric charging infrastructure at inland waterway terminals and non-major ports. This measure shall be implemented in coordination with the Harit Nauka Guidelines, the Inland Waterways Authority of India, and relevant state governments, with a target of 100% electric propulsion for newly built government-operated inland passenger vessels by 2030.

6.3 Infrastructure Build-Out and Transition Fuels

6.3.1 Building on the designation of Deendayal Port Authority (Kandla), Paradip Port Authority, and V.O. Chidambaranar Port Authority (Tuticorin) as Green Hydrogen Hubs under the National Green Hydrogen Mission, green bunkering infrastructure shall be scaled up and extended to all 14 major ports through a PPP model, with the Government providing up to 20% capital cost support through Viability Gap Funding, with provision for an additional 20% from in cases where project viability requires enhanced support. Infrastructure development shall be sequenced by fuel readiness, prioritising sustainable biofuels, green methanol, and green ammonia, followed by hydrogen. LNG bunkering infrastructure shall be supported as a transitional bridging fuel at ports where dedicated green fuel infrastructure is not yet operational, subject to a regulatory sunset aligned with India's 2035 emissions milestones. Green Fuel Development Zones shall be established within designated port premises for integrated green fuel production, storage, and refuelling operations, with viability gap funding and green bond issuance standards notified through SEBI to mobilise private capital for zone development.

6.3.2 A national demand aggregation mechanism shall be established, bringing together Indian shipping companies, fuel producers, and port operators to form buyer alliances, aggregate offtake commitments, and provide long-term demand certainty for green fuel producers. Carbon Credit Advance Purchase Agreements shall be made available through the mechanism to provide

producers with additional revenue certainty. This mechanism shall be coordinated through the Indian Maritime Decarbonisation Alliance (IMDA).

6.3.3 Green Maritime Corridors shall be designated on key domestic and international trade routes, providing dedicated infrastructure and preferential port tariffs for vessels operating on alternative fuels. Priority routes shall include India-Singapore, India-UAE, and India-Rotterdam, with initial domestic corridors on short-sea and feeder routes such as Chennai-Andaman and Visakhapatnam-Haldia, expanding progressively to full international trade corridors by 2035. Vessels operating on alternative fuels within designated green corridors shall be eligible for reduced port dues, priority berthing, and fuel subsidies. Newly constructed vessels of 500 GT and above operating under the Indian registry on designated green corridors shall be required to be dual-fuel or alternative-fuel capable, supported by financing mechanisms under the Green Shipping Fund and SBFAP incentives.

6.4 Deep Transition and Long-Term Fuel Pathways

6.4.1 Dedicated R&D investments shall be made in domestic electrolyser manufacturing, ammonia synthesis technologies, and advanced biofuel production to reduce India's dependence on imported green fuel technologies. Collaboration with the National Green Hydrogen Mission, National Biofuels Policy, MNRE, and the IMO Net-Zero Framework shall be formalised for coordinated action. A National Green Maritime Technology Research Fund shall be established under the Maritime Development Fund with dedicated allocations for e-fuel pilot development, ammonia propulsion R&D, and hydrogen maritime safety research, with risk-sharing mechanisms available for early-stage technology trials.

6.4.2 Synthetic e-fuels, including e-methanol and e-ammonia produced through electrolysis using renewable electricity, shall be recognised as a priority long-term maritime fuel pathway. The Government shall support domestic R&D in e-fuel production, promote pilot projects integrating renewable energy with e-fuel synthesis, and engage with IMO and bilateral partners on well-to-wake certification standards for e-fuels.

6.4.3 Nuclear propulsion for maritime applications shall be assessed as a long-horizon energy pathway. The Government shall study the feasibility of nuclear-powered commercial vessels and floating nuclear power support for port energy needs, in coordination with the Atomic Energy Regulatory Board (AERB) and Nuclear Power Corporation of India Limited (NPCIL), and in alignment with emerging IMO- International Atomic Energy Agency (IAEA) safety recommendations and the anticipated revision of the Nuclear Ship Safety Code. India shall engage in international research programmes and maintain regulatory readiness for nuclear-powered maritime assets as the technology and its global safety framework mature.

6.5 Capacity Building

6.5.1 A National Alternative Fuels Maritime Training Programme shall be established under the Directorate General of Maritime Administration (DGMA), covering safe handling, storage, transfer, and emergency response for all alternative maritime fuels including methanol, LNG, ammonia, hydrogen, and biofuels. Training shall be mandatory for all port personnel, vessel officers, and bunkering operatives at ports where alternative fuel operations are underway or planned. Alternative fuel competencies shall be integrated into all DGMA-approved maritime academy

curricula, aligned with IMO model courses on low-flashpoint fuels and the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF) Code.

6.5.2 Green Port Training Centres with dedicated alternative fuel simulation and safety infrastructure shall be established at Deendayal Port, V.O. Chidambaranar Port, and Paradip Port, leveraging their designation as Green Hydrogen Hubs. A Green Talent Fund shall provide scholarships, fellowships, and industry apprenticeships for specialised training in alternative fuel systems, ammonia and hydrogen safety engineering, and maritime energy transition management.

6.6 International Cooperation

6.6.1 Strategic bilateral partnerships for alternative fuel technology transfer, joint R&D, and green maritime corridor development shall be formalised with Norway, Singapore, Japan, Republic of Korea, Denmark, the Netherlands, and the United Arab Emirates, prioritising electrolyser technology, ammonia fuel engine development, hydrogen safety standards, and e-fuel certification frameworks. India shall actively participate in and seek to shape the development of the IMO Net-Zero Framework, GFI implementing regulations, and safety codes for low-flashpoint maritime fuels, ensuring that international standards reflect the operational realities and developmental priorities of major fuel-producing nations.

6.6.2 The India-Denmark Green Strategic Partnership pre-feasibility study on the Rotterdam-India-Singapore Green Shipping Corridor, expected in late 2026, shall be used as the basis for converting India's corridor ambitions into operationally specific project commitments with defined vessel targets, bunkering volumes, and fuel certification requirements. India shall engage with the Green Shipping Challenge and the Clydebank Declaration corridor framework to position Indian ports as preferred bunkering and fuel export hubs on key international trade routes.

6.7 Governance

6.7.1 This pillar shall be implemented under Working Group 2, led by the Directorate General of Maritime Administration in coordination with the Ministry of New and Renewable Energy and the Ministry of Petroleum and Natural Gas. DGMA shall be responsible for notifying fuel safety standards, GFI implementing regulations, marine biofuel bunkering standards aligned to IMO guidelines and applicable DGMA circulars, and dual-fuel operational requirements under the Merchant Shipping Act 2025. MNRE shall be responsible for coordinating green hydrogen and ammonia production targets under the National Green Hydrogen Mission and ensuring alignment between hub-level production commitments and maritime bunkering demand signals through IMDA. MoPNG shall be responsible for LNG bunkering infrastructure policy, the regulatory framework for transitional fuel supply at major ports, and coordination with domestic fuel producers on biofuel supply chain development. For the detailed governance framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

6.7.2 Deendayal Port Authority, Paradip Port Authority, and V.O. Chidambaranar Port Authority shall be responsible for operationalising Green Fuel Development Zones, scaling bunkering infrastructure at the three designated Green Hydrogen Hubs, and serving as the primary demand anchors for the national demand aggregation mechanism. The Indian Maritime Decarbonisation Alliance shall be

responsible for coordinating buyer alliances, aggregating offtake commitments, and managing Carbon Credit Advance Purchase Agreement frameworks across the sector.

6.7.3 The Working Group shall comprise DGMA, MNRE, MoPNG, the Indian Maritime Decarbonisation Alliance, the National Green Hydrogen Mission Authority, Deendayal Port Authority, Paradip Port Authority, V.O. Chidambaranar Port Authority, Indian Oil Corporation, and domestic fuel producers. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3. TARGETS

Short-Term (0–6 Months)

1. Initiate the process of development of the national marine biofuel certification standard .
2. Initiate the national framework for Green Fuel Development Zones at designated major ports, in formal coordination with the Ministry of New and Renewable Energy and other relevant ministries to anchor maritime sector decarbonisation within national green fuel supply planning, with VGF eligibility criteria and application procedures defined.
3. Constitute the Indian Maritime Decarbonisation Alliance (IMDA) and operationalise the national demand aggregation mechanism for green fuel offtake.

Medium-Term (6 Months–2 Years)

4. Operationalise commercial methanol bunkering at Kandla and V.O. Chidambaranar Port, and issue Expressions of Interest for methanol bunkering infrastructure at a minimum of three additional major ports.
5. Deliberate to designate the Kandla-Tuticorin route as India's first operational Green Maritime Corridor, with preferential tariff and priority berthing frameworks notified.

Long-Term (2–5 Years)

6. Strive to achieve 10% of total energy consumed by Indian-registered shipping from zero or near-zero GHG fuels, with green fuel bunkering infrastructure .
7. Green Maritime Corridors extended to India-Singapore, India-UAE, and India-Rotterdam, with dual-fuel requirements in force for eligible vessels on designated corridors and India recognised as a Clydebank Declaration corridor partner.

Pillar 7: Green technology

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

India's maritime sector is in active transition. Policy commitments under Maritime India Vision 2030 and the Maritime Amrit Kaal Vision 2047 have begun translating into on-ground technology deployment across ports, vessels, and digital infrastructure. The following captures what is deployed or actively underway as of mid-2026.

Port Energy and Electrification

Renewable energy adoption is the most visible area of progress across India's 14 major ports. Key deployments include:

I. Deendayal Port (Kandla): 20 MW solar and wind capacity, 1 MW electrolyser-based green hydrogen plant commissioned, 3,400 acres allocated for green hydrogen and ammonia development, 3.5 MTPA green ammonia-compatible jetty built.
II. Visakhapatnam Port: 10 MW solar installation operational since 2023.
III. Cochin Port: 1.5 MW floating solar system, 100 kWp and 150 kWp grid-connected rooftop solar plants, nine solar prosumers operational as of 2024.
IV. V.O. Chidambaranar Port (Tuticorin): 9 MW solar and wind mix under implementation, pilot green hydrogen plant commissioned April 2025, green methanol bunkering facility under development.
V. Paradip Port: 10 MW solar plant under commissioning, government-approved green hydrogen and ammonia jetty under PPP with 4 MTPA annual handling capacity.
VI. JNPA: 4.10 MW combined rooftop and ground-mounted solar capacity.
VII. Haldia Port: 2 MW solar PV plant operational since 2025.

