# Green Shipping-Implementation Roadmap

# Document control

## Revision history

| Revision No. | Date | Revision |
|---|---|---|
| **1.0** | xx | First Draft |

# List of Abbreviations

| Acronym | Full Form |
|---|---|
| **ABB** | ASEA Brown Boveri |
| **ADB** | Asian Development Bank |
| **AI** | Artificial Intelligence |
| **ASEAN** | Association of Southeast Asian Nations |
| **BAU** | Business as Usual |
| **BIMSTEC** | Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation |
| **bio-LNG** | Bio Liquefied Natural Gas |
| **BMS** | Battery Management Systems |
| **BRICS** | Brazil, Russia, India, China, South Africa |
| **BRSR** | Business Responsibility and Sustainability Reporting |
| **BWTS** | Ballast Water Treatment Systems |
| **CAPEX** | Capital Expenditure |
| **CCS** | Carbon Capture & Sequestration |
| **CCUS** | Carbon Capture, Utilization, and Storage |
| **CIF** | Climate Investment Fund |
| **CII** | Carbon Intensity Indicator |
| **ClassNK** | Nippon Kaiji Kyokai (Japanese Classification Society) |
| **$CO_2$** | Carbon Dioxide |
| **COP26** | 26th United Nations Climate Change Conference |
| **DAC** | Direct Air Capture |
| **DGS** | Directorate General of Shipping |
| **DSME** | Daewoo Shipbuilding & Marine Engineering |
| **ECGC** | Export Credit Guarantee Corporation of India Limited |
| **EEXI** | Energy Efficiency Existing Ship Index |
| **EEZ** | Exclusive Economic Zone |
| **EIB** | European Investment Bank |
| **EPR** | Extended Producer Responsibility |
| **ESG** | Environmental, Social, and Governance |
| **ETS** | Emission Trading Scheme |
| **EU** | European Union |
| **EU ETS** | European Union Emissions Trading System |
| **EUSRR** | European Union Ship Recycling Regulation |
| **EV** | Electric Vehicle |
| **EXIM** | Export–Import |
| **FAME India** | Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India |
| **FDI** | Foreign Direct Investment |
| **GCF** | Green Climate Fund |
| **GE** | General Electric |
| **GEF** | Global Environment Facility |
| **GHG** | Greenhouse Gas |
| **GTTP** | Green Tug Transition Programme |
| **HFO** | Heavy Fuel Oil |

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| **IMO** | International Maritime Organization |
| **IWT** | Inland Water Transport |
| **IWAI** | Inland Waterways Authority of India |
| **LNG** | Liquefied Natural Gas |
| **LR** | Lloyd's Register |
| **LCA** | Life Cycle Assessment |
| **MARPOL** | International Convention for the Prevention of Pollution from Ships |
| **MEPC** | Marine Environment Protection Committee (IMO) |
| **MNRE** | Ministry of New and Renewable Energy |
| **MoEFCC** | Ministry of Environment, Forest and Climate Change |
| **MoPSW** | Ministry of Ports, Shipping and Waterways |
| **MRV** | Monitoring, Reporting and Verification |
| **NGSP** | National Green Shipping Policy |
| **NOx** | Nitrogen Oxides |
| **OPEX** | Operating Expenditure |
| **OMC** | Oil Marketing Company |
| **$PM_{2.5}$** | Particulate Matter (2.5 microns) |
| **PSU** | Public Sector Undertaking |
| **RIS** | River Information System |
| **SOx** | Sulphur Oxides |
| **SBFAP** | Shipbuilding Financial Assistance Policy |
| **VGF** | Viability Gap Funding |

# 1 Indicative Action Pathway

Establish a **national green shipbuilding framework that defines measurable environmental standards for vessels constructed in Indian shipyards and positions the domestic shipbuilding industry to compete in emerging global green vessel markets.**

India currently accounts for **<1% of global shipbuilding output**, while **China, South Korea and Japan together produce over 90% of global tonnage**. However, India's shipbuilding sector is expanding under **Sagarmala, Maritime India Vision 2030 and the Shipbuilding Financial Assistance Policy (SBFA)**. Introducing green shipbuilding standards early allows India to **align future shipyard expansion with next-generation vessel technologies rather than legacy shipbuilding pathways.**

The short-term phase therefore focuses on **building the regulatory architecture, technology partnerships, and industrial readiness necessary to enable green vessel construction in India.**

# 2 Short-term Action Plan (0-6 Months)

## Pillar 1: Green Ship Building

### A. Establish a National Green Shipbuilding Standards Taskforce

Create a **multi-stakeholder technical taskforce responsible for developing India's Green Shipbuilding Framework**, which will define environmental standards and certification criteria for vessels constructed in Indian shipyards.

**Key Design Elements:**

The taskforce will develop the first version of India's **Green Shipbuilding Framework**, covering four core components:

1. **Green vessel performance standards**
   Define minimum energy-efficiency improvements beyond IMO baseline requirements for vessels constructed in India.

2. **Future-fuel readiness requirements**
   Establish design provisions that enable vessels to accommodate alternative fuels such as LNG, methanol or ammonia without major structural modification.

3. **Digital emissions monitoring requirements**
   Define minimum onboard systems required for monitoring fuel consumption and emissions performance.

4. **Lifecycle documentation standards**
   Introduce basic material traceability and recyclability documentation requirements aligned with emerging international ship lifecycle standards.

**Implementation Approach:**

The Ministry of Ports, Shipping and Waterways will notify the taskforce and designate the Directorate General of Shipping as the coordinating authority.