Port equipment electrification is progressing under Harit Sagar Green Port Guidelines, with electric rubber-tyred gantry cranes, automated guided vehicles, LED lighting systems, and electric yard tractors being deployed at major container terminals. Shore power (cold ironing) infrastructure is at an early stage, with deployment currently covering port craft operations and progressing toward EXIM vessel berths. Grid capacity augmentation remains the primary constraint.

Vessel Technology

The Green Tug Transition Programme (GTTP), launched October 2024, is India's most advanced vessel-level decarbonisation initiative. Phase 1 covers four pilot ports, Deendayal, JNPA, Paradip, and V.O. Chidambaranar, with two green tugs to be procured or chartered at each. Work orders have been placed at all four ports. India's first all-electric tug, being built by Atreya Shipyard for Deendayal Port with Kongsberg permanent magnet propulsion and energy storage systems, is expected to be delivered by late 2026. The programme targets 50 green tugs across all major ports by 2030 and full fleet transition by 2047.

The following vessel-level technologies are in pilot or early adoption, primarily through private sector and classification society-led initiatives rather than regulated mandates:

I. Air lubrication systems: reducing hull drag by injecting a carpet of air bubbles under the vessel hull, being trialled on select bulk carriers and tankers calling Indian ports.
II. Hull coating improvements: advanced low-friction and biofouling-resistant coatings being adopted on newbuilds and during dry-dock cycles, with documented fuel savings of 3 to 8%.

III. Wind-assisted propulsion: at evaluation stage for Indian-registry vessels, while globally rotor sails and suction sails are delivering verified fuel savings of up to 25% and have entered commercial scale deployment.
IV. Waste heat recovery systems: being specified in select newbuild designs at Indian shipyards, particularly for larger coastal and offshore supply vessels.
V. Hybrid propulsion: deployed on select inland waterway vessels and ferries under the Harit Nauka Guidelines framework.

Cochin Shipyard has been an active site for hydrogen fuel cell vessel development and is among the few Indian shipbuilders publicly engaged in zero-emission vessel design. Commercial deployment of hydrogen-propelled vessels remains limited domestically, though globally Japanese shipyards received orders for twelve hydrogen fuel cell vessels by April 2025.

International Technology Landscape:

The pace of green maritime technology commercialisation globally has accelerated considerably since 2023. Technologies that were experimental three to five years ago are now entering commercial deployment at scale:

I. Wind-assisted propulsion (rotor sails, suction sails, rigid wing sails) is delivering third-party verified fuel savings of 10 to 25% and is now specified in new vessel orders across bulk, tanker, and RoRo segments. The global market was estimated at USD 7.7 billion in 2025.
II. Ammonia-fuelled two-stroke engines entered commercial service in 2026, with MAN Energy Solutions and WartsilÃ¤ leading engine supply.
III. Methanol dual-fuel vessels are now in commercial operation globally, led by Maersk's methanol-powered containership fleet.
IV. Onboard carbon capture systems have completed initial sea trials on commercial vessels in Europe and Japan, with regulatory guidance from IMO.
V. Autonomous vessel operations under human oversight are progressing to commercial deployment, with the first fully crewless short-sea cargo operations expected by 2027 in regulated corridors in Northern Europe.
VI. Advanced hull materials, including fibre-reinforced polymer composites and titanium alloy components, are being adopted in naval and specialist vessel construction to reduce structural weight and improve lifecycle efficiency.
VII. Biofouling management is seeing a significant shift toward non-toxic, silicon-based and enzyme-active hull coatings that eliminate the need for biocidal antifouling paints, with regulatory pressure from IMO's biofouling guidelines accelerating adoption.

SECTION 2- POLICY MEASURES

7.1. Definition

Any system, equipment, process, material, or digital solution deployed across vessels, ports, or shipyards that measurably reduces greenhouse gas emissions, improves energy efficiency, or minimises environmental impact. Green Technology encompasses commercially available solutions

as well as emerging innovations that demonstrate verifiable environmental benefit on a well-to-wake basis.

7.2. Green technologies in shipbuilding and repair

The following technologies shall be promoted, incentivised, and progressively mandated across India's shipbuilding and repair sector:

7.2.1 Hybrid-electric and battery-electric propulsion systems for coastal, inland, and harbour vessels.

7.2.2 Green hydrogen and ammonia fuel cell propulsion systems for zero-emission newbuilds.

7.2.3 Wind-assisted propulsion systems including rotor sails, suction sails, and rigid wing sails, delivering verified fuel savings of 10 to 25% on applicable vessel types and routes.

7.2.4 Air lubrication systems reducing hull drag through sub-hull micro-bubble injection, with documented fuel savings of 5 to 10%.

7.2.5 Waste heat recovery systems capturing exhaust and jacket water heat for onboard power generation.

7.2.6 Advanced low-friction and biofouling-resistant hull coatings eliminating reliance on biocidal antifouling paints, with fuel efficiency improvements of 3 to 8%.

7.2.7 Onboard Carbon Capture and Storage (OCCS) systems for larger vessels where fuel switching is not immediately viable, subject to IMO regulatory guidance expected at MEPC 84.

7.2.8 Lightweight structural materials including fibre-reinforced polymer composites, reducing vessel weight and improving lifecycle energy efficiency.

7.2.9 AI-driven fuel optimisation and voyage management systems for real-time route, speed, and trim optimisation.

7.2.10 Dual-fuel and multi-fuel engine platforms providing operational flexibility across conventional and alternative fuel pathways.

7. 3. Alternative fuels related technologies

The following technologies shall support India's alternative fuel production, storage, distribution, and bunkering infrastructure:

7.3.1 Electrolyser systems for domestic green hydrogen production, including alkaline, PEM, and solid oxide technologies.

7.3.2 Ammonia synthesis and cracking technologies enabling ammonia as both a hydrogen carrier and a direct marine fuel.

7.3.3 Green methanol production systems integrated with renewable energy and biomass feedstocks.

7.3.4 Cryogenic storage and handling systems for liquefied hydrogen and ammonia at port and vessel level.

7.3.5 Advanced biofuel production technologies including second-generation cellulosic biofuels and hydrotreated vegetable oils suitable for direct blending without vessel modification.

7.3.6 Bunkering metering and quality assurance systems ensuring accurate GHG intensity measurement at the point of fuel delivery, aligned with IMO GFI reporting requirements.

7.3.7 Fuel cell systems for auxiliary power generation on vessels operating in port, reducing hotelling emissions.

7.3.8 Green Fuel Development Zone infrastructure integrating production, storage, and multi-fuel dispensing within designated port premises.

7. 4 Green technologies in ports

The following technologies shall be deployed across India's major and non-major ports:

7.4.1 Shore power Supply system's providing clean grid or renewable electricity to vessels at berth, eliminating auxiliary engine emissions during port stays.

7.4.2 Port-scale renewable energy systems including rooftop solar, ground-mounted solar, wind turbines, and floating solar installations.

7.4.3 Battery-based Energy Storage Systems balancing renewable generation and peak port load.

7.4.4 Electric and hybrid cargo handling equipment including rubber-tyred gantry cranes, rail-mounted gantry cranes, automated guided vehicles, and electric yard tractors.

7.4.5 IoT-based real-time emissions monitoring systems across port machinery, vessels at berth, and bunkering operations.

7.4.6 Digital twin platforms for port energy management, infrastructure planning, and emissions performance simulation.

7.4.7 Just-in-Time arrival coordination systems reducing vessel waiting time, auxiliary engine idling, and anchorage emissions.

7.4.8 Smart stormwater and oil-water separation systems for pollution containment within port premises.

7.4.9 Eco-dredging equipment including electrified or hybrid low-emission dredgers with silt containment systems.

7.4.10 Green building materials including recycled steel, fly ash bricks, and green-certified cement for port infrastructure construction and retrofit.

7.5 Green ship recycling technologies

The following technologies shall be adopted across India's ship recycling sector, anchored at Alang and other recycling clusters:

7.5.1 Automated and semi-automated cutting and dismantling systems reducing worker exposure to hazardous materials and improving operational efficiency.

7.5.2 Hazardous material containment and removal systems for asbestos, Polychlorinated biphenyls (PCBs), heavy metals, and other substances identified in the Inventory of Hazardous Materials.

7.5.3 Material recovery and sorting technologies maximising steel and non-ferrous metal recovery rates, supporting circular economy principles.

7.5.4 Soil and groundwater remediation systems for contaminated intertidal and shoreline zones.

7.5.5 Digital yard management platforms enabling real-time tracking of hazardous material flows, waste streams, and compliance documentation aligned with Hong Kong Convention (HKC) and EU Ship Recycling Regulation (EUSRR) requirements.

7.5.6 Renewable energy systems for yard operations including solar installations and battery storage, reducing fossil fuel dependence in cutting and processing operations.

7.6 Emerging and Futuristic Technologies

India's green maritime technology strategy shall extend beyond currently available solutions to position India as an active participant in the development, testing, and commercialisation of frontier maritime technologies. The following areas represent the global technology horizon and India's strategic research agenda:

7.6.1 Next-generation hull protection through enzyme-active, silicon-based, and biomimetic coatings, eliminating biocidal antifouling paints and reducing lifetime vessel fuel consumption.

7.6.2 Onboard Carbon Capture and Storage systems for large vessels on long international voyages where fuel switching is not viable within the 2030 to 2040 window, with Carbon Capture and Utilisation pathways converting captured CO_2 into synthetic fuels or construction materials.

7.6.3 Autonomous and AI-enabled vessel operations, including AI-based collision avoidance, remote monitoring systems, and regulatory frameworks for autonomous vessel certification.

7.6.4 Advanced operational optimisation through AI-based voyage management, predictive maintenance, fleet-level carbon management software, and port call optimisation platforms.

7.6.5 Material recovery and circular economy technologies for ship recycling, including AI-based material sorting, robotic dismantling systems, and blockchain-enabled traceability of recovered materials into downstream supply chains.

7.6.6 Structural lightweighting through fibre-reinforced polymer composites and advanced high-strength materials, leveraging India's existing capabilities in automotive and aerospace manufacturing.

7.6.7 Ocean-based carbon removal technologies including enhanced ocean alkalinity and blue carbon ecosystem restoration, supported through international research partnerships and pilot programmes.

7.7 Governance

7.7.1 This pillar shall be implemented under Working Group 4, led by the Directorate General of Maritime Administration in coordination with the Department of Science and Technology. DGMA shall be responsible for notifying the Green Technology Compliance Framework, administering technology certification and standardisation processes for vessels and shipyards, and overseeing the operationalisation of Maritime Green Technology Parks. DST shall be responsible for coordinating research and innovation funding, managing technology readiness assessments for emerging maritime technologies, and facilitating linkages between maritime technology development and India's broader industrial research ecosystem. For the detailed governance

framework and implementation architecture under the National Maritime Decarbonisation Policy, refer to Part IV: Policy Governance.

7.7.2 Indian Government recognised Class Societies shall be responsible for classification and technical verification of green maritime technologies deployed on Indian-flag vessels, providing assurance services for Onboard Carbon Capture and Storage pilots, and contributing to IMO technical working group processes on emerging technology standards. NCoEGPS shall be responsible for maintaining the national repository of green maritime technology data, coordinating the Innovation Forums, and providing technical secretariat support to the Working Group. The Maritime Development Fund shall be responsible for operationalising the National Green Maritime Technology Research Fund and disbursing risk-sharing mechanisms for early-stage technology trials.

7.7.3 The Working Group shall comprise DGMA, DST, Indian Register of Shipping, NCoEGPS, Indian Maritime University, technology providers, classification societies, academic institutions, and DPIIT. The Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the National Green Maritime Coordination Cell (NGMCC) administered by National Centre of Excellence in Green Port and Shipping (NCoEGPS), which shall consolidate pillar-level progress into biannual reporting to the Secretary MoPSW and annual reporting to Inter-Ministerial Taskforce on Maritime Decarbonisation (IMTMD).

SECTION 3- TARGETS

Next 2 Years (2026 to 2028)

1. A national Green Maritime Technology Research Fund shall be established under the Maritime Development Fund with dedicated allocations for onboard carbon capture, advanced hull coatings, autonomous vessel readiness, and AI-based optimisation systems.
2. At least one Onboard Carbon Capture and Storage pilot shall be initiated on an Indian-flag commercial vessel in partnership with a classification society and a technology provider.
3. Aim to designate one Indian-flag vessel for a full-voyage digital twin trial in partnership with a classification society, generating verified performance and emissions data for the national MRV framework.

Pillar 8: Pollution Prevention

SECTION 1: GLOBAL CONTEXT & INDIA'S POSITION

Maritime activities generate multiple categories of pollution that pose direct risks to coastal and marine environments. Ships and ports are sources of solid and liquid waste, oily water discharges, sewage, chemical effluents, air emissions, noise and accidental spills, each requiring systematic management and regulatory oversight. Globally, the IMO’s MARPOL convention and its six annexes provide the primary international framework governing pollution from ships, covering oil, noxious

liquids, sewage, garbage and harmful substance. The London protocol further regulates the dumping of wastes at sea. Leading maritime nations have progressively strengthened port reception infrastructure, discharge monitoring, spill response capability and noise management frameworks in alignment with these obligations.

India is a signatory to MARPOL and has ratified key annexes governing oil, sewage, garbage, and air emissions from ships. At the domestic level, the Environmental Protection Act, 1986, Solid Waste Management Rules, 2016 and Plastic Waste Management Rules, 2016 provide the regulatory basis for waste handling and discharge compliance applicable to port operations. The National Oil Spill Disaster Contingency Plan (NOS-DCP), administered by the Indian Coast Guard, governs spill preparedness and response at the national level. Several major ports have established waste reception facilities, harbour water quality monitoring programmes, and oil spill response equipment in compliance with CPCB and SPCB requirements. The Swachh Sagar platform has further strengthened waste reception reporting at the vessel - port interface.

However, implementation remains uneven across the sector. Waste reception facility capacity and utilisation vary significantly between major and non-major ports. Port discharge compliance, harbour water quality monitoring noise management, and hazardous waste handling practices are not uniformly implemented or reported. As India's maritime sector expands, a dedicated pollution prevention framework addressing solid and liquid waste, port discharges, noise, and spill response is essential to meet international obligations and protect India's coastal and marine environment.

SECTION 2: POLICY MEASURES

8.1 Definition

Pollution prevention in the maritime context refers to the systematic management and mitigation of solid and liquid waste, noise, accidental spills, and discharges arising from shipping and port operations to safeguard marine ecosystems, coastal environments, and human health, in accordance with applicable national regulations and international conventions including MARPOL and the London Protocol.

8.2 Waste Management and Port Discharges

8.2.1 Ports shall strengthen and maintain adequate waste reception facilities for ship-generated solid and liquid waste in compliance with MARPOL requirements, with waste volumes reported annually through the Swachh Sagar platform. Coverage and reporting compliance shall be progressively extended to all non-major ports above prescribed throughput thresholds

8.2.2 Compliance with applicable discharge standards for sewage, oily water, chemical effluents, and stormwater runoff shall be enforced across all major and non-major ports. Harbour water quality monitoring systems shall be established at all major ports and integrated with CPCB and SPCB reporting frameworks to enable continuous compliance tracking.

8.2.3 All major ports shall maintain documented hazardous waste management plans covering the handling, storage, and disposal of hazardous materials arising from maritime operations, with annual compliance reporting to CPCB and SPCB

8.2.4 The 5R approach — Refuse, Reduce, Reuse, Repurpose, and Recycle — as prescribed under the Harit Sagar Green Port Guidelines shall be adopted across all major ports for the management of ship-generated and port-operational solid waste, with waste segregation, treatment, and circular utilisation targets notified by the Government

8.2.5 Port authorities shall implement cargo spillage prevention and containment protocols for dry bulk, liquid bulk, and hazardous cargo handling operations, including dust suppression systems for coal, ore, and grain terminals, secondary containment for liquid bulk transfer points, and stormwater runoff treatment systems for cargo handling areas, in compliance with applicable CPCB and SPCB standards.

8.3 Oil Spill Prevention and Response

8.3.1 The existing National Oil Spill Disaster Contingency Plan (NOSDCP), administered by the Indian Coast Guard as the Central Coordinating Authority, shall be strengthened through integration with the national maritime MRV framework and the Green Port Digital Platform, enabling real-time pollution incident data to feed into the national environmental monitoring system.

8.4 Noise Pollution

8.4.1 Noise monitoring systems shall be operationalised at all major ports in accordance with the Noise Pollution (Regulation and Control) Rules 2000, with compliance data submitted to CPCB and relevant State Pollution Control Boards and integrated into port sustainability reporting under the Green Port Performance Index. DGMA shall, in coordination with MoEFCC, develop maritime-specific noise standards for port operations and vessel underwater radiated noise, aligned with IMO guidelines on underwater noise from commercial shipping and emerging international requirements, to protect marine ecosystems and coastal communities from cumulative noise impacts.

8.5 Research and Financial Support

8.5.1 Research and development of advanced waste treatment systems, noise reduction technologies, and spill response solutions shall be supported through the Maritime Development Fund (MDF). Strategic partnerships between shipping companies, port authorities, and environmental agencies shall be facilitated for research, testing, and training in maritime pollution control, including joint task forces for rapid response to oil spills and marine debris incidents.

8.5.2 Financial support mechanisms including grants and low-interest loans shall be made available to port operators and shipowners to facilitate adoption of pollution control technologies, waste management systems, and compliance infrastructure, with priority support extended to small port operators and non-major ports.

8.6 International Cooperation

8.6.1 India shall actively engage with the IMO and relevant MEPC processes to contribute to and align with evolving global pollution prevention standards under MARPOL and associated instruments and, shall pursue bilateral and multilateral cooperation frameworks for technology transfer, capacity building, and harmonised implementation of international pollution prevention obligations. India shall benchmark its port discharge standards, waste reception facility utilisation rates, and harbour water quality monitoring frameworks against leading maritime jurisdictions including Singapore, Rotterdam, and the Port of Antwerp, with findings incorporated into the biannual Green Port Performance review.

SECTION 3: TARGETS

Next 2 Years (2026-2028)

1. All major ports shall continue to implement existing discharge, waste management, and cargo spillage prevention obligations under applicable CPCB, SPCB, and MARPOL frameworks, with progressive extension of compliance requirements to non-major ports above prescribed throughput thresholds.
2. Port pollution prevention practices shall be benchmarked against leading international port jurisdictions and aligned with evolving IMO MEPC standards under MARPOL and associated instruments.
3. India shall strengthen implementation of its obligations under the London Protocol and relevant MARPOL Annexes, with active participation in IMO pollution prevention processes to contribute to and adopt emerging international standards.

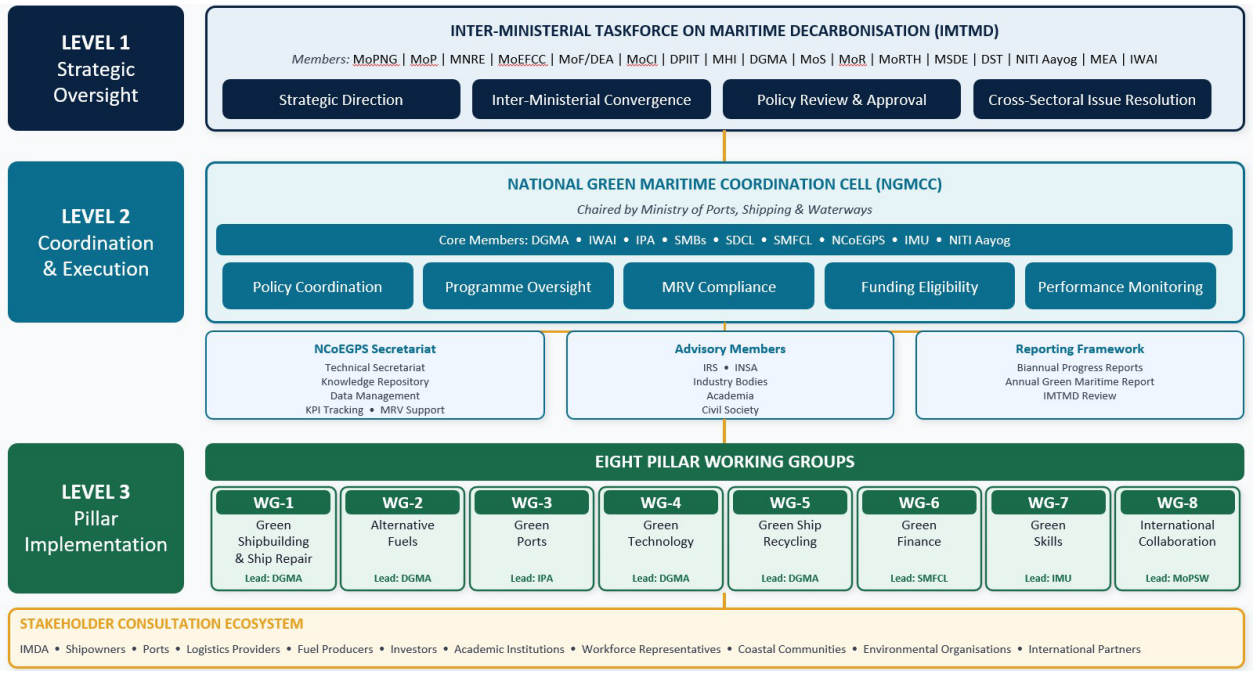
PART-IV: Policy Governance

6.1 Overview

6.1.1 The National Maritime Decarbonisation Policy shall be governed through a three-level institutional framework comprising an apex inter-ministerial body, a central coordination and execution cell, and eight pillar-specific working groups. This framework shall ensure that policy implementation is coordinated across ministries, grounded in verified performance data, and accountable to defined reporting obligations at each level.