To ensure that the framework is both **technically robust and practically implementable within Indian shipyards**, the taskforce will bring together four stakeholder groups covering regulation, technical expertise, shipbuilding operations, and marine technology providers.

| Stakeholder Group | Why They Are Required | Key Institutions | Role / Activities in the Taskforce |
|---|---|---|---|
| Regulatory Institutions | Provide policy authority and ensure alignment with maritime regulations, international conventions, and national shipping policy. | MoPSW, Directorate General of Shipping | Lead the taskforce, define regulatory scope of green ship standards, ensure alignment with IMO frameworks, and issue the final Green Shipbuilding Framework. |
| Technical and Classification Bodies | Provide engineering validation and ensure standards are technically credible and aligned with global ship classification practices. | Indian Register of Shipping, Indian Maritime University, IIT Madras (Ocean Engineering) | Develop technical parameters for green vessel performance, fuel readiness standards, and monitoring systems; validate engineering feasibility. |

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| Shipbuilding Industry | Ensure that the framework reflects the actual design, procurement, and construction capabilities of Indian shipyards. | Cochin Shipyard, L&T Shipbuilding, Goa Shipyard, Garden Reach Shipbuilders | Assess practical implementation within shipyard operations, provide feedback on construction feasibility, and test proposed design standards. |
| Marine Technology Providers | Provide insights into commercially available propulsion systems, hybrid technologies, and digital monitoring solutions. | Wartsila, MAN Energy Solutions, ABB Marine | Advise on propulsion technologies, energy efficiency systems, fuel transition technologies, and digital emissions monitoring solutions that can be adopted in Indian vessels. |

**Benchmark**

South Korea established a similar governance structure under the **Green Ship-K Programme**, where a national taskforce first defined green ship classification standards before launching public financing and subsidy programmes for low-emission vessels.[1]

## B. Introduce a National Green Ship Classification Framework

Establish a **national green ship classification framework** that defines measurable performance standards for vessels constructed in Indian shipyards and enables certification of green vessels under the National Green Shipping Policy.

**Key Design Elements**

The Green Ship Classification Framework will introduce a **tiered certification structure** to recognise progressive levels of environmental performance in new vessels constructed in India.

The framework will initially apply to vessel categories where Indian shipyards already have strong construction capabilities, including coastal cargo vessels, offshore support vessels, patrol vessels, and inland vessels.

The classification system will include three tiers.

| Tier | Classification Level | What Should Be Achieved | Technologies / Design Measures to be Considered | Benchmark Reference |
|---|---|---|---|---|
| Tier 1 | High Efficiency Vessel | Vessel must achieve **≥10–15% energy efficiency improvement** beyond IMO baseline requirements (EEDI/EEXI). Focus is on improving conventional vessel performance without major fuel transition. | Hull optimisation (advanced coatings, hydrodynamic design), high-efficiency propellers, waste heat recovery systems, variable speed drives, energy management systems, voyage optimisation software, digital fuel monitoring systems. | Singapore Green Ship Programme; EU EEDI improvement standards. |
| Tier 2 | Future Fuel Ready Vessel | Vessel must be designed so that **conversion to alternative fuels can occur without major structural modifications.** Efficiency improvement target ≥15–20% beyond IMO baseline. | Methanol-ready or LNG-ready fuel piping, reserved tank space for alternative fuels, structural reinforcement for cryogenic tanks, modular fuel supply systems, scalable power management systems, hybrid propulsion readiness, battery integration capability. | DNV “Fuel Ready” notation; ABS ammonia-ready standards; Japan alternative fuel vessel roadmap. |

[1] https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/NAP/R.O.K%20National%20Action%20Plan%20-%20Toward%20Green%20Shipping%20by%202050.pdf

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| Tier 3 | Zero Emission Ready Vessel | Vessel must be capable of operating with **zero-carbon propulsion technologies** once fuel supply infrastructure becomes available. Focus is on design compatibility rather than immediate deployment. | Hydrogen propulsion compatibility, ammonia-ready propulsion architecture, battery-electric propulsion systems for short sea vessels, fuel cell integration capability, advanced energy storage systems, full digital energy optimisation systems. | Norway zero-emission ferry programmes; EU hydrogen vessel pilots; Japan zero-emission ship initiative. |

**Certification Criteria Across Tiers:**

| Performance Dimension | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| Energy Efficiency | ≥10–15% improvement beyond IMO baseline | ≥15–20% improvement | ≥20% improvement |
| Fuel Transition Capability | Conventional fuel systems | LNG/methanol ready | Hydrogen/ammonia ready |
| Digital Monitoring | Basic fuel monitoring systems | Integrated energy management systems | Full digital optimisation & emissions monitoring |
| Power System Architecture | Conventional propulsion | Hybrid-ready | Electric / fuel cell compatible |

**Recommended vessel categories for early green shipbuilding adoption in India**

In the Indian context, early green shipbuilding adoption should be concentrated in vessel categories where domestic yards already possess construction capability, where public or commercial demand is visible, and where low- or zero-emission technologies are operationally feasible without waiting for full deep-sea fuel infrastructure. Accordingly, the first wave of implementation should prioritise inland and urban passenger ferries, harbour tugs, coastal short-sea cargo vessels, and selected offshore service vessels. This sequencing is more practical than attempting early deployment in large ocean-going merchant segments, where India currently faces greater technology, supply-chain, and capital barriers.

| Priority | Vessel Category | Why it is suitable for early adoption in India | Latest quantified signal / evidence base |
|---|---|---|---|
| **Priority 1** | **Inland / urban passenger ferries** | This remains the strongest first-mover category because ferries operate on **fixed routes, short sailing distances, predictable duty cycles, and return-to-base operations**, which make **battery-electric and hybrid-electric propulsion** far more practical than for blue-water vessels. The demand side is also easier to anchor because state governments and urban transport agencies can procure these vessels directly. | Kochi Water Metro is deploying **23 battery-electric ferries**, with the broader system designed to operate across **15 routes covering more than 75 km of waterways**[2]. GRSE is also building **one next-generation electric ferry** for the Government of West Bengal along |