6.1.2 The National Green Maritime Coordination Cell (NGMCC), housed within the Ministry of Ports, Shipping and Waterways, shall serve as the central operating platform responsible for the coordinated execution of all eight pillars of the NMDP. The NGMCC shall be formally notified through a Government of India Resolution under the Allocation of Business Rules of MoPSW, conferring on it the status of a permanent statutory authority with binding directive powers over certification eligibility, MRV compliance, and access to central maritime funding schemes.

6.1.3 The proposed organisational flow is as indicated below:



6.2 Level 1- Apex Policy Governance

6.2.1 The first level of the governance framework shall comprise an Inter-Ministerial Taskforce on Maritime Decarbonisation(IMTMD), constituted as the apex body responsible for high-level policy direction, inter-ministerial convergence, and resolution of cross-ministry issues that cannot be addressed at the coordination level. The IMTMD shall be chaired by the Secretary, Ministry of Ports, Shipping and Waterways, and shall meet annually to review NMDP implementation progress and issue strategic guidance.

6.2.2 The IMTMD shall comprise the following ministries and bodies:

i. Ministry of Petroleum and Natural Gas
ii. Ministry of Power
iii. Ministry of New and Renewable Energy
iv. Ministry of Environment, Forest and Climate Change
v. Ministry of Finance / Department of Economic Affairs
vi. Ministry of Commerce and Industry
vii. Department for Promotion of Industry and Internal Trade
viii. Ministry of Heavy Industries
ix. Directorate General of Maritime Administration
x. Ministry of Steel
xi. Ministry of Railways
xii. Ministry of Road Transport and Highways
xiii. Ministry of Skill Development and Entrepreneurship
xiv. Department of Science and Technology
xv. NITI Aayog
xvi. Ministry of External Affairs
xvii. Inland Waterways Authority of India

6.2.3 The Chair may co-opt any additional Ministry, Department, Regulatory Body, Public Sector Undertaking, Technical Institution, or Domain Expert as deemed necessary for specific agenda items or on a standing basis

6.3 Level 2- Coordination and Execution

6.3.1 The second level of the governance framework shall comprise the National Green Maritime Coordination Cell (NGMCC), which shall oversee the execution and coordination of all eight pillars of the NMDP. The NGMCC shall be housed within the Ministry of Ports, Shipping and Waterways and shall function as the central operational platform for implementation oversight, MRV compliance, finance integration, technology standardisation, and just transition safeguards across all pillars.

6.3.2 The permanent institutional membership of the NGMCC shall be as follows:

i. Ministry of Ports, Shipping and Waterways (MoPSW) - Chair
ii. Directorate General of Maritime Administration (DGMA)- Primary Regulatory Authority
iii. Inland Waterways Authority of India (IWAI)- Inland Waterway Implementation
iv. Indian Ports Association (IPA)- Major Port Coordination
v. State Maritime Boards (SMB)- Non-Major Port and Coastal State Interface
vi. Sagarmala Development Company Limited (SDCL)- Port Infrastructure Programme
vii. Sagarmala Finance Corporation Limited (SMFCL)- Green Maritime Finance Window

viii. National Centre of Excellence in Green Ports and Shipping (NCoEGPS)- Permanent Secretariat

ix. Indian Maritime University (IMU)- Maritime Education and Research

x. NITI Aayog- Observer

6.3.3 The following bodies shall serve as rotational advisory members of the NGMCC, participating in a supporting and enabling capacity across relevant pillar working groups:

i. Indian Register of Shipping (IRS)

ii. Indian National Shipowners Association (INSA)

iii. Ship Recycling Industry Representatives

iv. Technical Institutions and Academic Experts

v. Civil Society and Workforce Observers

vi. OEM and Logistics Industry Representatives

6.3.4 The NGMCC shall operate through the following accountability and reporting framework. A Biannual Implementation and Emissions Progress Report shall be submitted to the Secretary, MoPSW every six months. An Annual Green Maritime Report shall be published for public disclosure on an annual basis. An NMDP Implementation Review shall be submitted to the IMTMD annually. Pillar Working Group progress updates shall be submitted on a continuous basis to the NGMCC Secretariat, which shall be administered by NCoEGPS.

6.4 Level 3 — Pillar Working Groups

6.4.1 The third level of the governance framework shall comprise eight dedicated Pillar Working Groups. Each Working Group shall coordinate directly with its sectoral stakeholders and report on a continuous basis to the NGMCC Secretariat administered by NCoEGPS. The composition of each Working Group shall be as follows:

6.4.2 Working Group 1: Green Shipbuilding and Ship Repair

The Working Group shall be led by the Directorate General of Maritime Administration (DGMA)

Key Responsibilities**:**

I. DGMA- Green Ship Certification Framework in-line with IMO Framework, Green Ship Design Standards, Shipbuilding Financial Assistance Scheme (SBFAS) performance-linked framework, GCI-linked compliance and MRV reporting

II. Ministry of Heavy Industries and DPIIT- Green Shipbuilding Cluster designation, domestic manufacturing capability in green maritime technologies

III. Sagarmala Finance Corporation Limited (SMFCL) and Maritime Development Fund (MDF)- Green retrofit and newbuild financing windows, NGMCC-certified eligibility criteria

Working Group Members shall include: Indian National Shipowners Association, Indian Register of Shipping, Cochin Shipyard Limited, Ministry of Heavy Industries, Department for Promotion of Industry and Internal Trade (DPIIT), Indian shipbuilding industry representatives

6.4.3 Working Group 2: Alternative Fuels

The Working Group shall be led by the Directorate General of Maritime Administration in coordination with the Ministry of New and Renewable Energy and the Ministry of Petroleum and Natural Gas.

Key Responsibilities:

I. DGMA- Fuel safety standards, GFI implementing regulations, support for national marine biofuel certification standard, dual-fuel certification requirements under the Merchant Shipping Act 2025

II. MNRE- Green hydrogen and ammonia production targets under the National Green Hydrogen Mission, alignment of hub-level production commitments with maritime bunkering demand

III. MoPNG- LNG bunkering infrastructure policy, regulatory framework for transitional fuel supply at major ports, coordination with domestic biofuel supply chains

IV. Deendayal Port Authority, Paradip Port Authority, and V.O. Chidambaranar Port Authority — Operationalisation of Green Fuel Development Zones, bunkering infrastructure at designated Green Hydrogen Hubs, demand anchoring for the national demand aggregation mechanism

V. IMDA- Coordination of buyer alliances, aggregation of offtake commitments, Carbon Credit Advance Purchase Agreement frameworks

Working Group Members shall include: Indian Maritime Decarbonisation Alliance, National Green Hydrogen Mission Authority, Deendayal Port Authority, Paradip Port Authority, V.O. Chidambaranar Port Authority, Indian Oil Corporation, and domestic fuel producers.

6.4.4 Working Group 3: Green Ports

The Working Group shall be led by the Indian Ports Association in coordination with the Major Port Authorities.

Key Responsibilities:

I. Indian Ports Association- Coordination of GPPI adoption across all major ports, oversight of Harit Sagar Green Port Guidelines compliance, facilitation of the Annual Port Sustainability Forum

II. Major Port Authorities- Operationalisation of electrification timelines, renewable energy targets, OPS infrastructure, and the National Green Port Digital Platform within respective port jurisdictions

III. National Port Sustainability Council- Institutional oversight of the green ports agenda, inter-agency coordination, and Green Ports Working Group governance

IV. State Maritime Boards- Extension of GPPI reporting and Green Port Certification to non-major ports above prescribed throughput thresholds

V. Ministry of Power and State DISCOMs- Grid capacity augmentation and tariff harmonisation required for shore power implementation across major ports

VI. NCoEGPS- Technical secretariat support, national repository of port sustainability performance data

Working Group Members shall include: State Maritime Boards, NCoEGPS, Inland Waterways Authority of India, Ministry of Power, State Distribution Companies, and port operators.

6.4.5 Working Group 4: Green Technology

The Working Group shall be led by the Directorate General of Maritime Administration in coordination with the Department of Science and Technology.

Key Responsibilities:

I. DGMA- Green Technology Compliance Framework, technology certification and standardisation for vessels and shipyards, operationalisation of Maritime Green Technology Parks
II. DST- Research and innovation funding coordination, technology readiness assessments for emerging maritime technologies, linkages with India's broader industrial research ecosystem
III. Indian Register of Shipping- Classification and technical verification of green maritime technologies on Indian-flag vessels, assurance services for OCCS pilots, contribution to IMO technical working group processes on emerging technology standards
IV. NCoEGPS- National repository of green maritime technology data, coordination of Innovation Forums, technical secretariat support to the Working Group
V. MDF- Operationalisation of the National Green Maritime Technology Research Fund, disbursement of risk-sharing mechanisms for early-stage technology trials

Working Group Members shall include: Indian Register of Shipping, NCoEGPS, Indian Maritime University, technology providers, classification societies, academic institutions, and DPIIT.

6.4.6 Working Group 5: Green Ship Recycling

The Working Group shall be led by the Directorate General of Maritime Administration in coordination with the Ministry of Environment, Forest and Climate Change.