[2] https://watermetro.co.in/

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| | | | with **13 hybrid ferries** ordered by the state[3]. |
| **Priority 2** | **Harbour tugs / port service craft** | Tugs are highly suitable because they operate within **port limits**, have **short and repetitive duty cycles**, and can transition first to **hybrid-electric** and then to **full-electric** propulsion with shore-based support. Unlike many other vessel classes, they also benefit from a visible government procurement pathway through the major ports. | India has launched the **Green Tug Transition Programme (GTTP)** targeting **50 green tugs by 2030**, with **16 green tugs planned in Phase 1 (2024–2027)**. Major ports will deploy at least **two green tugs each**, while other ports will deploy at least **one tug each**[4]. |
| **Priority 3** | **Coastal short-sea cargo vessels** | This is the strongest category for scaling beyond demonstration because it links green shipbuilding to **real logistics demand** under Sagarmala and coastal-shipping expansion. These vessels can adopt a practical first-wave pathway: **high-efficiency conventional designs, diesel-electric / hybrid systems, and methanol-ready or LNG-ready architecture**, without depending on immediate zero-carbon bunkering availability. | Major Indian ports handled **195.82 million tonnes of coastal cargo in FY 2024–25**, and India had **1,041 Indian-flagged vessels engaged in coastal trade as of June 2024**. Indian shipyards already have experience constructing vessels in the **3,000–8,000 DWT coastal cargo range**, including diesel-electric general cargo vessels and multipurpose vessels. |
| **Priority 4** | **Selected offshore / wind service vessels** | This is best positioned as a **targeted technology-demonstration and capability-building category**, not the first mass-deployment category. The rationale is still strong: India already has offshore vessel construction know-how, and hybrid propulsion is proven internationally in this segment. It is especially relevant for offshore wind support and service operations, where hybrid, methanol-ready, and battery-assisted designs are now commercially visible. | Indian shipyards such as Cochin Shipyard have secured international orders for **hybrid wind farm service operation vessels (SOVs)** and **methanol-ready hybrid commissioning service operation vessels (CSOVs)**. |
| **Priority 5** | **Selected patrol / utility craft** | This is a useful **government-led demonstration category**, especially where central or state agencies can absorb modest first-cost premiums in exchange for fuel savings, lower signatures, and domestic capability development. It is less suitable as the main commercial launch category, but still valuable for proving hybridisation, digital monitoring, and compact battery systems. | Shipyards such as GRSE, Goa Shipyard, and Cochin Shipyard currently maintain large orderbooks for patrol and offshore patrol vessels, providing opportunities to integrate hybrid propulsion or advanced energy monitoring systems in future designs. |

**<u>Categories that should be treated as second-wave, not first-wave</u>**

| Category | Why not first-wave |
|---|---|

[3] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2132315&reg=3&lang=2
[4] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2198444&reg=3&lang=1

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| **Large ocean-going container ships / large tankers / LNG carriers** | India does not yet have the same scale, vendor depth, or green propulsion integration ecosystem as Korea, China, or Japan for these segments. The capital intensity is high, the technology risk is higher, and early failures would weaken policy credibility. |
| **Complex naval combatants as a primary green-shipbuilding category** | Indian defence yards absolutely have shipbuilding capability, but naval procurement cycles, mission requirements, and confidentiality make them less suitable as the main "market-making" category for a civilian green shipbuilding framework. Defence-led pilots can still be useful later, especially for hybrid auxiliary or patrol platforms. |
| **Full zero-emission blue-water merchant vessels** | This is too ambitious for the first 6 months because India still faces gaps in bunkering, alternative fuel systems, marine batteries at scale, and domestic integration capability. The near-term objective should be **efficiency-first, hybrid-first, and fuel-ready-first**, not immediate full zero-emission deployment. This is also broadly consistent with the NGSP's technology-neutral and phased approach. |

**What this means for the tier framework**

| Tier | Best-fit Indian vessel categories | Practical interpretation |
|---|---|---|
| **Tier 1 – High Efficiency Vessel** | Coastal cargo vessels, offshore support vessels, patrol / utility craft, tugs | Focus on hull optimisation, efficient propulsion, energy management, digital monitoring, and low-risk emissions reduction packages. |
| **Tier 2 – Future-Fuel Ready Vessel** | Coastal cargo vessels, offshore service vessels, larger tugs | Focus on **methanol-ready / LNG-ready / hybrid-ready** design, reserved tank space, electrical margins, modular piping, and digital MRV architecture. |
| **Tier 3 – Zero-Emission Ready Vessel** | Inland passenger ferries, urban ferries, selected harbour craft | Focus on **battery-electric / battery-hybrid / fuel-cell-ready** architectures where route profile and charging logic actually make zero-emission operation practical. |

## C. Develop the Regulatory and Design Framework for Alternative-Fuel-Ready Vessels

Develop a **national regulatory and technical framework governing alternative marine fuels and future-fuel-ready vessel design**, ensuring that vessels constructed in Indian shipyards can transition to low- and zero-carbon fuels without major structural redesign.

**Key Design Elements:**

**1. Development of Rules for Alternative Marine Fuels**

Establish national guidelines governing the **safe use, storage, and certification of alternative marine fuels** in vessels built in India.

The framework should initially prioritise fuels that are technically feasible within the current Indian maritime ecosystem, including:

- LNG
- Methanol
- Hybrid-electric propulsion systems

Longer-term fuels such as **ammonia and hydrogen** should initially be addressed through **design-readiness requirements**, rather than immediate operational deployment.

**2. Embed "Future-Fuel Ready by Design" Standards**

Introduce **design-stage provisions ensuring that vessels constructed today remain compatible with future fuel transitions**.

Key design provisions should include:

- reserved space for future fuel tanks
- structural reinforcement allowances
- electrical capacity margins
- modular piping and fuel supply architecture
- documentation demonstrating retrofit feasibility

This approach prevents **technology lock-in and stranded ship assets**, while allowing shipowners to adopt alternative fuels when infrastructure becomes available.

**Implementation Approach:**

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Regulatory Gap Assessment** | Conduct a structured review of existing international regulations governing alternative marine fuels and identify gaps in India's current regulatory framework. This review will cover safety requirements, vessel design standards, bunkering systems and certification processes. | The assessment will use international frameworks such as the **IMO International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)** and classification society standards such as **DNV's Fuel Ready notation and ABS alternative fuel guidance**. |
| **Development of Alternative Fuel Regulatory Guidelines** | Draft national guidelines governing the safe design and operation of vessels using LNG, methanol and hybrid propulsion systems. The guidelines will define fuel storage systems, safety distances, bunkering procedures, and vessel approval requirements. | Several countries have introduced fuel-specific frameworks before large-scale deployment. **Singapore and Norway issued early regulatory guidance for LNG-fuelled vessels**, enabling their shipyards to adopt LNG propulsion while infrastructure was still developing. |

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| **Future-Fuel-Ready Vessel Design Standards** | Introduce mandatory design provisions ensuring vessels constructed in Indian shipyards can accommodate future alternative fuels without major redesign. Design approval submissions should demonstrate space reservation for fuel tanks, structural reinforcement allowances, modular piping systems, and electrical capacity margins. | Major classification societies already apply similar design approaches. For example, **DNV and ABS offer ammonia-ready and methanol-ready ship notations**, where vessels are designed with structural allowances that enable future fuel conversion. |
| **Industry Validation and Technology Assessment** | Engage shipyards, propulsion system manufacturers, and shipowners to evaluate the feasibility and cost implications of the proposed fuel-ready design standards and regulatory requirements. | Countries such as **Japan and Norway have used industry working groups to validate fuel-ready vessel designs before regulatory rollout**, ensuring shipyards can implement new standards without major cost disruptions. |
| **Regulatory Notification and Integration with Ship Approval Process** | Issue the final guidelines through DG Shipping and integrate them into the existing ship design approval process used for vessels built in Indian shipyards. | This ensures that fuel-ready standards become part of the **standard ship approval and classification process**, rather than creating a separate certification system. |

## D. Establish Green Ship Technology Partnerships and Transfer Mechanisms

Set up a **targeted technology transfer and industrial partnership programme** for the green-ship systems that Indian yards do not yet fully control in-house, so that early green shipbuilding does not depend entirely on imported turnkey packages.

**<u>India Technology Gap Analysis for Green Shipbuilding</u>**

| Technology Area | Current Capability in Indian Shipyards | Specific Gap in Indian Context | Why It Matters for India's Green Shipbuilding Transition |
|---|---|---|---|
| **Battery-electric propulsion systems** | Indian shipyards such as Cochin Shipyard and GRSE have built electric and hybrid ferries and are integrating battery propulsion packages supplied by foreign OEMs. | India lacks domestic manufacturing of **marine-grade battery packs, battery management systems (BMS), thermal protection systems, and integrated marine energy storage modules**. Most battery systems are imported or supplied as integrated packages by foreign vendors. | Battery-electric propulsion is the most practical near-term pathway for **ferries, harbour craft and some port vessels**. Without domestic integration capability, India will remain dependent on imported propulsion packages. |

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| **Hybrid propulsion and energy management systems** | Indian yards are able to integrate hybrid propulsion when supplied by system integrators such as Wärtsilä or ABB. Hybrid vessels are already being built for offshore support and ferry segments. | India does not yet have strong domestic capability in **DC grid vessel architecture, power management systems, hybrid propulsion control software, and high-efficiency power converters**. | Hybrid propulsion systems are likely to become the dominant pathway for **coastal cargo vessels, offshore vessels, and port service vessels** in the medium term. |
| **Methanol-ready propulsion systems** | Indian shipyards have started building methanol-ready vessels (for example hybrid service vessels), showing that the design architecture can be implemented. | India lacks domestic manufacturing and integration capability for **methanol fuel supply systems, fuel injection equipment, safety monitoring systems, and engine control systems required for methanol propulsion**. | Methanol is widely seen as one of the most realistic transition fuels for global shipping. Developing methanol-ready capability allows Indian yards to remain competitive in export markets. |
| **Ammonia-ready vessel design** | Some Indian yards are capable of incorporating structural design allowances for alternative fuels. | India lacks domestic experience with **ammonia fuel containment systems, fuel treatment systems, toxicity monitoring, and safety systems required for ammonia-powered ships**. | Ammonia is expected to be an important long-term marine fuel for large ocean-going vessels. Even if ammonia propulsion is not immediately deployed, **design readiness is essential to avoid stranded assets**. |
| **Hydrogen propulsion and fuel cell systems** | Hydrogen propulsion has not yet been deployed in Indian shipbuilding projects, although pilot concepts exist globally. | India lacks domestic capability in **marine hydrogen fuel cells, hydrogen storage systems, cryogenic fuel tanks, and integration of fuel cell propulsion architectures into vessel design**. | Hydrogen propulsion may become relevant for **short-sea and passenger vessels in the long term**, but in the short term India should focus on **design readiness rather than deployment**. |
| **Digital vessel monitoring and energy optimisation systems** | India has strong digital engineering capability but most onboard energy optimisation systems used in vessels are supplied by foreign marine technology companies. | India lacks a standardised domestic platform for **fuel consumption monitoring, emissions reporting, vessel energy optimisation, and integration with maritime MRV systems**. | Digital monitoring systems will become essential for **performance-based incentives, emissions reporting, and carbon regulation compliance**. |
| **Marine battery charging infrastructure and shore integration** | Initial electric ferry projects have begun integrating charging systems with shore infrastructure. | India lacks standardised solutions for **high-capacity marine charging systems, shore power integration, and port-vessel energy management systems**. | Charging infrastructure is critical for scaling **electric ferries and electric harbour craft**, especially in urban water transport systems. |

**Priority technology transfer tracks for India**

India should not try to acquire everything at once. The short-term programme should focus on three priority transfer tracks.