Key Responsibilities:

I. DGMA- Administration of the Recycling of Ships Act 2019 and Recycling of Ships Regulations 2026, operationalisation of the National Ship Recycling Portal, oversight of HKC and EUSRR yard-level compliance
II. MoEFCC- Environmental clearance processes, coordination with CPCB on discharge and emissions standards for ship recycling facilities, alignment of national GHG accounting framework with India's NDC reporting obligations
III. State Maritime Board- State-level coordination of yard compliance roadmaps, worker welfare programmes, environmental monitoring at ship recycling clusters, and issuance and maintenance of DASR
IV. Bureau of Indian Standards- Notification of recycled ship steel standards and certification mechanisms
V. Bureau of Energy Efficiency- Development of carbon footprint certification methodology for recycled ship steel across the value chain

VI. FSDF- Joint administration with Ministry of Steel to finance yard infrastructure upgradation, environmental compliance, and green steel initiatives

Working Group Members shall include: Ship Recycling Industry Association,State Maritime Board, Ministry of Steel, Indian Register of Shipping, Bureau of Indian Standards, Bureau of Energy Efficiency, and HKC compliance bodies.

6.4.7 Working Group 6: Green Finance

The Working Group shall be led by Sagarmala Finance Corporation Limited in coordination with the Ministry of Finance.

Key Responsibilities:

I. SMFCL- Operationalisation of the dedicated green maritime finance vertical, administration of MDF green conditionality criteria, facilitation of taxonomy-aligned financing instruments for ports, shipyards, shipping companies, and fuel infrastructure developers

II. Ministry of Finance- Maritime sector inclusion under India's sovereign green bond framework, coordination with RBI and SEBI on green maritime bond and sustainability-linked loan standards, alignment with India's Climate Finance Taxonomy Framework

III. RBI- Priority sector lending guidelines for green maritime projects

IV. SEBI- Green bond issuance standards and ESG disclosure requirements for listed maritime entities

V. MoEFCC- Coordination of the maritime carbon market framework with India's domestic carbon market architecture and Article 6 engagement at UNFCCC

VI. MNRE- Alignment of green hydrogen and ammonia financing pathways with maritime bunkering demand signals through Indian Maritime Decarbonisation Alliance (IMDA)

Working Group Members shall include: Reserve Bank of India, SEBI, Asian Development Bank, World Bank, Green Climate Fund, New Development Bank, European Investment Bank, IRENA, green bond issuers, and maritime lenders.

6.4.8 Working Group 7: Green Skills

The Working Group shall be led by the Indian Maritime University in coordination with the Ministry of Skill Development and Entrepreneurship.

Key Responsibilities:

I. IMU- Development and maintenance of the National Green Maritime Skills Framework, integration of green competency modules into DGMA-approved curricula, oversight of the national network of Green Maritime Training and Simulation Centres, administration of the IMU-NCoEGPS Research Consortium

II. MSDE- Alignment of green maritime occupational standards with the National Skills Qualifications Framework, coordination of the Skill Council for Green Jobs, integration of maritime green skills pathways into national skilling programmes and Recognition of Prior Learning mechanisms

III. DGMA- Notification of the national accreditation framework for Green Maritime Training Centres, approval of role-specific certification pathways for seafarers, bunkering personnel, and port operators, alignment of training standards with applicable IMO instruments and the STCW Convention as revised

IV. MDF- Operationalisation of the Green Talent Fund, including scholarship, fellowship, and apprenticeship disbursement mechanisms and industry co-funding arrangements

Working Group Members shall include: DGMA-approved maritime academies, Skill Council for Green Jobs, IWAI training centres, port training centres, and classification societies.

6.4.9 Working Group 8: International Collaboration

The Working Group shall be led by the Ministry of Ports, Shipping and Waterways in coordination with the Ministry of External Affairs.

Key Responsibilities:

1. MoPSW- Coordination of India's Green Shipping Challenge commitments, Clydebank Declaration corridor framework engagement, and positioning of Indian ports as preferred bunkering and fuel export hubs on key international trade routes
2. MEA- Management of bilateral maritime cooperation agreements with Norway, Singapore, Japan, Republic of Korea, Denmark, the Netherlands, and the United Arab Emirates, and coordination of green maritime diplomacy through bilateral and multilateral channels
3. IMO National Focal Point- Representation of India's positions at IMO MEPC on the Net-Zero Framework, GFI implementing regulations, and safety codes for low-flashpoint maritime fuels
4. Indian Maritime Decarbonisation Alliance (IMDA)- Coordination of international demand aggregation partnerships and engagement with Zero Emission Maritime Buyers Alliance (ZEMBA) and equivalent global buyer alliances

Working Group Members shall include: IMO National Focal Point, Indian Maritime Decarbonisation Alliance, bilateral partner missions, Green Shipping Challenge Secretariat, Clydebank Declaration partners, and multilateral development banks.

6.5 Stakeholder Consultation Framework

6.5.1 Periodic stakeholder consultations shall be conducted to ensure that NMDP implementation remains grounded in industry realities, coastal community needs, and emerging technological developments. Consultations shall be coordinated through the Indian Maritime Decarbonisation Alliance and the NCoEGPS secretariat, with below suggested engagement mechanisms:

i. Shipowners and shipping companies can engage through INSA representation on the NGMCC Advisory and through Working Group 1 and Working Group 2 consultations.

ii. Port operators and logistics providers shall engage through IPA representation on the NGMCC, Working Group 3 consultations, and the Annual Port Sustainability Forum.

iii. Financial institutions and investors shall engage through the SMFCL-led Green Maritime Finance Working Group 6.

iv. Technology developers and service providers shall engage through Working Group 4 and NCoEGPS-led Innovation Forums.

v. The ship recycling industry shall engage through Working Group 5 and in coordination with the State Maritime Board.

vi. Academic and research institutions shall engage through the IMU-NCoEGPS Research Consortium and Working Group 7.

vii. Coastal communities and local authorities shall engage through the Just Transition Safeguards mechanism within the NGMCC and in coordination with the Ministry of Fisheries, Animal Husbandry and Dairying.

viii. Environmental organisations shall engage through MoEFCC coordination and through Working Group 5 and Working Group 3 consultations.

ix. International partners shall engage through Working Group 8, the IMO National Focal Point, and MEA bilateral channels.

6.6 Monitoring, Evaluation and Review

6.6.1 The implementation of the NMDP shall be monitored through Key Performance Indicators drawn from MRV datasets maintained on NLP-Marine and other designated data sources. The NGMCC shall be responsible for maintaining performance datasets used for funding and compliance decisions. Indicators shall cover maritime GHG emissions and carbon intensity, renewable energy utilisation at major ports, alternative fuel adoption, number of certified green vessels and ports, Green Port Performance Index scores, green maritime investment mobilised, and maritime workforce training outcomes.

6.6.2 The NMDP shall be reviewed at least once every five years to incorporate emerging technologies, international regulatory developments, industry feedback, and evolving national climate objectives. The first review shall be completed by 2031.

PART V: International Cooperation and Diplomacy

1. International Cooperation as a Strategic Imperative

India's maritime decarbonisation agenda cannot be pursued in isolation. The sector operates within a globally integrated regulatory, financial, and technological ecosystem, one that is undergoing rapid and irreversible transformation. Three imperatives make international cooperation a structural necessity rather than a diplomatic preference.

The first is regulatory alignment. The IMO's revised GHG Strategy, the entry into force of the Hong Kong Convention, the EU's Fit for 55 package, and the emerging Net-Zero Framework under MARPOL Annex VI are collectively reshaping the terms on which ships access international trade routes, ports admit vessels, and capital flows to maritime projects. India's fleet, ports, and recycling yards operate within this system. The ability to influence, anticipate, and align with these frameworks rather than react to them determines whether India's maritime sector remains competitive or faces progressive market exclusion.

The second is technology access. The green maritime transition is technology-intensive, and the frontier technologies like ammonia-fuelled engines, onboard carbon capture, wind-assisted propulsion, hydrogen fuel systems, digital MRV platforms, are being developed and commercialised primarily in Norway, Denmark, Japan, South Korea, the Netherlands, and Singapore. India does not currently have domestic commercial capability across these technology clusters. Structured bilateral and multilateral partnerships are the fastest and most cost-effective pathway to technology transfer, joint R&D, and domestic capability development.

The third is financing. The scale of investment required for India's green maritime transition cannot be met through domestic public finance alone. Accessing international green finance flows, multilateral concessional capital, and sustainability-linked private finance requires India to demonstrate alignment with international green finance standards and build structured relationships with the multilateral institutions and international financial partners who are increasingly the gatekeepers of climate-aligned capital.

Taken together, these imperatives mean that international cooperation is not a supplementary activity, but it is a core enabler of the NMDPF's implementation across every pillar.

2. Global Maritime Decarbonisation Landscape — Technology and Regulatory Context

2.1 Green Technology

The pace of green maritime technology commercialisation has accelerated considerably since 2023. Technologies that were experimental three to five years ago are entering commercial deployment at scale, creating both an opportunity and an urgency for India to engage with the global technology ecosystem now rather than after standards and supply chains have consolidated without Indian participation.

- Wind-assisted propulsion including rotor sails, suction sails, and rigid wing sails, is delivering third-party verified fuel savings of 10–25% and is now specified in new vessel orders across bulk carrier, tanker, and RoRo segments. The global market was estimated at USD 7.7 billion in 2025.
- Ammonia-fuelled two-stroke engines entered commercial service in 2026, with MAN Energy Solutions and Wärtsilä leading engine supply globally.
- Methanol dual-fuel vessels are now in commercial operation, led by large containership operators, establishing methanol as a near-term transition fuel with growing bunkering infrastructure.
- Onboard carbon capture systems have completed initial sea trials on commercial vessels in Europe and Japan, with IMO regulatory guidance expected at MEPC 84 in 2026 — a development that will significantly affect compliance pathway choices for the global fleet.
- Autonomous vessel operations under human oversight are progressing toward commercial deployment, with the first crewless short-sea cargo operations expected by 2027 in regulated corridors in Northern Europe, signalling a medium-term transformation in crew requirements and vessel design.

2.2 Regulations

2.2.1 International Maritime Organisation (IMO):

- The IMO Net-Zero Framework under MARPOL Annex VI encompassing the GFI-based fuel standard and an economic instrument with Tier 1 and Tier 2 compliance levels is the defining global regulatory development of the current period.
- Operational efficiency and design standards remain in effect, including the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII), which grade vessels based on their annual operational performance
- Data collection systems (DCS) - Requires vessels to monitor and report data on fuel consumption, voyage details and emissions.