**Track 1: Battery-electric and hybrid systems for ferries, tugs and harbour craft**
This is the most practical first track because India already has visible projects in electric ferries, hybrid ferries, and green tugs. The transfer focus should be on marine battery packs, battery management systems, charging interfaces, power conversion systems, and integrated energy-management software. Norway is the strongest benchmark partner here because its maritime decarbonisation programmes, backed by Enova and the Green Shipping Programme, scaled battery-electric and hybrid vessel deployment through technology demonstration before mass adoption.

**Track 2: Methanol-ready propulsion and fuel systems for coastal cargo and offshore vessels**
India should treat methanol-ready systems as the first serious fuel-transition track for shipbuilding. DG Shipping’s own

coastal green shipping material notes that methanol technologies are currently more advanced than ammonia and hydrogen for near-term marine use. The transfer focus here should be on fuel supply modules, piping architecture, control systems, engine integration, and design standards. South Korea and Japan are the strongest practical benchmarks because both are moving aggressively on methanol- and ammonia-capable ship technology through shipyards, class societies, and industrial OEM partnerships.

**Track 3: Digital energy optimisation and compliance systems**

India should treat digital vessel optimisation as a core green-shipbuilding capability, not an accessory. Singapore is the strongest benchmark because its green shipping programme combines technical standards with operational performance incentives and digitalisation. Denmark is also relevant for energy-efficient design and vessel performance optimisation. The short-term objective should be to secure software and systems partnerships for fuel monitoring, voyage optimisation, onboard energy dashboards, and MRV-compatible reporting.

## Preferred Partner Countries and Why They Matter

India does not need to replicate the entire technological ecosystem of leading shipbuilding nations immediately. Instead, the short-term objective should be to **combine international technology access with domestic shipyard integration capability**, allowing Indian shipyards to gradually develop expertise in green vessel design and construction.
Strategic partnerships with countries that already lead in specific green maritime technologies will enable India to **accelerate its transition to green shipbuilding while avoiding high development costs and long technology learning curves.**

| Partner Country | Current Leadership in Green Maritime Technologies | Why This Partner Matters for India | Practical Areas of Collaboration for India |
|---|---|---|---|
| **Norway** | Global pioneer in battery-electric vessels, hybrid ferries and maritime decarbonisation programmes. Norway has deployed hundreds of electric and hybrid vessels in domestic ferry operations and has built a mature ecosystem around marine batteries, hybrid propulsion and charging infrastructure. | Norway's experience is directly relevant to India's **urban ferry, inland vessel and harbour craft segments**, which represent the most practical first wave of green shipbuilding in India. | Technology partnerships on **marine battery systems, battery management systems, charging infrastructure and hybrid propulsion integration**. Collaboration could include demonstration vessels, pilot ferry routes and integration of Norwegian propulsion packages in Indian-built vessels. |
| **South Korea** | One of the world's largest shipbuilding nations with strong government-backed programmes for **green ship technologies**, including methanol-ready vessels, ammonia propulsion systems and advanced ship design optimisation. | Korea's shipyards have extensive experience in **integrating alternative-fuel propulsion systems into commercial vessels**, which is relevant for India's coastal cargo and offshore vessel segments. | Technology cooperation on **methanol-ready ship design, hybrid propulsion systems, energy-efficient ship design and fuel transition engineering**. Joint research and industrial collaboration with Korean shipyards can accelerate India's capability to design future-fuel-ready vessels. |
| **Japan** | Leading developer of **ammonia-powered vessels and alternative marine fuel systems**, supported by strong collaboration between shipyards, classification societies and technology companies. | Japan's experience is particularly relevant for India's **future-fuel-ready ship design standards**, especially for ammonia and hydrogen fuel systems that may become important in the longer term. | Collaboration on **fuel system safety standards, ammonia-ready ship design, and development of regulatory guidelines for alternative marine fuels**. Japan's class societies and shipbuilders could support the development of Indian design guidelines. |

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| **Singapore** | Global maritime hub with strong expertise in **maritime digitalisation, green port programmes and vessel emissions monitoring systems**. Singapore has implemented policy frameworks linking green ship certification with port incentives and digital emissions reporting. | Singapore's approach is highly relevant to India's **green ship certification framework and digital monitoring architecture**, which will require reliable vessel performance data and emissions monitoring. | Cooperation on **digital vessel monitoring systems, maritime emissions reporting platforms, and operational incentives linked to green vessel certification**. Singapore's policy model can also inform India's regulatory architecture. |
| **Denmark** | Global leader in **energy-efficient ship design, maritime engineering and propulsion technologies**, supported by advanced marine equipment manufacturers and naval architecture expertise. | Denmark's strengths in **efficient vessel design and propulsion systems** can help Indian shipyards improve energy performance in coastal cargo vessels, offshore vessels and harbour craft. | Partnerships with Danish maritime engineering companies and design houses to improve **hull efficiency, propulsion optimisation and energy management systems** in vessels built in India. |

## E. Develop a Domestic Green Maritime Technology Ecosystem

Establish a domestic ecosystem for integration, assembly, and gradual localisation of key green ship technologies, enabling Indian shipyards to move from importing complete propulsion packages to developing domestic capability in green vessel systems.

**Key Design Elements**

The objective of this action is not to fully indigenise all green maritime technologies immediately. Instead, the short-term focus should be on **localising integration capability and building domestic supply chains around critical subsystems** that support the vessel categories prioritised under the Green Shipbuilding pillar.

Three technology clusters should be prioritised.

**1. Battery-electric and hybrid vessel systems**

Develop domestic capability for integrating marine battery systems and hybrid propulsion architectures used in ferries, harbour craft and port vessels.

**Key systems include:**

- marine battery enclosures and integration modules
- battery management systems
- hybrid propulsion control systems
- shore charging interfaces

**2. Alternative-fuel-ready vessel components**

Develop capability for integrating fuel systems supporting methanol-ready and future-fuel-ready vessel designs.

**Key systems include:**

- modular fuel piping and storage systems
- methanol fuel supply modules
- fuel safety monitoring systems
- integrated engine control systems

**3. Digital vessel monitoring and optimisation systems**

Develop digital platforms that enable vessels to monitor fuel consumption, emissions performance and operational efficiency.

**Key systems include:**

- onboard fuel monitoring systems
- energy optimisation software
- emissions monitoring systems compatible with maritime MRV frameworks

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Identify priority subsystems for localisation** | Prepare a **Green Maritime Technology Localisation List** identifying subsystems that can realistically be assembled or manufactured in India in the near term. Initial focus should be on marine battery integration modules, hybrid propulsion power electronics, modular methanol fuel supply systems, and vessel energy monitoring hardware. | This list should prioritise technologies aligned with vessels India already builds (ferries, tugs, offshore vessels). South Korea adopted a similar targeted approach under its Green Ship programme by identifying priority technologies before launching industrial support programmes. |
| **Develop shipyard–technology OEM partnerships** | Facilitate structured partnerships between Indian shipyards and global propulsion system manufacturers to transfer integration capability for hybrid propulsion systems, battery-electric propulsion packages, and alternative fuel systems. | Indian yards such as Cochin Shipyard and GRSE already integrate foreign propulsion systems; the next step is developing local integration capability rather than importing fully packaged propulsion modules. Norway used similar industrial partnerships to scale hybrid ferries. |
| **Establish green vessel integration capability in major shipyards** | Support development of specialised engineering teams within major Indian shipyards focused on integration of hybrid propulsion, battery systems and alternative fuel systems. | Most Indian shipyards already possess strong hull construction capability but rely on external vendors for advanced propulsion systems. Developing in-house integration expertise will significantly improve domestic green shipbuilding capability. |
| **Create maritime technology testbeds through pilot vessels** | Use early green vessel projects (electric ferries, green tugs, hybrid offshore vessels) as testbeds for integrating domestic or locally assembled green ship components. | Norway's maritime decarbonisation programme demonstrated the importance of demonstration vessels for building technical expertise across shipyards and equipment suppliers. |

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| **Align technology localisation with national manufacturing programmes** | Integrate green maritime technologies into existing national industrial initiatives such as Make in India and Production Linked Incentive schemes for advanced manufacturing. | Linking shipbuilding decarbonisation to national manufacturing policies will attract investment into marine propulsion equipment, power electronics and energy storage manufacturing. |

## F. Develop Policy Framework for Greening the Second-Hand Fleet

Introduce **environmental entry standards for second-hand vessels joining the Indian registry**, ensuring that fleet expansion through second-hand acquisitions does not undermine India's long-term maritime decarbonisation objectives.

India's merchant fleet has historically expanded through the acquisition of second-hand vessels, which remain an important pathway for fleet growth due to lower capital costs and faster deployment timelines. However, without environmental entry standards, there is a risk that fleet expansion could lead to the import of older, less energy-efficient vessels that may struggle to comply with emerging global decarbonisation regulations.

The proposed framework therefore focuses on **performance-based environmental standards rather than vessel age restrictions**, aligning the Indian registry with international maritime regulations while maintaining competitiveness for shipowners.

### Key Design Elements

The environmental entry framework should incorporate three core elements.

**1. Alignment with IMO Energy Efficiency Regulations**
Second-hand vessels entering the Indian registry should demonstrate compliance with international energy efficiency standards already applicable under the IMO framework.

Key requirements may include:

- **Energy Efficiency Existing Ship Index (EEXI) compliance**
- **Ship Energy Efficiency Management Plan (SEEMP)**
- basic operational energy efficiency measures where required

These requirements ensure that vessels joining the Indian fleet are compatible with global emissions reduction pathways.

**2. Mandatory Emissions Monitoring Capability**
Vessels joining the Indian flag should be equipped with basic **fuel consumption monitoring and reporting systems**.

These systems enable shipowners and regulators to track operational efficiency and emissions performance and prepare the fleet for future carbon-intensity regulations.

**3. Retrofit Pathways for Efficiency Improvement**
Where vessels do not initially meet the desired efficiency performance levels, shipowners should be allowed to undertake **energy efficiency retrofit measures** as part of the registration process.

Typical retrofit measures may include:

- propeller upgrades
- advanced hull coatings
- energy-saving devices

- digital fuel monitoring systems

This approach improves fleet efficiency without disrupting the second-hand vessel acquisition market.

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Assess environmental profile of vessels entering the Indian fleet** | Conduct an analysis of second-hand vessels currently joining the Indian registry, including vessel age, fuel efficiency and emissions performance. | India's fleet growth relies heavily on second-hand acquisitions. Understanding the efficiency profile of these vessels will help define realistic regulatory thresholds. |
| **Define environmental entry standards for vessel registration** | Introduce environmental compliance requirements for vessels entering the Indian registry, including EEXI certification, SEEMP documentation and basic emissions monitoring capability. | These requirements align with IMO regulations that already apply globally, ensuring the framework remains practical for shipowners. |
| **Introduce retrofit compliance pathways** | Allow vessels to meet environmental entry standards through targeted efficiency retrofits where required. | Efficiency retrofits are widely used globally to extend vessel life while improving energy performance. |
| **Integrate environmental checks into vessel registration procedures** | Update vessel registration and inspection processes to verify compliance with environmental entry standards. | Integrating checks into existing inspection procedures ensures implementation without creating additional regulatory complexity. |

# Pillar 2: Green Retrofits

## A. Establish a National Green Retrofit Framework

Establish a **National Green Retrofit Framework** that defines eligible retrofit technologies, certification standards, and verification procedures for emissions-reduction retrofits undertaken on vessels operating under the Indian flag or retrofitted in Indian shipyards.

The framework will create a **national reference structure for retrofit interventions**, enabling shipowners, shipyards and regulators to align on what constitutes a "green retrofit" and how emissions reductions will be measured and verified.