2.2.2 European Mandates

- The EU Emissions Trading System (EU ETS)- Shipping companies must surrender emissions allowances for voyages within the EU and a portion of international voyages
- FuelEU Maritime - Imposes strict limits on the yearly average greenhouse gas intensity of the energy used onboard a ship, with reduction targets spanning every five years through 2050
- Monitoring, Reporting and Verification (EU MRV): Requires vessels to monitor and report fuel consumption, emissions and other voyage data on EU-related voyages.

2.2.3 Other Global Mandates

- The Clydebank Declaration, signed by a growing coalition of nations committed to establishing green shipping corridors, and the Green Shipping Challenge launched at COP27, are creating a diplomatic architecture for corridor development that India must actively engage with.
- The Sustainable Fuel Certification Scheme and the IMO's LCA standards for marine fuels are establishing the certification infrastructure that will determine which fuels qualify as green

in international trade, a standard-setting process in which India has a direct interest as both a fuel-producing and fuel-consuming nation.

India's international cooperation agenda must be calibrated to this landscape, not merely tracking global developments but actively shaping the standards, corridors, and financial frameworks that will govern the sector for the next two decades.

3. India's Current International Engagement Landscape

India's international maritime cooperation portfolio spans bilateral partnerships, multilateral forum participation, corridor development frameworks, and programme-level engagements. While several of these are at varying stages of operationalisation, together they constitute a foundation on which the NMDPF's diplomatic agenda can be systematically built.

3.1 Bilateral Engagements

3.1.1 Norway — India's most substantive bilateral maritime relationship on decarbonisation. Engagement is anchored in the India-Norway bilateral Green Maritime Cooperation framework under the Green Voyage 2050 programme. Areas of active collaboration include alternative fuel safety standards, green propulsion systems, wind-assisted propulsion technology, and maritime decarbonisation financing. Norway's Green Shipping Programme is one of the most advanced national green shipping ecosystems globally and provides a policy and technology reference model for several NMDPF pillars.

3.1.2 Denmark — The India-Denmark Green Strategic Partnership includes a dedicated Centre of Excellence on green maritime cooperation. A pre-feasibility study on the Rotterdam-India-Singapore Green Shipping Corridor, being developed under this partnership, is expected in late 2026 and will form the basis for converting India's corridor ambitions into operationally specific project commitments with defined vessel targets, bunkering volumes and fuel certification requirements. Bilateral cooperation also extends to green skills, with faculty exchange and specialised certification programmes under development through Danish Maritime Authority mechanisms.

3.1.3 Japan — India and Japan maintain broad maritime and clean energy cooperation through bilateral economic and infrastructure partnerships. Japan's global leadership in ammonia fuel technologies, advanced shipbuilding and low-carbon industrial systems presents significant opportunities for future technology transfer and joint research supporting India's maritime decarbonisation agenda. Collaboration currently remains primarily technology- and industry-oriented rather than a dedicated bilateral green shipping programme..

3.1.4 Netherlands — India cooperates with the Netherlands on sustainable ports, logistics and circular economy initiatives through government and port-to-port engagement. Rotterdam's experience in alternative fuel bunkering, digital ports and industrial circularity provides valuable reference models for India's port decarbonisation and green corridor development.

3.1.5 Singapore — India and Singapore signed a Memorandum of Understanding on Maritime Digitalisation and Decarbonisation, establishing a formal framework for collaboration on maritime

innovation, digital systems, decarbonisation initiatives and the development of a green and digital shipping corridor. The partnership leverages Singapore's position as the world's largest bunkering hub and India's growing role as a major cargo and potential green fuel hub on Asia-Pacific trade routes.

3.2 Multilateral Forum Engagements

3.2.1 International Maritime Organization (IMO) — India participates actively in MEPC processes, including the development of the IMO Net-Zero Framework, GFI implementing regulations, the Sustainable Fuel Certification Scheme, IMO LCA standards for marine fuels, and safety codes for low-flashpoint fuels. India's engagement is calibrated to ensure that international standards reflect the operational realities and developmental priorities of major fuel-producing and fuel-consuming nations, consistent with the CBDR-RC principle.

3.2.2 IMO — GloLitter Partnerships Project — India has been designated as a Lead Partner Country under the GloLitter Partnerships Project, a joint IMO-FAO initiative helping developing countries tackle marine plastic litter from shipping and fisheries. India has published a dedicated National Action Plan under this programme, making it one of the most advanced developing-country participants in the global marine litter governance architecture.

3.2.3 International Maritime Organization – GreenVoyage2050 - India actively engages with IMO capacity-building programmes supporting National Action Plans, green fuel readiness, port decarbonisation and implementation of the IMO GHG Strategy.

3.2.4 International Organization for Standardization (ISO) **-** India participates in ISO technical committees relevant to maritime environmental management, sustainable procurement and greenhouse gas accounting, supporting harmonisation with international standards.

3.2.5 Hong Kong International Convention (HKC) - Following the entry into force of the HKC, India's ship recycling framework is increasingly integrated with the global convention architecture, making engagement through IMO implementation processes a key component of its international cooperation strategy.

4. India's Position in Global Maritime Governance

4.1 India's Overarching Posture

India approaches global maritime governance as a constructive and active participant engaging substantively in the development of international frameworks while ensuring that the pace, design, and burden-sharing of the global maritime transition reflects the developmental realities of major emerging economies. This posture is anchored in the principle of Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC), which India has consistently articulated across climate and environmental negotiations and which applies with equal force to the maritime sector.

India is not a passive recipient of internationally determined standards. As the world's largest democracy, a top-five global maritime nation by multiple metrics, and an emerging hub for shipbuilding, ship recycling, alternative fuel production, and port infrastructure, India has both the standing and the strategic interest to shape the international frameworks within which it will

operate for the next five decades. The NMDPF positions international engagement not merely as alignment with external requirements but as an active exercise of India's maritime diplomacy.

4.2 IMO Engagement — Key Processes and India's Positions

The IMO's revised GHG Strategy (2023) establishes indicative checkpoints of 20% emissions reduction by 2030 and 70% by 2040, with net-zero by or around 2050. The implementing instrument, the Net-Zero Framework under MARPOL Annex VI encompasses a GHG Fuel Intensity standard and an economic instrument with Tier 1 and Tier 2 compliance levels.

India's engagement on the Net-Zero Framework is calibrated to three priorities.

1. Ensuring that the GFI trajectory and compliance timelines reflect the infrastructure readiness and fuel availability constraints of developing and emerging economies, not only the decarbonisation ambitions of advanced maritime nations.
2. Ensuring that the economic instrument particularly the Tier 2 levy and the reward mechanism for zero and near-zero emission fuels does not disproportionately burden developing-country flag states and shipowners without corresponding technology transfer and financing support.
3. Ensuring that alternative fuel safety standards, certification frameworks, and LCA methodologies under development at IMO reflect the production realities of nations like India that are positioning as upstream green fuel producers particularly for green hydrogen, green ammonia, and green methanol.

India actively participates in MEPC processes and shall seek to formalise its positions through the inter-ministerial coordination architecture established under the NMDPF, ensuring that India's MEPC delegation reflects a unified national view across Ministry of Ports, Shipping and Waterways (MoPSW), Ministry of External Affairs (MEA), Ministry of Environment, Forest and Climate Change (MoEFCC) and the Ministry of Finance

5. Strategic Priorities for India's Maritime Diplomacy

India's international cooperation agenda is organised around 7 key pillars of NMDPF, each cutting across multiple goals and requiring coordinated diplomatic, institutional, and technical engagement.

5.1 Green Ships and Retrofitting

India's international cooperation agenda under this pillar shall focus on technology access, standards harmonisation, and shipping-side enablers for green corridor development. Green shipping corridors are addressed substantively under Green Fuels; references here are limited to vessel-side obligations and retrofit requirements.

5.1.1 ***Industry and Institutional Partnerships***

- India shall engage with Denmark, the Maersk Mc-Kinney Møller Centre and the Global Centre for Maritime Decarbonisation to accelerate hydrogen and methanol technology pathways for Indian-flagged and Indian-built vessels.
- India shall partner with classification societies and accredited testing laboratories to standardise Life-Cycle Emissions Reporting (LCER) frameworks applicable to Indian fleet segments.

- India shall participate in IMO's pilot for fuel lifecycle GHG validation under the GHG Fuel Standard (GFS) by 2027.
- India shall collaborate with Norway to access expertise on vessel retrofitting, energy efficiency technologies, and wind-assisted propulsion systems.
- India shall engage technology leaders in advanced engine technologies, onboard carbon capture and storage, advanced energy storage systems, and air lubrication systems to facilitate technology transfer and co-development with Indian shipyards.

5.1.2 ***Multilateral Engagement***

- India shall participate in Green Voyage 2050 (Phase 2) with focus on propulsion innovation and operational efficiency measures applicable to the Indian fleet.
- India shall align its vessel emission standards and retrofit guidelines with evolving IMO Tier III technical and operational measures, and shall engage actively in MEPC processes to safeguard its interests as a major flag and port state.

5.1.3 ***Green Shipping Corridors***

- India shall progress its participation in green shipping corridors including IMEC, the Rotterdam–India–Singapore route, the India–Singapore corridor, and the India–UAE corridor. Vessel readiness, retrofit requirements, and flag state obligations under these corridors shall be taken forward through bilateral engagement with corridor partner nations and relevant classification societies.

5.2 Green Ports

India's port sustainability agenda has a significant international cooperation dimension that extends beyond technology transfer into diplomatic positioning, knowledge exchange, and brand building.

5.2.1 ***Sister-Port Partnerships***

- India shall establish formal bilateral sister-port arrangements between Indian major ports and leading international green ports as a structured mechanism for benchmarking, best practice exchange, and joint pilot deployments.
- Priority partner ports shall include Rotterdam, PSA Singapore, the Port of Oslo, Yokohama, and Busan, reflecting the geographic spread of India's bilateral maritime partnerships and the technology clusters most relevant to India's port decarbonisation agenda.

5.2.2 ***Multilateral Platform Engagement***

- India shall engage with the European Green Ports Initiative and the Asian Smart Ports Network as the two most substantive multilateral port sustainability platforms to benchmark Indian port performance and access global best practice.
- Engagement shall specifically target clean energy and electrification, alternative fuels and zero-emission technologies, digital and smart port systems, and R&D collaboration on emerging port decarbonisation technologies.

- India shall seek to position Indian ports as active contributors within the global green ports ecosystem, moving beyond technology recipient status to co-develop standards and share implementation learnings from one of the world's largest port development programmes.

5.3 Green Ship Recycling

India's international cooperation under this pillar shall focus on regulatory alignment, bilateral partnerships, and knowledge exchange to position Indian ship recycling yards as globally preferred, environmentally sound facilities.