Given that a large portion of the vessels operating in the Indian maritime ecosystem will remain in service for another **10–20 years**, retrofitting existing ships represents one of the most practical pathways for achieving near-term emissions reductions.

**Key Design Elements**

**1. Classification of Retrofit Interventions**

Retrofit technologies should be categorised into standardised intervention groups to provide clarity for shipowners and shipyards.

These may include:

- **Energy efficiency retrofits**
  (propeller upgrades, hull coatings, energy-saving devices)
- **Propulsion system upgrades**
  (hybrid propulsion systems, battery-assisted propulsion)
- **Digital emissions monitoring systems**
  (fuel consumption monitoring, voyage optimisation systems)
- **Alternative-fuel-ready modifications**
  (structural provisions enabling future fuel transition)

**2. Retrofit Certification and Verification**
The framework should define **technical verification procedures** ensuring that retrofit projects deliver measurable efficiency improvements.

Certification should confirm:

- retrofit installation compliance
- expected fuel efficiency improvement
- compatibility with international maritime regulations

**3. Alignment with Global Decarbonisation Regulations**

Retrofit interventions should support vessel compliance with global regulatory frameworks such as:

- **Energy Efficiency Existing Ship Index (EEXI)**
- **Carbon Intensity Indicator (CII)**

This ensures that retrofit investments undertaken by shipowners remain relevant under evolving international emissions regulations.

**Implementation Approach**

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Develop national retrofit classification structure** | Define categories of retrofit interventions including energy efficiency upgrades, hybrid propulsion integration, digital monitoring systems and alternative-fuel-ready modifications. | Standardising retrofit categories helps shipowners understand which interventions qualify as "green retrofits." Japan and Singapore have adopted similar classification approaches in retrofit guidance programmes. |
| **Develop technical guidance for retrofit implementation** | Publish technical guidance outlining recommended retrofit technologies, expected efficiency improvements and engineering considerations. | Providing technical guidance reduces uncertainty for shipowners and ensures retrofit projects are implemented effectively. |
| **Establish retrofit certification procedures** | Introduce a verification process to confirm that retrofit interventions meet defined technical and environmental performance standards. | Certification provides credibility and allows retrofit projects to qualify for future incentive programmes. |
| **Integrate retrofit standards with vessel inspection processes** | Update vessel inspection and compliance procedures to incorporate retrofit certification and monitoring requirements. | Integrating retrofit verification into existing inspection processes ensures practical implementation without creating additional regulatory layers. |

## B. Identify Priority Retrofit Technologies for the Indian Fleet

Develop a **National Green Retrofit Technology Catalogue** identifying retrofit solutions that can deliver measurable emissions reductions for vessels operating in Indian waters and for ships visiting Indian shipyards.

The catalogue will provide **technical guidance to shipowners, shipyards and regulators** on the most effective retrofit technologies, expected efficiency gains, and engineering feasibility for different vessel types.

Given that a large share of vessels operating in the Indian maritime ecosystem are **existing ships acquired through the second-hand market**, identifying practical retrofit pathways will be essential for improving fleet efficiency while maintaining operational viability.

**Key Design Elements**

**1. Energy Efficiency Retrofit Technologies**
These technologies reduce fuel consumption through improvements in hull hydrodynamics and propulsion efficiency.

Typical interventions include:

- propeller upgrades and optimisation
- energy-saving devices such as ducts and fins
- advanced hull coatings that reduce friction

**2. Propulsion System Retrofit Technologies**
These technologies improve propulsion efficiency through partial electrification and hybridisation.

Typical retrofit options include:

- battery-assisted propulsion systems
- hybrid propulsion systems
- shaft generator systems that optimise engine loading

**3. Digital Monitoring and Operational Efficiency Systems**
Digital technologies allow shipowners to monitor fuel consumption and optimise vessel operations.

Typical interventions include:

- fuel consumption monitoring systems
- voyage optimisation software
- emissions monitoring platforms

**Implementation Approach**

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Map retrofit potential across the Indian fleet** | Conduct a rapid assessment of the Indian merchant fleet and coastal fleet to identify vessel categories with the highest retrofit potential. Priority segments should include coastal cargo vessels (3,000–10,000 DWT), offshore support vessels, harbour tugs, passenger ferries and government-operated vessels. | India’s coastal fleet and offshore vessels represent the most practical candidates for retrofits because they operate on predictable routes and remain in service for long durations. |

| | | |
|---|---|---|
| **Identify retrofit measures suitable for each vessel category** | Develop a vessel-segment retrofit matrix identifying the most applicable technologies for each vessel category. For example: energy-saving devices for bulk carriers and cargo vessels; hybrid propulsion for ferries and harbour craft; digital fuel monitoring systems for most vessel types. | Japan and Norway have used similar retrofit technology matrices to guide shipowners on retrofit feasibility and expected emissions reductions. |
| **Quantify expected efficiency improvements** | Compile international performance data on retrofit technologies and estimate potential fuel savings and emissions reductions achievable for the Indian fleet. | Studies show energy-saving devices and hull optimisation can reduce fuel consumption by approximately 5–10%, while hybrid propulsion systems can deliver higher savings in certain vessel segments. |
| **Publish a National Green Retrofit Technology Catalogue** | Issue a structured catalogue describing priority retrofit technologies, vessel applicability, estimated efficiency gains, and engineering requirements. | This catalogue will serve as a technical reference for shipowners considering retrofit investments and will also support future retrofit incentive schemes. |
| **Integrate retrofit guidance with vessel compliance requirements** | Ensure retrofit technologies identified in the catalogue support vessel compliance with international regulations such as EEXI and CII. | Aligning retrofit guidance with IMO efficiency regulations ensures retrofit investments remain relevant for long-term regulatory compliance. |

## C. Develop Green Retrofit Capability in Indian Shipyards

Strengthen the capability of Indian shipyards to undertake **energy-efficiency upgrades, hybrid propulsion integration, and alternative-fuel-readiness modifications** for vessels undergoing maintenance and drydock cycles.

While Indian shipyards have strong experience in vessel construction and repair, the ability to implement **decarbonisation retrofits such as propulsion system upgrades, hybridisation and digital emissions monitoring integration** remains limited.

Developing retrofit engineering capability will enable Indian shipyards to serve both the **domestic fleet and the wider regional retrofit market**, positioning India as a competitive hub for maritime retrofit services.

**<u>Key Design Elements</u>**

### 1. Engineering capability for retrofit design and integration

Shipyards must develop specialised engineering expertise to design and implement retrofit interventions, including:

- propulsion system modifications
- hybrid propulsion integration
- installation of energy-saving devices
- integration of digital emissions monitoring systems

### 2. Dedicated retrofit teams within major shipyards

Large Indian shipyards should establish specialised teams focused on retrofit engineering and execution.

These teams should be responsible for:

- retrofit feasibility assessments
- engineering design for retrofit projects
- integration of propulsion and energy systems
- coordination with classification societies for retrofit certification

**3. Alignment with drydock and repair operations**

Retrofit interventions should be integrated into **routine vessel drydock cycles**, which typically occur every **2.5–5 years**.

Integrating retrofits with scheduled maintenance reduces downtime and improves cost-effectiveness for shipowners.

**Implementation Approach**

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Identify shipyards with retrofit potential** | Conduct an assessment of Indian shipyards with strong repair and drydock capability that could undertake retrofit projects. Priority candidates include Cochin Shipyard, L&T Shipbuilding, Goa Shipyard, GRSE and major private repair yards. | These shipyards already handle vessel maintenance and repair activities, making them natural candidates for retrofit work. |
| **Develop specialised retrofit engineering teams** | Encourage major shipyards to establish dedicated engineering teams focused on energy-efficiency upgrades, hybrid propulsion integration and digital monitoring system installation. | Retrofit projects require multidisciplinary expertise covering propulsion systems, electrical integration and hull modifications. |
| **Introduce technical training programmes for retrofit technologies** | Develop training programmes for shipyard engineers and technicians on installation of energy-saving devices, hybrid propulsion systems and emissions monitoring equipment. | Countries such as Norway and Japan have introduced specialised training programmes to build retrofit engineering capability in shipyards. |
| **Integrate retrofit services into ship repair operations** | Promote integration of retrofit services into existing ship repair and drydock operations offered by Indian shipyards. | Many retrofit projects globally are implemented during scheduled drydock periods to minimise operational disruption. |
| **Promote Indian shipyards as regional retrofit hubs** | Develop strategies to attract retrofit projects from regional fleets operating in the Indian Ocean region. | Several Asian shipyards have successfully expanded into the retrofit market by leveraging existing repair infrastructure. |

## D. Establish Financing Mechanisms to Accelerate Green Retrofit Adoption

Develop financial mechanisms that enable shipowners to undertake energy-efficiency and decarbonisation retrofits by reducing the upfront capital burden associated with retrofit investments.

While many retrofit technologies offer long-term fuel savings, the initial investment required for equipment upgrades, propulsion modifications and system integration often discourages shipowners from undertaking retrofit projects. Establishing targeted financing mechanisms will therefore be critical to accelerate adoption of retrofit technologies across the Indian fleet.

**Key Design Elements**

**1. Concessional financing for retrofit investments**

Shipowners undertaking approved retrofit interventions should have access to concessional financing mechanisms that reduce capital costs associated with retrofit projects.

Eligible retrofit measures may include:

- installation of energy-saving devices

- hybrid propulsion upgrades
- fuel monitoring and optimisation systems
- alternative-fuel-ready vessel modifications

**2. Alignment with green finance and climate funding**

Retrofit projects can qualify as **green investments**, allowing shipowners to access sustainable finance instruments such as green loans or climate-linked financing.

Aligning retrofit programmes with international green finance standards will help attract private sector investment into maritime decarbonisation.

**3. Linking retrofit certification with financial incentives**

Retrofit projects verified under the **National Green Retrofit Framework** should be eligible for financial support mechanisms, ensuring that incentives are linked to measurable emissions reductions.

**Implementation Approach**

| Implementation Component | What Will Be Done | Practical Considerations / International Reference |
|---|---|---|
| **Define eligible retrofit categories for financing** | Issue a notification under the National Green Retrofit Framework identifying retrofit measures eligible for financial support. Priority categories should include propeller optimisation, energy-saving devices (ESDs), hybrid propulsion upgrades, digital fuel monitoring systems, and waste heat recovery installations. | These retrofit technologies are widely deployed globally and can typically reduce fuel consumption by **5–15%**, making them attractive candidates for financing programmes. |
| **Create a Green Maritime Retrofit Financing Window** | Establish a dedicated retrofit financing window within existing maritime financing channels such as the **Shipping Development Fund or public sector maritime lending programmes**, allowing shipowners to apply for retrofit loans with concessional interest rates. | Concessional financing is commonly used in maritime decarbonisation programmes; Norway's **Enova funding scheme** subsidises low-emission vessel upgrades and retrofits. |
| **Link retrofit certification with financing eligibility** | Require retrofit projects to obtain certification from the **Indian Register of Shipping (IRS)** confirming expected efficiency improvements before qualifying for financing support. | Linking financing to certification ensures funds are directed toward projects that deliver measurable emissions reductions. |
| **Support retrofit investments during scheduled drydock cycles** | Encourage shipowners to undertake retrofit upgrades during mandatory drydock cycles (typically every **2.5–5 years**) by providing financing approval aligned with drydock planning timelines. | Aligning financing with drydock schedules minimises operational disruption and reduces retrofit implementation costs. |
| **Enable access to international climate finance** | Position retrofit projects as eligible investments under international green finance frameworks such as **green shipping initiatives and climate transition funds**, enabling Indian shipowners to access blended finance and sustainability-linked loans. | Many global shipping companies are already accessing sustainability-linked loans tied to vessel efficiency improvements and emissions reduction targets. |