5.3.1 ***Regulatory Alignment and Compliance***

- India shall engage with IMO and flag state administrations to progress formal HKC authorisation for eligible Indian yards and ensure India's ship recycling regulatory framework remains aligned with evolving international standards.
- India shall engage with the European Commission and relevant EU member state authorities to understand EUSRR requirements and facilitate compliance readiness for Indian yards seeking to recycle European-flagged vessels.

5.3.2 ***Bilateral and Multilateral Partnerships***

- India shall establish partnerships with Japan, and South Korea to access expertise in environmentally sound recycling practices, yard infrastructure upgradation, worker safety systems, and hazardous material management.
- India shall participate actively in international ship recycling forums to contribute India's experience as the world's largest ship recycling nation and shape global standards in a manner consistent with India's development interests.

5.3.3 ***Knowledge Exchange and Technical Cooperation***

- India shall explore potential knowledge exchange and technical support under the Safe and Environmentally Sound Recycling of Ships (SENSREC) programme, a collaboration between the Government of Norway and IMO to support developing countries in implementing the Hong Kong Convention

5.4 Green Finance

India's green maritime transition requires international capital at a scale that domestic public finance cannot provide alone. The strategic priority is to build the institutional relationships, taxonomy alignments, and project pipelines that make India's maritime sector eligible for and attractive to international green finance flows. Three tracks of international financial engagement shall be pursued simultaneously.

5.4.1 ***Multilateral Concessional Finance***

- India shall deepen the engagement with the Green Climate Fund, Global Environment Facility, and AIIB to develop co-financing arrangements for green maritime infrastructure, with a focus on alternate fuels infrastructure, port electrification, and digital MRV systems.

5.4.2 ***Sustainability-linked Private Finance***

- Engagement with Poseidon Principles signatory banks, representing approximately USD 185 billion in global ship finance, to ensure that Indian maritime entities and financial institutions are positioned to access and participate in sustainability-linked ship finance arrangements.

5.4.3 ***Green Bond Market Development***

- Leveraging partnerships with Standard Chartered, Lloyd's Register, Climate Fund Managers, and APM Terminals to structure India's first green maritime bond issuances and develop the second-party assurance infrastructure required for international credibility.

5.4.4 ***Maritime ESG Taxonomy***

- The taxonomy shall be aligned with the EU Taxonomy, ICMA Green Bond Principles, and IFC Performance Standards ensuring that Indian maritime entities accessing international capital markets can demonstrate alignment with globally recognised green finance standards.

5.5 Green Skills

India's green maritime skills agenda has a direct international dimension — both in terms of accessing global green maritime expertise and in positioning India as a preferred hub for green maritime training and certification.

- Partnerships with BIMCO, EMSA, and IMA-accredited training institutions shall be institutionalised to support international recognition of Indian maritime qualifications, alignment of India's green skills curriculum with globally recognised certification frameworks, and access to specialised training in alternative fuel handling, MRV systems, and green port operations.
- Mutual recognition agreements with IMO, leading classification societies, and global maritime academies shall be pursued to ensure that Indian seafarers and maritime professionals trained in India's green skills ecosystem are recognised and employable internationally.
- Bilateral green skills cooperation with Denmark and Japan, covering faculty exchange, joint curriculum development, and specialised certification programmes, shall be formalised through existing bilateral maritime cooperation frameworks.
- Training exchange programmes between India's Maritime Energy Training Facility and leading international cruise operators including Viking and Royal Caribbean shall be operationalised as part of the inland and coastal waterway green transition agenda.
- India's longer-term aspiration shall be to become a net exporter of green maritime training — developing India-origin certification programmes, training methodologies, and green maritime education products deployable across Indian Ocean Region states and developing maritime nations.

5.6 Green Fuels and Bunkering

India's geographic positioning at the intersection of East–West and Middle East–Asia trade routes creates a structural opportunity to emerge as a regional hub for alternative marine fuels. Realising this opportunity requires coordinated international engagement across fuel certification, corridor

development, bilateral partnerships, and multilateral standard-setting moving from corridor aspiration to operationally specific bunkering commitments.

5.6.1 ***Multilateral and Bilateral Engagement***

- India shall deepen engagement under the India–Denmark Green Strategic Partnership**,** including through the Maersk Mc-Kinney Møller Centre, to accelerate methanol and hydrogen fuel pathways and progress the Rotterdam–India–Singapore corridor pre-feasibility study expected in late 2026.
- India shall engage with the UAE on upstream green hydrogen and green ammonia production particularly from Abu Dhabi as a natural supply relationship with India's bunkering infrastructure development along the India–Middle East–Europe route.
- India shall seek to accede to the Clydebank Declaration**,** formally committing to green shipping corridor development, and shall engage with the Green Shipping Challenge to position Indian ports as preferred bunkering and fuel export hubs on key international trade routes.
- India shall engage wit**h** EU Fit for 55 processes and the International Fuel Certification Framework under MEPC to monitor regulatory developments that affect market access for Indian-bunkered vessels on European trade routes, and align domestic standards accordingly.

5.6.2 ***Green Shipping Corridors***

India shall progress four priority corridor commitments, with bunkering infrastructure, fuel certification, and financing dimensions coordinated across corridor partner nations:

- Rotterdam–India–Singapore: The most strategically significant corridor, traversing the Europe–Middle East–Asia route. Developed under the India–Denmark Green Strategic Partnership; pre-feasibility study expected late 2026. India's role is as a mid-route bunkering and fuel certification hub, with Kochi and JNPA as primary Indian port nodes.
- India–Singapore: Anchored in high-volume bilateral trade and Singapore's position as the world's largest bunkering hub; focus on co-developing certification and supply chain architecture for South Asia–Southeast Asia trade.
- India–UAE: Aligned with IMEC and the India–UAE bilateral relationship; positions Indian west coast ports as green bunkering waypoints on the India–Middle East–Europe route, with upstream fuel supply linkages to Abu Dhabi.
- IMEC Green Infrastructure Backbone: India's corridor diplomacy shall be coordinated with IMEC infrastructure planning to ensure green bunkering, shore power, and alternative fuels investments are sequenced with IMEC port development timelines.

5.6.3 ***DNV–IMO Alternative Fuels Study: Strategic Implications for India's Bunkering Diplomacy***

The *Study on Potential Demand and Pricing of Alternative Marine Fuels in India* (DNV, 2026), conducted in partnership with DG Shipping and MoPSW, provides the analytical foundation for India's green fuels diplomacy. Four findings are directly relevant to India's international engagement:

- Credible near-term bunkering demand lies with cargo-calling vessels, not passing traffic — India's corridor and bunkering diplomacy must therefore be anchored in ports with strong origin-destination cargo volumes, particularly Mundra, JNPA, Chennai, and Tuticorin.

- Container shipping is the most predictable early adopter segment, given its concentration among large operators with decarbonisation commitments and predictable route patterns — bilateral engagement with major container shipping nations and operators should be prioritised accordingly.
- Delivered fuel cost competitiveness is the primary determinant of bunkering decisions — meaning India's international engagement must extend beyond infrastructure commitments to active work on port charge rationalisation, GST treatment of marine fuels, and fiscal support mechanisms that close the cost gap with competing hubs.
- India's opportunity lies in clustered multi-port bunkering hubs rather than isolated pilots — a hub-and-spoke architecture across Kandla/Deendayal, JNPA, Kochi, Tuticorin, and Paradip is more credible and scalable, and should form the basis of India's bunkering offer to corridor partners.

The study proposes a phased approach — *Establish (2026–2030), Scale (2030–2035), and Position (2035–2047)* — that India shall use as the reference framework for sequencing its international bunkering commitments and corridor operationalisation timelines.

5.7 Green Technology

India's most immediate international cooperation need is access to frontier green maritime technologies not yet domestically available at commercial scale. The strategic priority is to convert aspirational bilateral partnerships into structured technology transfer arrangements with defined deliverables, timelines, and domestic capability development components.

5.7.1 ***Priority Technology Clusters***

- India shall pursue international partnerships for advanced engine technologies for alternative fuels like ammonia, methanol, and hydrogen with MAN Energy Solutions, Wärtsilä, and leading Japanese and Korean OEMs as primary counterparts.
- India shall engage European and Japanese technology developers on onboard carbon capture and storage systems, where commercial deployment-ready technology exists and Indian shipyards and operators require structured access.
- India shall partner with Norwegian and Danish developers on wind-assisted propulsion systems, where leading intellectual property and installation experience is concentrated, to enable pilot deployments on Indian-flagged vessels.
- India shall engage European and East Asian OEMs on advanced energy storage systems and air lubrication systems for integration into Indian newbuild and retrofit programmes.
- India shall engage Singapore, Norway, and Denmark the most advanced deployment environments on digital MRV platforms and autonomous vessel systems, with a focus on regulatory alignment and technology piloting at Indian ports.

5.7.2 ***Partnership Framework***

- Partnerships with Norway, Denmark, Japan, Republic of Korea, the Netherlands, Singapore, and the UAE shall be the primary vehicles for technology transfer under this pillar.
- Each partnership shall be structured around a defined technology cluster, a joint R&D programme, a pilot deployment commitment in India, and a domestic capability development

pathway progressing from technology import to joint manufacturing and eventually to export-ready Indian green maritime technology products.

5.8 Pollution Prevention

India's international cooperation under this pillar shall focus on aligning domestic pollution prevention frameworks with global conventions, advancing India's leadership in IMO-led environmental programmes, and building bilateral and multilateral partnerships for marine pollution abatement across noise, litter, biofouling, ballast water, and air emissions.

5.8.1 ***IMO Programme Engagement***

- India shall deepen its engagement under the GloLitter Partnerships Programme a joint IMO–FAO initiative to reduce plastic litter and other solid waste from ships and fisheries as a priority commitment under this pillar, progressing from awareness and capacity building to measurable port waste reception facility improvements and crew training at scale.
- India shall engage with IMO's GloFouling Partnerships Programme to address biofouling as both a pollution and biosecurity risk, aligning India's anti-fouling management frameworks with the IMO Biofouling Guidelines and contributing to the development of a mandatory instrument currently under consideration at MEPC.
- India shall engage with GloNoise under IMO's relevant programmes to address underwater radiated noise and biofouling as co-benefits of the green shipping transition.

5.8.2 ***Convention Alignment and Bilateral Engagement***

- India shall strengthen implementation of MARPOL Annexes across all six pollution categories oil, noxious liquid substances, harmful substances in packaged form, sewage, garbage, and air emissions and shall engage bilaterally with port state control regimes to ensure Indian-flagged vessels and Indian ports meet or exceed prevailing international standards.
- India shall engage with key partner nations on port waste reception facility standards, ship-generated waste management protocols, and circular economy linkages between ship recycling and broader marine waste reduction objectives.
- India shall align its Ballast Water Management implementation with the IMO BWM Convention, engaging with type-approval authorities and bilateral partners to accelerate onboard treatment system adoption across the Indian-flagged fleet and ensure Indian ports have adequate reception and monitoring capacity.

5.8.3 ***Regional Cooperation***

- India shall engage with SACEP (South Asia Co-operative Environment Programme) and the Regional Seas Programme to advance coordinated pollution prevention action across the Indian Ocean region, positioning India as the lead maritime nation in driving regional adoption of IMO pollution prevention standards.
- India shall pursue bilateral cooperation agreements with Indian Ocean rim states on marine litter, underwater noise, and air emissions from shipping, building on India's existing maritime diplomacy partnerships to extend pollution prevention commitments beyond flag state obligations into regional environmental leadership.

5.9 Indian Ocean Centre of Excellence — IOCE Smart

The Indian Ocean Centre of Excellence for Smart and Sustainable Shipping is a significant institutional vehicle for regional maritime leadership. Proposed to be anchored at the Indian Maritime University with NGMCC oversight, IOCE Smart shall serve as the knowledge, policy, and capacity building hub for Indian Ocean Region states navigating the green maritime transition.

A DGMA-led assessment and stakeholder engagement process is underway, with MEA coordination to ensure that the Centre's mandate aligns with India's broader Indian Ocean diplomacy objectives. The NMDPF

designates operationalisation of IOCE Smart as a near-term institutional priority, with a target of formal establishment within the short-term horizon.

IOC Smart's programme mandate shall cover policy advisory support for Indian Ocean littoral states, green maritime technology demonstration and transfer, alternative fuels safety and certification training, MRV system capacity building, and annual Indian Ocean Green Maritime Forum convening — positioning India as the regional reference point for sustainable shipping governance.

6. Institutional Architecture for Maritime Diplomacy

6.1 Coordination Structure

Effective international cooperation requires a dedicated institutional architecture that connects India's maritime technical expertise with its diplomatic capabilities. Currently, maritime international engagement is distributed across MoPSW, DGMA, MEA, and MoEFCC without a unified coordination mechanism. The NMDPF establishes a structured architecture to address this gap.

The **NGMCC International Cooperation Working Group** shall function as the nodal coordination mechanism for all maritime diplomacy activities under the NMDPF. Its mandate covers bilateral partnership development and monitoring, multilateral forum preparation and follow-up, corridor governance oversight, IMO delegation coordination, and international cooperation target tracking. The Working Group shall include representation from MoPSW, DGMA, MEA, MoEFCC, SMFCL, IRS, and relevant industry associations.

The **Inter Ministerial Taskforce on Maritime Decarbonisation (IMTMD)** shall ensure that India's international maritime positions are coordinated across ministries — particularly MEA, Ministry of Finance, MoEFCC, and Ministry of External Affairs before IMO MEPC sessions, bilateral negotiations, and multilateral forum engagements.

MEA coordination shall be institutionalised through a dedicated maritime diplomacy desk within MEA's economic diplomacy division, ensuring that maritime cooperation agenda items are incorporated into bilateral summit processes, trade agreement negotiations, and multilateral climate forum engagements.

6.2 Annual Maritime Diplomacy Calendar – *Indicative

India's international maritime engagement shall be structured around a defined annual calendar of diplomatic events, forum participations, and bilateral review meetings. The calendar shall include:

Month	Event	Type	Lead	Partners	Notes
January	IOCE Smart Governing Board Meeting (Q1)	Institutional	MoPSW	IMU, MEA	Quarterly once operationalised (Proposed)
March	MEPC Session (Spring) — preparation, position finalisation	Multilateral	DGS / NGMCC WG	MEA, MoEFCC, MoF	Pre-session inter-ministerial coordination required
	Singapore Maritime Week	International Event	MoPSW	SMFCL, IRS	India Maritime Pavilion; annual
April	MEPC Session (Spring) — post-session debrief	Multilateral	DGS / NGMCC WG	MEA, MoEFCC	Coordinated through NGMCC Working Group
	IOCE Smart Governing Board Meeting (Q2)	Institutional	MoPSW	IMU, MEA	Quarterly once operationalised (Proposed)
May	Nor-Shipping (biennial, Oslo)	International Event	MoPSW	SMFCL, IRS	India Maritime Pavilion; odd years
June	GloLitter NAP Annual Review	Programme Review	DGS	IMO, FAO	Annual review of India's National Action Plan
July	IOCE Smart Governing Board Meeting (Q3)	Institutional	MoPSW	IMU, MEA	Quarterly once operationalised
September	Annual National Green Shipping Dialogue	National Convening	MoPSW / NGMCC	Bilateral partners, multilateral institutions, corridor co-developers	International segment to be incorporated

October	MEPC Session (Autumn) — preparation, position finalisation	Multilateral	DGS / NGMCC WG	MEA, MoEFCC, MoF	Pre-session inter-ministerial coordination required
November	MEPC Session (Autumn) — post-session debrief	Multilateral	DGS / NGMCC WG	MEA, MoEFCC	Coordinated through NGMCC Working Group
	Europort (biennial, Rotterdam)	International Event	MoPSW	SMFCL, IRS	India Maritime Pavilion; odd years
December	Bilateral Review Meetings	Bilateral	MoPSW / NGMCC WG	Norway, Denmark, Japan, South Korea, Singapore, UAE, Netherlands	Annual review: technology transfer, corridors, green finance
December	IOCE Smart Governing Board Meeting (Q4) + Annual Report	Institutional	MoPSW	IMU, MEA	Annual public report on IOR capacity building outcomes

Annex 1: Abbreviations and Key Terms

AFS Convention	International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001/2008).
ALS	Air Lubrication System — micro-bubbles under hull to reduce frictional resistance; 5–10% fuel saving.
Basel Convention	Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989).
BWMC	Ballast Water Management Convention (2004/2017) — controls invasive species via ballast water treatment.
CBAM	Carbon Border Adjustment Mechanism — EU carbon price on imports from countries without equivalent pricing.
CBDR-RC	Common But Differentiated Responsibilities and Respective Capabilities — UNFCCC equity principle.
CCTS	Carbon Credit Trading Scheme — India's domestic carbon market under the EC Amendment Act 2022.
CII	Carbon Intensity Indicator — annual A–E operational GHG intensity rating for ships above 5,000 GT.
Clydebank Declaration	COP 26 government commitment to establish green shipping corridors; 30+ signatory states.
CRZ	Coastal Regulation Zone — Indian regulatory framework governing coastal land use and development.
DASR	Document of Authorisation to conduct Ship Recycling
DWT	Dead weight tonnage
EEDI	Energy Efficiency Design Index — mandatory CO2 performance standard for new ships (in force 2013).
EEXI	Energy Efficiency Existing Ship Index — one-time technical standard for existing ships (in force 2023).
EPA	Environment (Protection) Act, 1986 — India's principal umbrella environmental legislation.
EUSRR	European Union Ship Recycling Regulation
EU ETS	EU Emissions Trading Scheme — extended to maritime from January 2024.

FuelEU Maritime	EU regulation setting lifecycle GHG intensity limits for marine fuels at EU ports (from 2025).
GFI	Goal-based Fuel Intensity — IMO lifecycle GHG intensity standard for marine fuels (~2028 entry).
GHG	Greenhouse Gas — CO2, CH4, N2O and others; shipping contributes approximately 2.9% of global GHG.
Green Hydrogen Mission	India's National Green Hydrogen Mission (2023) targeting 5 MMTPA production by 2030.
Harit Sagar	India's Green Port Guidelines (2023) — framework for port decarbonisation and green bunkering.
HKC	Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (2009/2025).
ICMA	International Capital Market Association
IHM	Inventory of Hazardous Materials — mandatory ship document under the HKC listing hazardous content.
IGF Code	International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (in force 2017).
ILO	International Labour Organisation — UN agency establishing labour standards including for seafarers.
IMO	International Maritime Organisation — UN specialised agency for maritime safety and environment.
IRS	Indian Register of Shipping — India's national classification society; authorised IMO surveyor.
JIT Arrival	Just-in-Time Arrival — speed reduction to reach berth precisely when available, eliminating idle burn.
London Protocol	1996 Protocol to London Convention — governs ocean dumping; 2006 amendment covers marine CCS.
MAKV	Mission Amrit Kaal Vishwa Guru — India's 2047 centenary vision of Viksit Bharat.
MARPOL	International Convention for the Prevention of Pollution from Ships (73/78).
MIV 2030	Maritime India Vision 2030 — India's strategic framework for maritime sector development.
MLC 2006	Maritime Labour Convention — international minimum standards for seafarers' working conditions.

MRV	Measurement, Reporting and Verification — architecture for tracking and confirming GHG emissions.
NAPCC	National Action Plan on Climate Change (2008) — India's eight national climate missions.
NDC	Nationally Determined Contribution — national climate action plan under the Paris Agreement.
Poseidon Principles	Ship finance framework aligning bank lending portfolios with IMO GHG strategy trajectory (2019).
SDGs	Sustainable Development Goals — 17 goals of the UN 2030 Agenda (adopted 2015).
Sea Cargo Charter	Cargo owner and charterer commitment to disclose climate alignment of chartered shipping (2020).
SEEMP	Ship Energy Efficiency Management Plan — operational efficiency document required for all ships.
SIGHT	Strategic Interventions for Green Hydrogen Transition — production-linked incentive under Green H2 Mission.
SMFCL	Sagarmala Finance Corporation Limited
SOLAS	International Convention for the Safety of Life at Sea (current version 1974).
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.
UNCLOS	UN Convention on the Law of the Sea (1982/1994) — foundational legal architecture for ocean governance.
UNFCCC	United Nations Framework Convention on Climate Change (1992/1994).
WAPS	Wind-Assisted Propulsion Systems — Flettner rotors, rigid wing sails, kite sails; 5–30% fuel saving.
WHR	Waste Heat Recovery — recovering exhaust heat to generate auxiliary power; 3–10% fuel saving.
WtW / WtT / TtW	Well-to-Wake / Well-to-Tank / Tank-to-Wake — lifecycle GHG accounting boundary definitions.